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

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H04N 5/14 (2006.01)

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

(58) **Field of Classification Search** 345/102
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,795,053	B1 *	9/2004	Funamoto et al.	345/102
7,119,786	B2 *	10/2006	Cui	345/102
2002/0070914	A1 *	6/2002	Bruning et al.	345/102
2003/0001815	A1 *	1/2003	Cui	345/102
2003/0222884	A1 *	12/2003	Ikeda et al.	345/589
2005/0057485	A1 *	3/2005	Diefenbaugh	345/102

* cited by examiner

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(57) **ABSTRACT**

A method of driving a liquid crystal display includes arranging an externally provided first data into a histogram for each frame, producing a second data having an expanded contrast using the histogram, determining a control value by extracting a peak value at a position where brightness components are concentrated in a distribution, and controlling a brightness of a back light in accordance with a gray level of the control value.

30 Claims, 9 Drawing Sheets

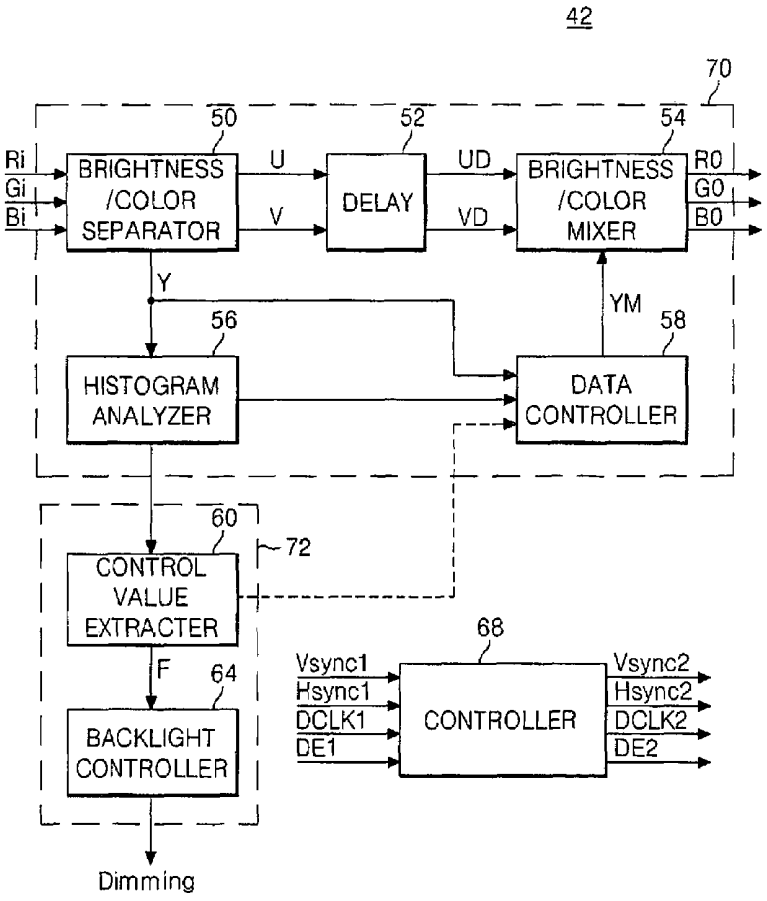


FIG. 1
RELATED ART

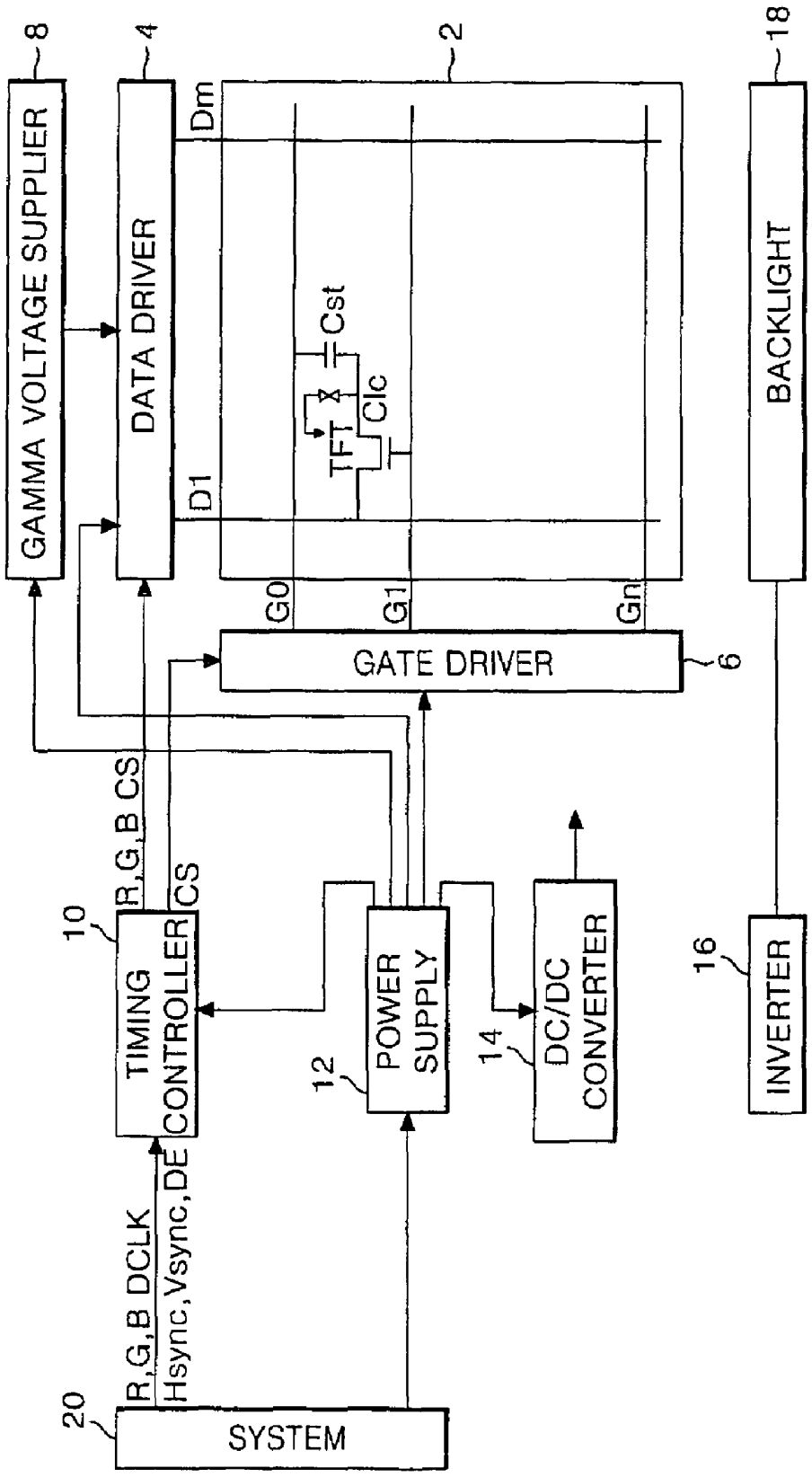


FIG.2

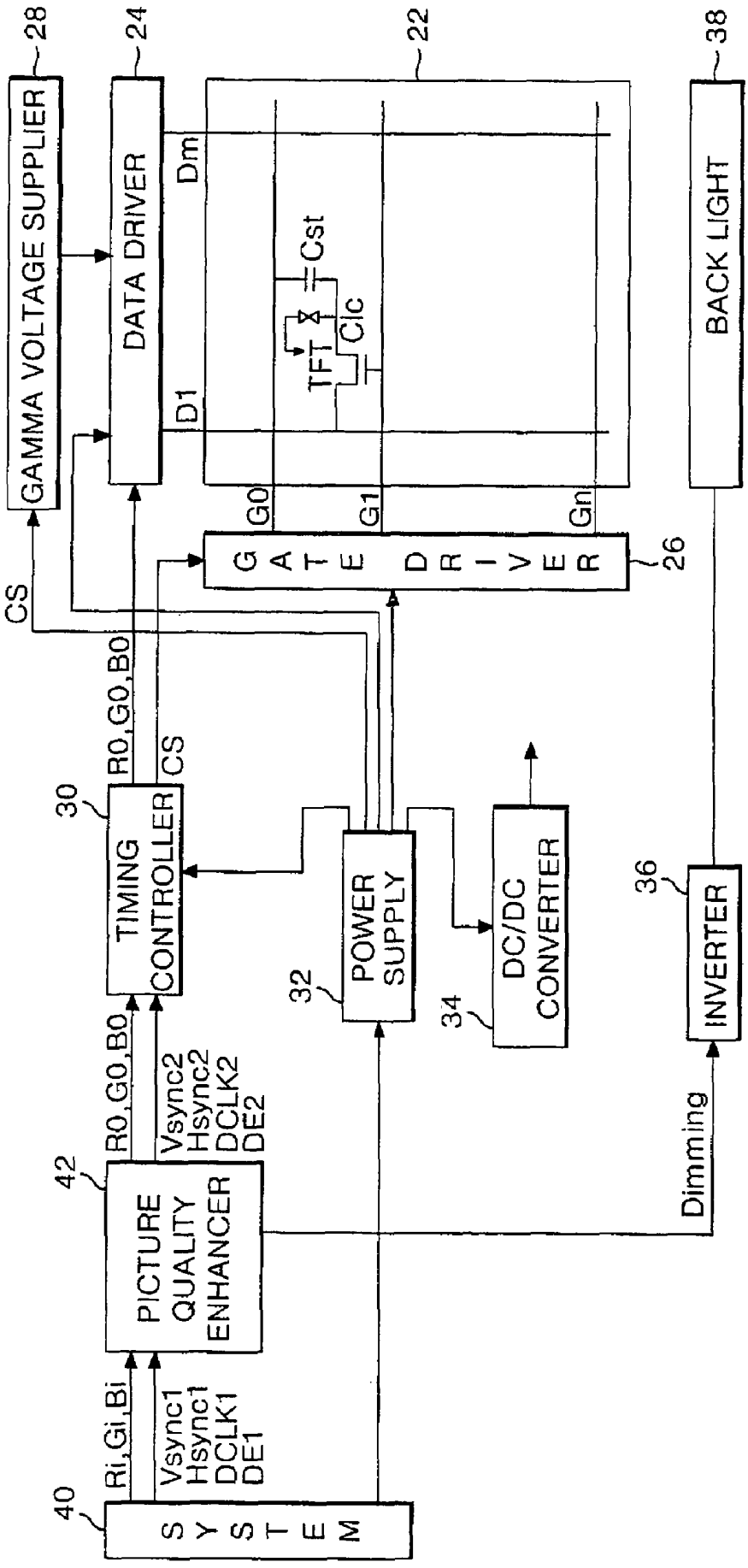

28
GAMMA VOLTAGE SUPPLIER
24
DATA DRIVER
22
38
BACK LIGHT
Dm
D1
Cst
Clc
TFT
G0
G1
Gn
GATE DRIVER
26
CS
R0,G0,B0
CS
30
TIMING CONTROLLER
32
POWER SUPPLY
34
DC/DC CONVERTER
36
INVERTER
R0,G0,B0
Vsync2
Hsync2
DCLK2
DE2
42
PICTURE QUALITY ENHANCER
Dimming
Ri,Gi,Bi
Vsync1
Hsync1
DCLK1
DE1
40
SYSTEM

FIG.3

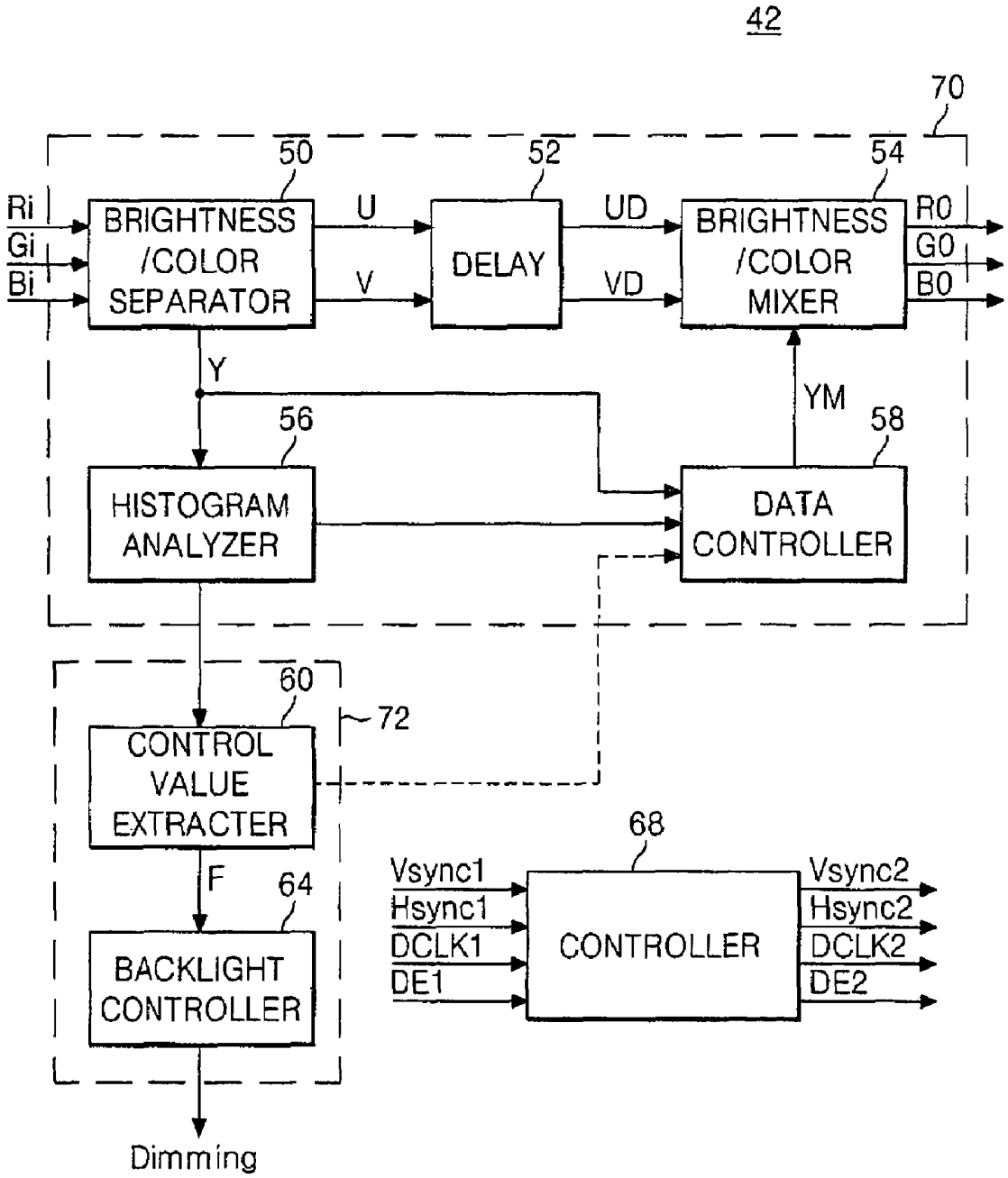

42
70
50
52
54
Ri
Gi
Bi
BRIGHTNESS /COLOR SEPARATOR
U
V
DELAY
UD
VD
BRIGHTNESS /COLOR MIXER
R0
G0
B0
Y
YM
56
58
HISTOGRAM ANALYZER
DATA CONTROLLER
60
72
CONTROL VALUE EXTRACTER
F
64
BACKLIGHT CONTROLLER
Dimming
68
Vsync1
Hsync1
DCLK1
DE1
CONTROLLER
Vsync2
Hsync2
DCLK2
DE2

FIG. 4

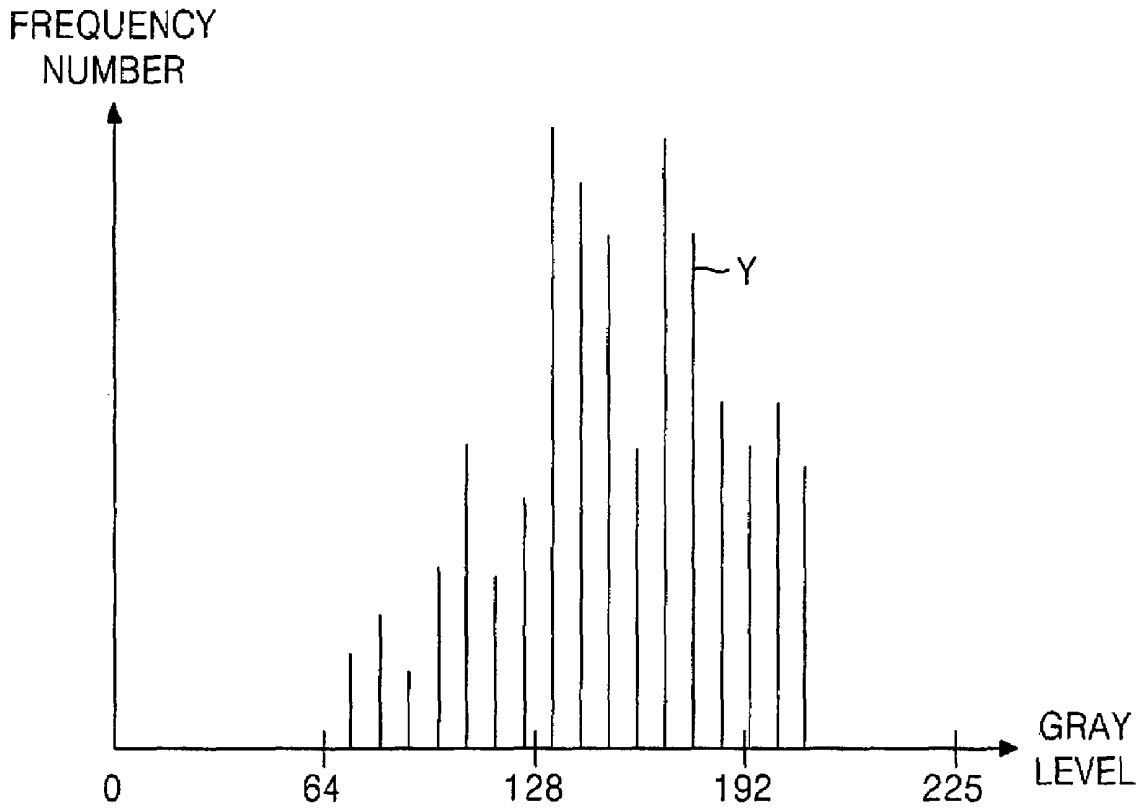


FIG. 5

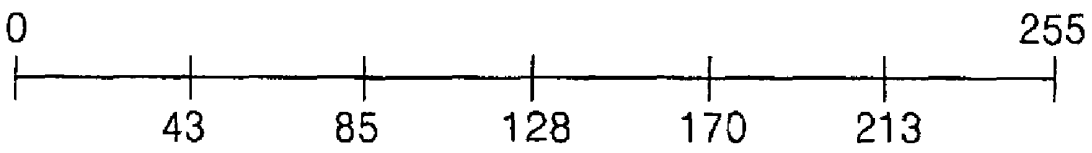


FIG.6

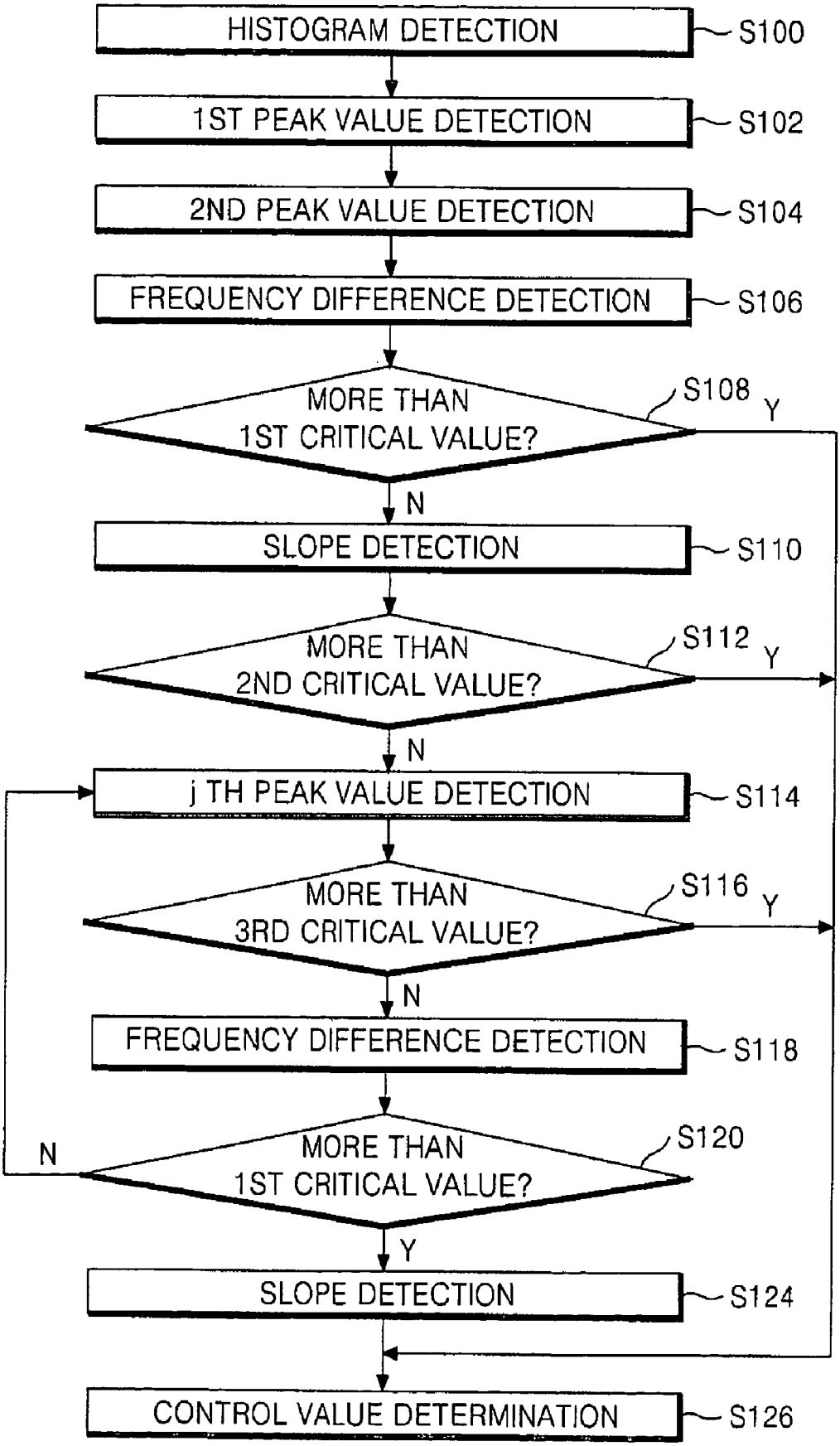

HISTOGRAM DETECTION
S100
1ST PEAK VALUE DETECTION
S102
2ND PEAK VALUE DETECTION
S104
FREQUENCY DIFFERENCE DETECTION
S106
MORE THAN 1ST CRITICAL VALUE?
S108
Y
N
SLOPE DETECTION
S110
MORE THAN 2ND CRITICAL VALUE?
S112
Y
N
j TH PEAK VALUE DETECTION
S114
MORE THAN 3RD CRITICAL VALUE?
S116
Y
N
FREQUENCY DIFFERENCE DETECTION
S118
MORE THAN 1ST CRITICAL VALUE?
S120
N
Y
SLOPE DETECTION
S124
CONTROL VALUE DETERMINATION
S126

FIG. 7A

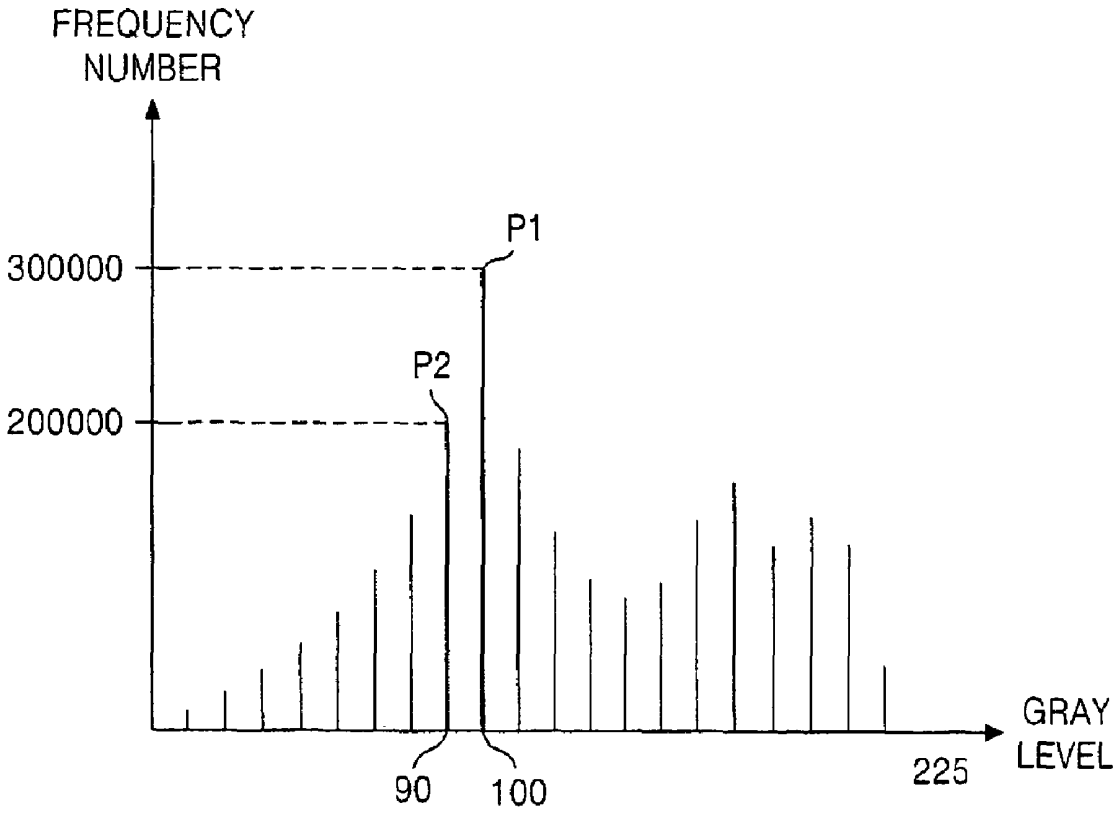


FIG.7B

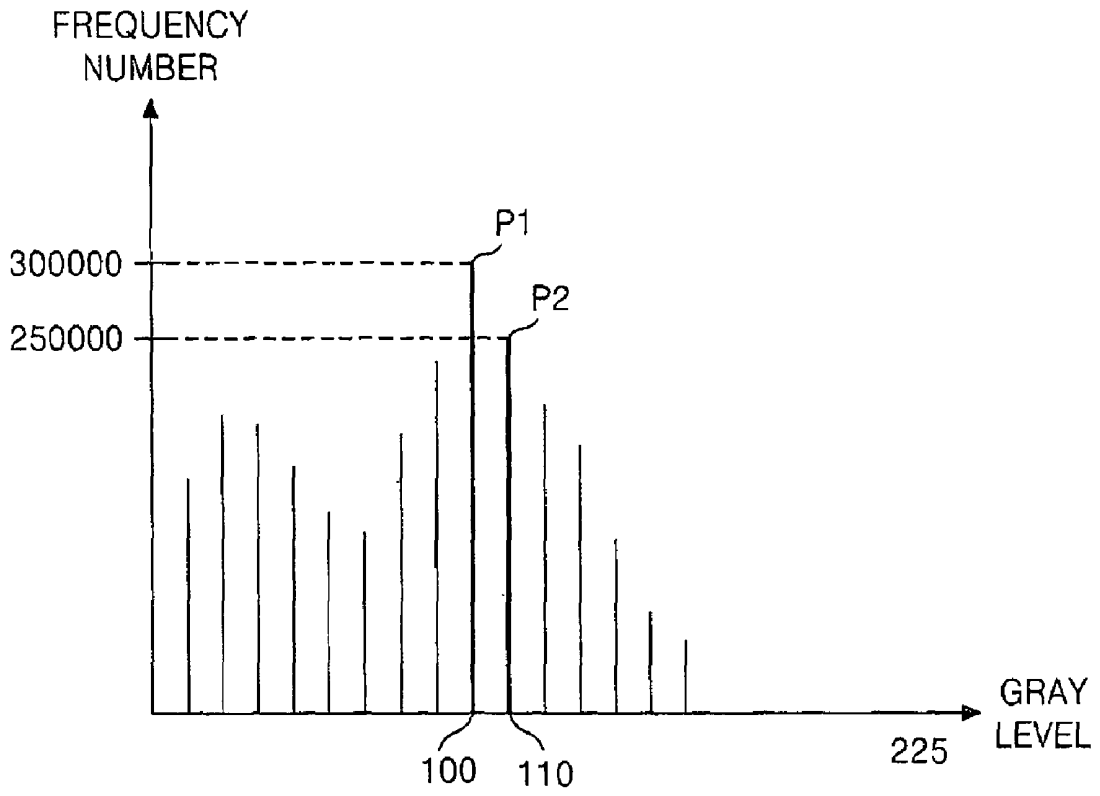
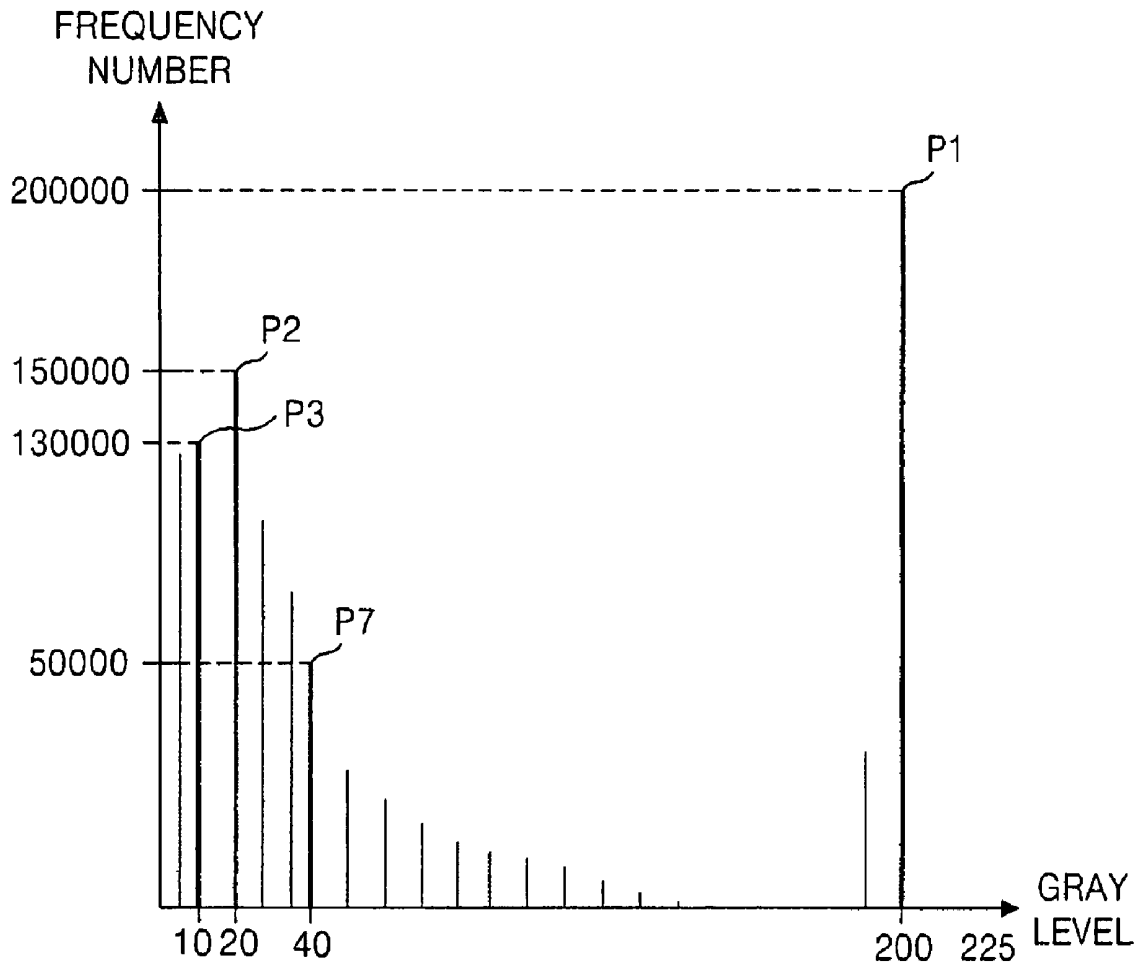


FIG. 7C


FREQUENCY NUMBER
200000
150000
130000
50000
P1
P2
P3
P7
10
20
40
200
225
GRAY LEVEL

METHOD AND APPARATUS FOR DRIVING LIQUID CRYSTAL DISPLAY

This application claims the benefit of Korean Patent Application No. P2003-99330 filed in Korea on Dec. 29, 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 having a picture with a contrast ratio.

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 in an active matrix structure having a switching device associated with each cell. LCDs have been applied to display devices such as computer monitors, office equipments, cellular phones, and the like. The switching device for the active matrix LCD mainly includes a thin film transistor (TFT).

FIG. **1** is a schematic block diagram of a configuration of a driving apparatus for a liquid crystal display in accordance with related art. Referring to FIG. **1**, the related art LCD driving apparatus includes a liquid crystal display panel **2** having an m×n number of liquid crystal cells Clc arranged in a matrix structure, an m number of data lines D**1** to Dm and an n number of gate lines G**1** to Gn crossing each other and thin film transistors TFT provided adjacent to the crossings, a data driver **4** that applies data signals to the data lines D**1** to Dm of the liquid crystal display panel **2**, a gate driver **6** that applies scanning signals to the gate lines G**1** to Gn, a gamma voltage supplier **8** that supplies the data driver **4** with gamma voltages, a timing controller **10** that controls 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 "DC/DC converter", that generates voltages supplied to the liquid crystal display panel **2** using a voltage from a power supply **12**, and an inverter **16** that drives a back light **18**. The system **20** applies a plurality of signals to the timing controller. The applied signals include vertical/horizontal signals Vsync and Hsync, clock signals DCLK, a data enable signal DE and R, G and B data.

The liquid crystal display panel **2** includes a plurality of liquid crystal cells Clc arranged in a matrix structure at crossings of 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 to thereby keep constant a voltage of the liquid crystal cell Clc. Alternatively, the storage capacitor Cst can be provided between the pixel electrode of the liquid crystal cell Clc and a common electrode line.

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 (Red), G (Green) and B (Blue) 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 that controls the gate driver **6** and the data driver **4** using the vertical/horizontal synchronizing signals Vsync and Hsync and the clock signal DCLK input from the system **20**. Herein, the control signal CS that controls the gate driver **6** comprises a gate start pulse GSP, a gate shift clock GSC and a gate output enable signal GOE, etc. Further, the control signal CS that controls the data driver **4** comprises 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 R, G and B data from the system **20**. The timing controller applies the re-aligned R, G and B data to the data driver **4**.

The DC/DC converter **14** boosts or drops the level of a voltage input from the power supply **12** from a value of 3.3V. The DC/DC converter supplies the converted voltage 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** drives the back light **18** to the back light **18** by applying a driving voltage (or driving current). The back light **18** generates light in accordance with the driving voltage (or driving current) from the inverter **16** and applies the generated light to the liquid crystal display panel **2**.

To display a vivid image on the liquid crystal display panel **2** driven in this manner, a distinct contrast between brightness and darkness of a data must be represented. However, since the related art does not disclose a method of rendering a distinct contrast of the data, it is difficult to display a vivid image using the related art liquid crystal display panel. Furthermore, since the related art back light **18** produced a constant brightness level irrespective of the input data, it is difficult to display a dynamic and fresh image using the related art back light unit.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a method and apparatus for driving liquid crystal display that substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention to provide a method for driving a liquid crystal display having expanded contrast ratio in accordance with an input data.

Another object of the present invention to provide an apparatus for driving a liquid crystal display with expanded contrast ratio in accordance with an input data.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. These and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages, and in accordance with the purpose of the present invention, as embodied and broadly described, the method of driving a liquid crystal display includes arranging an externally provided first data into a histogram for each frame, producing a second data having an expanded contrast using the histogram, determining a control value by extracting a peak value at a position

where brightness components are concentrated in a distribution, and controlling a brightness of a back light in accordance with a gray level of the control value.

In another aspect, the method of driving a liquid crystal display includes arranging externally provided data into a histogram for each frame, determining a control value which includes extracting a peak value at a position where brightness components are concentrated in a distribution, and controlling a brightness of a back light in accordance with a gray level of the control value.

In another aspect, the driving apparatus for a liquid crystal display includes a brightness/color separator that extracts brightness components from a first data, a histogram analyzer that converts the brightness components into a histogram for each frame, a data processor that produces a second data having an expanded contrast using the histogram, a control value extractor that extracts as a control value a peak value at a central part of the histogram, and a back light controller that controls brightness of a back light in response to the control value.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the present invention and together with the description serve to explain the principles of that invention. In the drawings:

FIG. **1** is a schematic block diagram of a configuration of a driving apparatus for a liquid crystal display in accordance with related art;

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

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

FIG. **4** is a graph of a sample histogram analyzed by the exemplary histogram analyzer shown in FIG. **3**;

FIG. **5** depicts a plurality of regions divided for the purpose of controlling brightness of the back light by the exemplary back light controller shown in FIG. **3**;

FIG. **6** is a flow chart representing a process of extracting a control value from the exemplary control value extractor shown in FIG. **3**; and

FIG. **7**A to FIG. **7**C are explanatory graphs of histograms illustrating a process of extracting a control value in FIG. **6**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawing.

FIG. **2** is a schematic block diagram of a configuration of an exemplary driving apparatus for a liquid crystal display according to an embodiment of the present invention. Referring to FIG. **2**, the LCD driving apparatus according to the above-mentioned embodiment of the present invention includes a liquid crystal display panel **22** having an m×n number of liquid crystal cells Clc arranged in a matrix structure. The LCD includes an m number of data lines D**1** to Dm and an n number of gate lines G**1** to Gn crossing each other. Thin film transistors (TFT) are adjacent to crossings of the data lines and the gate lines. The LCD includes a data driver **24** that applies data signals to the data lines D**1** to Dm of the liquid crystal display panel **22** and a gate driver **26** that applies scanning signals to the gate lines G**1** to Gn. The LCD further includes a gamma voltage supplier **28** for supplying the data driver **24** with gamma voltages. The LCD also includes a timing controller **30** that controls the data driver **24** and the gate driver **26** using a second synchronizing signal from a picture quality enhancer **42**. The LCD also has a DC/DC converter **34** that generates voltages supplied to the liquid crystal display panel **22** using a voltage from a power supply **32**. In the LCD, an inverter **36** that drives a back light unit **38**. A picture quality enhancer **42** selectively emphasizes a contrast of an input data into the LCD and applies a brightness control signal Dimming corresponding to the input data to the inverter **36**. A 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 arrangement. The liquid crystal cells are positioned at the crossings between the data lines D**1** to Dm and the gate lines G**1** to Gn. The thin film transistor TFT provided in each liquid crystal cell Clc applies a data signal from one of the data lines D**1** to Dm to the liquid crystal cell Clc in response to a scanning signal from one of the gate lines G**0** to Gn. 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. Alternatively, the storage capacitor can be provided between the pixel electrode of the liquid crystal cell Clc and a common electrode line to keep constant 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**. Thereby, the gate driver selects horizontal lines of the liquid crystal display panel **22** to be supplied with the data signals.

The timing controller **30** generates the control signals CS that controls 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** input from the picture quality enhancer **42**. Herein, the control signal CS that controls the gate driver **26** comprises a gate start pulse GSP, a gate shift clock GSC and a gate output enable signal GOE, etc. Further, the control signal CS that controls the data driver **24** comprises 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**. The timing controller **30** applies the re-aligned Ro, Go and Bo data to the data driver **24**.

The DC/DC converter **34** boosts or drops the level of a voltage input from the power supply **32** from a value of 3.3V. The DC/DC converter supplies the converted voltage 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 corresponding to the brightness control signal Dimming from the picture quality enhancer **42** to the back light **38**. In other words, the driving voltage 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 to the liquid crystal display panel **22** in accordance with the driving voltage from the inverter **36**.

Alternatively, the inverter **36** can apply a driving current corresponding to the brightness control signal Dimming from the picture quality enhancer **42** to the back light **38**. In this case, the 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**. Thus, the back light **38** applies light to the liquid crystal display panel **22** in accordance with the driving current from the inverter **36**.

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

The picture quality enhancer **42** generates a brightness control signal Dimming corresponding to the extracted brightness components. The picture quality enhancer **42** applies the brightness control signal to the inverter **36**. Specifically, the picture quality enhancer **42** extracts from the brightness components a control value for controlling the back light, and generates the brightness control signal Dimming using the extracted control value. Herein, the picture quality enhancer **42** divides the brightness of the back light corresponding to gray levels of the brightness components into at least two regions, and generates the brightness control signal Dimming such that region selection corresponds to the control value.

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** using 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** input from the system **40**. Herein, the second data enable signal DE**2** is synchronized with the second data Ro, Go and Bo.

FIG. **3** is a detailed block diagram of the exemplary picture quality enhancer shown in FIG. **2**. As shown in FIG. **3**, the picture quality enhancer **42** includes an image signal modulator **70**, a back light controller **72** and a control unit **68**. The image signal modulator **70** generates the second data Ro, Go and Bo using the first data Ri, Gi and Bi. The back light controller **72** generates the brightness control signal Dimming under control of the image signal modulator **70**. The control unit **68** generates 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. The image signal modulator **70** generates second data Ro, Go and Bo in which a contrast is partially emphasized based on 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 controller **58**.

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

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

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

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

FIG. **4** is a graph of a sample histogram analyzed by the exemplary histogram analyzer shown in FIG. **3**. The histogram analyzer **56** divides the brightness components Y of each frame into gray levels for that frame. In other words, the histogram analyzer **56** arranges the brightness components Y of each frame in accordance with the gray levels, thereby obtaining a histogram as shown in FIG. **4**. Herein, the shape of the histogram varies in accordance with the brightness components of the first data Ri, Gi and Bi.

The data controller **58** generates modulated brightness components YM having an emphasized contrast using the analyzed histogram from the histogram analyzer **56**. Specifically, the data controller **58** can generate modulated brightness components YM using various methods. Exemplary schemes that can be used by the above-mentioned data controller **58** as modulating methods for expanding image contrast are disclosed in Korean Patent Applications Nos. 2003-036289, 2003-040127, 2003-041127, 2003-80177, 2003-81171, 2003-81172, 2003-81173 and 2003-81175, which are pre-filed by Applicants and are hereby incorporated herein. Alternatively, the data controller **58** can generate the modulated components YM having an emphasized contrast using a well-known method. On the other hand, the data controller **58** can generate the modulated brightness components YM with reference to a control value from the control value extractor **60**.

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

The brightness/color mixer **54** generates second data Ro, Go and Bo using the modulated brightness components YM and the delayed chrominance components UD and VD. Herein, the second data Ro, Go and Bo are 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** have been produced using modulated brightness components YM with an expanded contrast, they have more expanded contrast than the first data Ri, Gi and Bi. The second data Ro, Go and Bo are applied to the timing controller **30**.

The controller 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 Vsync2 and Hsync2, the second clock signal DCLK2 and the second data enable signal DE2 in synchronization with the second data Ro, Go and Bo, and applies the generated signals Vsync2, Hsync2, DCLK2 and DE2 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. Herein, the control value controls a change in brightness of the back light **38**. A peak value within a region containing a concentration of the brightness components is selected as the control value. Specifically, a gray level of the peak value is selected as the control value.

FIG. **5** depicts a plurality of regions divided for the purpose of controlling brightness of the back light by the exemplary back light controller shown in FIG. **3**. 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 gray levels of the brightness components Y into a plurality of areas, and controls the back light **38** in such a manner that each area corresponds to a different brightness of light. In other words, the back light control **64** grasps a gray level of the control value, and generates a brightness control signal Dimming that corresponds to the area which contains the control value.

The control value extractor **60** extracts a control value from the histogram analyzer **56** to apply the control value to the back light control **64**. Herein, the control value extractor **60** extracts a control value that corresponds to a characteristic of the histogram. In other words, the present control value extractor **60** selects a peak value at a position having a high concentration of the brightness components. If a peak value at the position containing a concentration of the brightness components is selected as the control value, then the brightness of picture can be adjusted in correspondence with the brightness of the data.

The control value can be selected as the most-frequent value, which is the value having the highest frequency of occurrence in the histogram. However, if the most-frequent value is selected as the control value, then an image with brightness characteristic contrary to the desired brightness from a specific image is displayed causing a deterioration of display quality. For instance, when the moon rises at a dark background, if a most-frequent value is selected as the control value, then total brightness (i.e., gray levels corresponding to the moon) is highly controlled to thereby fail to display a desired image. Accordingly, the present control value extractor **60** selects a peak value at a position where the brightness components are highly concentrated as the control value, thereby always displaying a desired brightness of image on the liquid crystal display panel **22**.

FIG. **6** is a flow chart representing a process of extracting a control value from the exemplary control value extractor shown in FIG. An operation procedure of the control value extractor **60** will be described in detail with reference to the flow chart depicted in FIG. **6**. Referring to FIG. **6**, firstly, at step S**100**, the histogram analyzer **56** arranges the brightness components Y for each frame in order of gray levels, to thereby generate a histogram. In this case, the generated brightness components varies in correspondence with the first data Ri, Gi and Bi. For instance, at step S**100**, a histogram as shown in FIG. **7**A can be generated.

FIG. **7**A to FIG. **7**C are explanatory graphs of histograms illustrating a process of extracting a control value in FIG. **6**. In FIG. **7**A, the vertical axis represents a frequency of occurrence while the horizontal axis does a gray level. The frequency of occurrence in the horizontal axis is determined by the display resolution of the liquid crystal display panel **22**. For example, if the liquid crystal display panel **22** has a display resolution of 1024×768, the highest value of the frequency of occurrence in the vertical axis is determined to be 983040.

If a histogram has been generated at step S**100**, then the control value extractor **60** detects a first peak value P**1** from the histogram at step S**102**. The first peak value P**1** is a value having the highest frequency of occurrence in the histogram (i.e., a most-frequent value). In FIG. **7**A, the first peak value P**1** is selected as 300000. At step S**104**, the control value extractor **60** detects a second peak value P**2**. The second peak value P**2** is a value having the second highest frequent of occurrence in the histogram. In FIG. **7**A, the second peak value P**2** is selected as 2000000.

At step S**106**, the control value extractor **60** having detected the first and second peak values P**1** and P**2** generates a normalized frequency difference between the first peak value P**1** and the second peak value P**2**. The normalized frequency difference is generated by calculating the difference between the second peak value P**2** and the first peak value P**1** and dividing the calculated difference by the second peak value P**2**. In other words, the frequency difference generated at step **106** is calculated by subtracting the low value P**2** from the high value P**1** and then dividing the subtracted value by the low value P**2**. For example, at step S**106**, a value subtracted, by the second peak value P**2**, from the first peak value P**1** is set to 100000, and the frequency difference results in 0.5 if the subtracted value is divided by the second peak value P**2**.

At step S**108**, the control value extractor **60** checks whether the frequency difference generated at step **106** exceeds a first threshold value. Herein, the first threshold value is set to 0.5 or more. More specifically, the frequency difference obtained in step **106** is a value representing a normalized frequency difference between the first peak value P**1** and the second peak value P**2**. Experimentally, if the frequency difference between the first peak value P**1** and the second peak value P**2** is set to 0.5 or more, then most of the brightness components are positioned at the first peak value P**1**. Hereinafter, it will be assumed that the first threshold value should be set to 0.5.

Since the frequency difference is set higher than the first threshold value at step **108**, the control value extractor **60** determines **100** as the control value at step **126**. The control value is the gray level associated with the first peak value. Thereafter, the control value determined at step S**126** is applied to the back light controller **64** and the data controller **58**. The back light controller **64** generates a brightness control signal Dimming such that a light having brightness corresponding to the determined control value can be produced. The data controller **58** generates the modulated brightness components YM such that a contrast ratio can be improved in accordance with the control value.

In an embodiment of the present invention, a frequency difference between the first peak value P**1** and the second peak value P**2** is detected, and a gray level of the first peak value P**1** is set to a control value when the frequency difference exceeds the first threshold value. Accordingly, in the above-referenced embodiment the present invention, it becomes possible to select the first peak value having the highest brightness as the control value, thereby adjusting brightness in correspondence with a data.

Hereinafter, another embodiment of the present invention will be described in reference to FIG. **6** and FIG. **7**B. An explanation of FIG. **6** will be briefly made in conjunction with the forgoing related descriptions. Referring to FIG. **6**

and FIG. **7**B, firstly, at step S**100**, a histogram as shown in FIG. **7**B is generated by the histogram analyzer **56**. If the histogram has been generated at step **100**, then the control value extractor **60** extracts a first peak value P**1** and a second peak value P**2** from the histogram at steps S**102** and S**104**. In FIG. **7**B, the first peak value P**1** is selected as 300000 while the second peak value P**2** is selected as 250000. The control value extractor **60** having detected the first and second peak values P**1** and P**2** at steps S**102** and S**104** calculates a frequency difference between the first and second peak values P**1** and P**2** at step S**106**. At step S**106**, a value obtained by subtracting the second peak value P**2** from the first peak value P**1** is set to 500000, and the frequency difference result is 0.2 obtained by dividing the subtracted value by the second peak value P**2**.

At step S**108**, the control value extractor **60** checks whether the frequency difference generated at step **106** exceeds a first threshold value. At step S**108**, the frequency difference is set lower than the first threshold value of 0.5. If the frequency difference is set lower than the first threshold value at step S**108**, then the control value extractor **60** generates a slope between the first and second peak values P**1** and P**2** at step S**110**. The slope is determined by dividing a variation amount along the vertical axis by a variation amount along the horizontal axis. In FIG. **7**B, the vertical axis variation amount of the first and second peak values P**1** and P**2** is set to 50000 while the horizontal axis variation amount thereof is set to 10. Thus, the slope is set to 5000 at step **110**.

At step S**112**, the control value extractor **60** checks whether the slope generated at step S**110** exceeds the second threshold value. Herein, the second threshold value is determined to be in the thousands, for example, a value between 1000 and 9999. More specifically, the second threshold value is indicative of whether the first peak value P**1** is close to the second peak value P**2**. Experimentally, if the first and second peak values P**1** and P**2** have thousands of value, then the peak value P**1** and the second peak value P**2** are positioned in such a manner to be close to each other from the histogram. In reality, the second threshold value is determined differently, for example in accordance with the resolution of the liquid crystal display panel **22**. Hereinafter, a description will be made, assuming that the second threshold value should be 1000, for explanatory purposes.

Since a generated value of the slope has been set higher than the second threshold value at step S**112**, the control value extractor **60** determines the control value to be 100, which is a gray level value of the first peak value P**1** at step S**126**. Experimentally, if the slope between the first and second peak values P**1** and P**2** exceeds the second threshold value, then most brightness components are adjacent to the first peak value P**1**. Thus, the control value extractor **60** determines the control value to be 100, which is a gray level value of the first peak value P**1** when the slope between the first and second peak values P**1** and P**2** exceeds the second threshold value.

Thereafter, the control value determined at step S**126** is applied to the back light controller **64** and the data controller **58**. The back light controller **64** generates a brightness control signal Dimming such that a light having brightness corresponding to the control value input thereto can be produced. The data controller **58** generates the modulated brightness components YM such that a contrast ratio can be improved with reference to the control value.

Hereinafter, an explanation as to still another embodiment of the present invention will be made with reference to FIG. **6** and FIG. **7**C. Referring to FIG. **6** and FIG. **7**C, firstly, at step S**100**, a histogram as shown in FIG. **7**C is generated by the histogram analyzer **56** (for example, when the moon rises over the dark background). If the histogram has been generated at step **100**, then the control value extractor **60** extracts a first peak value P**1** and a second peak value P**2** from the histogram at steps S**102** and S**104**. In FIG. **7**C, the first peak value P**1** is selected as 200000. The second peak value P**2** is selected as 150000.

After having detected the first and second peak values P**1** and P**2** at steps S**102** and S**104**, the control value extractor **60** calculates a frequency difference between the first and second peak values P**1** and P**2** at step S**106**. At step S**106**, a value obtained by subtracting the second peak value P**2** from the first peak value P**1** is set to 50000. The corresponding frequency difference is approximately 0.33 obtained by dividing the subtracted value by the second peak value P**2**.

At step S**108**, the control value extractor **60** checks whether the frequency difference generated at step **106** exceeds a first threshold value. At step S**108**, the frequency difference is set lower than the first threshold value, which is 0.5. If the frequency difference is lower than the first threshold value at step S**108**, then the control value extractor **60** generates a slope between the first and second peak values P**1** and P**2** at step S**110**. In FIG. **7**C, the vertical axis variation amount of the first and second peak values P**1** and P**2** is set to 50000 while the horizontal axis variation amount thereof is set to 180. Thus, the slope is approximately 278 at step **110**.

At step S**112**, the control value extractor **60** checks whether the slope generated at step S**110** exceeds the second threshold value. Herein, the slope of 278 calculated at step S**112** is lower than the second threshold value. If the frequency difference is lower than the second threshold value, then the control value extractor **60** detects a third peak value P**3** (i.e., j=3) having the frequency of occurrence next to the second peak value P**2** at step S**114**.

At step S**116**, after having detected the third peak value P**3**, the control value extractor **60** checks whether a repetition round of steps S**114** to S**120** exceeds a third threshold value. Herein, the third threshold value is a value representing the maximum number of repetitions for steps S**114** to S**120**, and is set lower than the total number of gray levels in the horizontal axis of the histogram, for example, a value of 253 or less. More specifically, since the histogram, as shown in FIG. **7**C, has gray levels of 0 to 255, the maximum number of peak values to be obtained from the histogram is set to 256. Herein, since the first to third peak values P**1** to P**3** have been detected prior to step S**114**, the maximum repetition round of steps S**114** to S**120** is determined to be 253 or less. Thus, the third threshold value is determined to be a value between 1 and 253.

If the repetition round is less than the third threshold value at step S**116**, then the control value extractor **60** generates a frequency difference between a peak value generated at step S**114** (i.e., the third peak value P**3**) and the second peak value P**2**. At step S**118**, a value obtained by subtracting the third peak value P**3** from the second peak value P**2** is set to 20000, and the corresponding frequency difference is approximately 0.15 obtained by dividing the subtracted value of 20000 by the third peak value P**3**. Herein, the second peak value P**2** may be replaced by the first peak value P**1** at step S**118**.

At step S**120**, the control value extractor **60** checks whether the frequency difference generated at step S**118** exceeds the first threshold value. If the frequency difference is smaller than the first threshold value at step S**120**, then steps S**114** to S**120** are repeated. Meanwhile, the control

value extractor **60** detects a peak value one level lower than the peak value detected at the previous step at step S**114**. In other words, if the third peak value P**3** has been detected at the previous step, then the control value extractor **60** detects a fourth peak value P**4** having the frequency of occurrence one level lower than the third peak value P**3** to thereby repeat steps S**116** to S**120**.

The control value extractor **60** repeats steps S**114** to S**120** at a predetermined round to obtain a sixth peak value P**6**, and, if the sixth peak value P**6** is lower than the first threshold value, detects a seventh peak value P**7** at step S**114**. The control value extractor **60** having detected the seventh peak value P**7** generates a frequency difference between the seventh peak value P**7** and the second peak value P**2** (or the first peak value P**1**) at step S**118**. At step S**118**, a value obtained by subtracting the seventh peak value P**7** from the second peak value P**2** is set to 100000, and the frequency difference is given to approximately 2 by dividing the subtracted value by the third peak value P**3**.

After obtaining the frequency difference of 2 at step S**118**, the control value extractor **60** checks at step S**120** whether the frequency difference exceeds the first threshold value. If the frequency difference is larger than the first threshold value, then the control value extractor **60** obtains a slope between the first peak value P**1** and the seventh peak value P**7** and a slope between the second peak value P**3** and the seventh peak value P**7** at step S**124**. At step S**124**, the slope between the first peak value P**1** and the seventh peak value P**7** is 973.5 while the slope between the second peak value P**2** and the seventh peak value P**7** is 5000.

Subsequently, the control value extractor **60** compares the magnitudes of the slopes obtained at step S**124** to determine a peak value having a larger slope to be a control value. Herein, since the slope between the second peak value P**2** and the seventh peak value P**7** is larger than the slope between the first peak value P**1** and the seventh peak value P**7**, a gray level value of the second peak value P**2**, which is 20, is determined to be a control value. In other words, the control value extractor **60** selects a gray level value of the second peak value P**2** as a control value because the seventh peak value P**7** is positioned in such a manner to be close to the second peak value P**2**. Herein, if the slope between the seventh peak value P**7** and the first peak value P**1** is larger than the slope between the seventh peak value P**7** and the second peak value P**2**, then a gray level of the first peak value P**1** is selected as the control value.

The control value determined at step S**126** is applied to the back light controller **64** and the data controller **58**. The back light controller **64** generates a brightness control signal Dimming such that a light having brightness corresponding to the control value input thereto can be produced. The data controller **58** generates the modulated brightness components YM such that a contrast ratio is improved with reference to the control value.

In embodiments of the present invention, if the repetition round of steps S**114** to S**120** exceeds the third threshold value, then the control value extractor **60** selects an average value as a control value at step S**126**. In other words, in the above-mentioned embodiment of the present invention, if a desired peak value is not selected at steps S**100** to S**120**, then a gray level value of the average value of the histogram is selected as a control value. Thus, when brightness is distributed evenly at a whole area, the average value is selected as a control value.

Alternatively, in another embodiment of the present invention, if the repetition round of steps S**114** to S**120** exceeds the third threshold value, then control value extractor **60** can set a data and brightness of the back light in the same method as the related art. In other words, in another embodiment of the present invention, if a desired peak value is not selected at steps S**100** to S**120**, then the brightness of the back light is controlled similarly with the related art (i.e., a predetermined brightness). In this case, a contrast of the data may be not expanded.

The inverter **36** controls the back light **38** such that a light corresponding to the brightness control signal Dimming supplied from the back light controller **64** is applied to the liquid crystal display panel **22**. In other words, in embodiments of the present invention, the second data Ro, Go and Bo having an expanded contrast are produced in correspondence with the brightness components Y for one frame of the externally provided first data Ri, Gi and Bi, thereby displaying a vivid image. Furthermore, the brightness of the back light **38** is controlled in accordance with the brightness components Y for one frame of the first data Ri, Gi and Bi, thereby displaying a vivid image. Moreover, in embodiments of the present invention, the control value is extracted from an area at which a lot of brightness is distributed, so that it becomes possible to prevent a high brightness from being displayed on the dark field or to prevent a low brightness from being displayed within the bright field.

As described above, according to various embodiments of the present invention, the brightness components are extracted from the first data and the second data having an expanded contrast are produced using the extracted brightness components, thereby displaying a vivid image. Furthermore, the brightness of the back light is controlled by the brightness components extracted from the first data, thereby displaying a vivid image. Moreover, according to the various embodiments of the present invention, a peak value where brightness components are concentrated in distribution is set to a control value determining a brightness characteristic of the back light, so that it becomes possible to prevent a high brightness from being displayed in the dark field.

It will be apparent to those skilled in the art that various modifications and variations can be made in embodiments the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A method of driving a liquid crystal display, comprising:

arranging an externally provided first data into a histogram for each frame;

producing a second data having an expanded contrast using the histogram;

determining a control value by extracting a peak value at a position where brightness components are concentrated in a distribution; and

controlling a brightness of a back light in accordance with a gray level of the control value.

2. The method of claim **1**, wherein determining the control value includes:

extracting a first peak value having the highest frequency of occurrence from the histogram;

extracting a second peak value having the second highest frequency of occurrence from the histogram;

detecting a frequency difference representing a difference in the frequency of occurrence between the first peak value and the second peak value; and

specifying the control value as a gray level of the first peak value when the frequency difference exceeds a first threshold value.

3. The method of claim 2, wherein detecting the frequency difference includes dividing a value obtained by subtracting the second peak value from the first peak value by the second peak value.

4. The method of claim 2, wherein detecting the frequency difference includes subtracting a peak value having a low frequency of occurrence from a peak value having a high frequency of occurrence and dividing the subtracted value by the peak value having the low frequency of occurrence.

5. The method of claim 2, wherein the first threshold value is 0.5 or more.

6. The method of claim 2, further comprising:

detecting a slope between the first peak value and the second peak value when the frequency difference is lower than the first threshold value; and

specifying the control value as the gray level of the first peak value when the slope exceeds a second threshold value.

7. The method of claim 6, wherein detecting the slope includes dividing a variation amount in the frequency of occurrence corresponding to the vertical axis of the histogram by a variation amount in the gray level corresponding to the horizontal axis of the histogram.

8. The method of claim 6, wherein the second threshold value is in a range from 1000 to 9999.

9. The method of claim 6, further comprising:

a modified peak detection step of detecting a modified peak value having the frequency of occurrence next to the second peak value when the slope is lower than the second threshold value;

a modified frequency detection step of detecting a modified frequency difference between the modified peak value and the second peak value; and

a modified decision step of determining whether the frequency difference exceeds the first threshold value.

10. The method of claim 9, wherein the modified peak detection step, the modified frequency detection step and the modified decision step are repeated when the modified frequency difference is lower than the first threshold value at the modified decision step.

11. The method of claim 10, further including:

changing the modified peak value into a peak value having a frequency of occurrence next to the frequency of occurrence of the modified peak value extracted at the modified peak detection step; and

repeating the modified peak detection step, the modified frequency detection step and the modified decision step.

12. The method of claim 9, wherein the modified frequency difference exceeds the first threshold value at the third step, further comprising:

detecting a first slope between the modified frequency difference and the first peak value when;

detecting a second slope between the modified frequency difference and the second peak value; and

determining a magnitude of each of the first and second slopes.

13. The method of claim 12, wherein the first slope is larger, and the gray level of the first peak value is set to the control value.

14. The method of claim 12, wherein the second slope is larger, and the gray level of the second peak value is set to the control value.

15. The method of claim 10, further comprising:

checking a repetition round of the modified peak detection step, the modified frequency detection step and the modified decision step; and

checking whether the repetition round is lower than a third threshold value.

16. The method of claim 15, wherein the third threshold value is lower than a total gray level number in the horizontal axis of the histogram.

17. The method of claim 16, wherein the third threshold value is 253 or less.

18. The method of claim 15, wherein the repetition round exceeds the third threshold value, and an average value of the histogram is set to the control value.

19. The method of claim 15, wherein the repetition round exceeds the third threshold value, and the brightness of the back light is controlled such that a predetermined brightness of light can be provided.

20. A method of driving a liquid crystal display, comprising:

arranging externally provided data into a histogram for each frame;

determining a control value which includes extracting a peak value at a position where brightness components are concentrated in a distribution; and

controlling a brightness of a back light in accordance with a gray level of the control value.

21. The method of claim 20, wherein the step of determining a control value includes:

extracting a first peak value having the highest frequency of occurrence from the histogram;

extracting a second peak value having the second highest frequency of occurrence from the histogram;

detecting a frequency difference representing a difference in the frequency of occurrence between the first peak value and the second peak value; and

specifying the control value as a gray level of the first peak value when the frequency difference exceeds a first threshold value.

22. The method of claim 21, wherein detecting the frequency difference includes subtracting a peak value having a low frequency of occurrence from a peak value having a high frequency of occurrence and dividing the subtracted value by the peak value having the low frequency of occurrence.

23. The method of claim 21, wherein the first threshold value is 0.5 or more.

24. The method of claim 21, further comprising:

detecting a slope between the first peak value and the second peak value when the frequency difference is lower than the first threshold value; and

setting the control value as the gray level of the first peak value when the slope exceeds a predetermined second threshold value.

25. The method of claim 24, wherein the second threshold value is in the range from 1000 to 9999.

26. The method of claim 24, further comprising:

detecting a modified peak value having the frequency of occurrence next to the second peak value when the slope is lower than the second threshold value;

generating a modified frequency difference between the modified peak value and the second peak value; and

determining whether the frequency difference exceeds the first threshold value.

27. The method of claim 26, wherein the modified frequency difference exceeds the first threshold value, further comprising:

detecting a first slope between the modified frequency difference and the first peak value when;

detecting a second slope between the modified frequency difference and the second peak value; and

determining a magnitude of each of the first and second slopes.

28. The method of claim **27**, wherein the first slope is larger, and the gray level of the first peak value is set to the control value.

29. The method of claim **27**, wherein the second slope is larger, and the gray level of the second peak value is set to the control value.

30. A driving apparatus for a liquid crystal display, comprising:

a brightness/color separator that extracts brightness components from a first data;

a histogram analyzer that converts the brightness components into a histogram for each frame;

a data processor that produces a second data having an expanded contrast using the histogram;

a control value extractor that extracts as a control value a peak value at a central part of the histogram; and

a back light controller that controls brightness of a back light in response to the control value.

* * * * *

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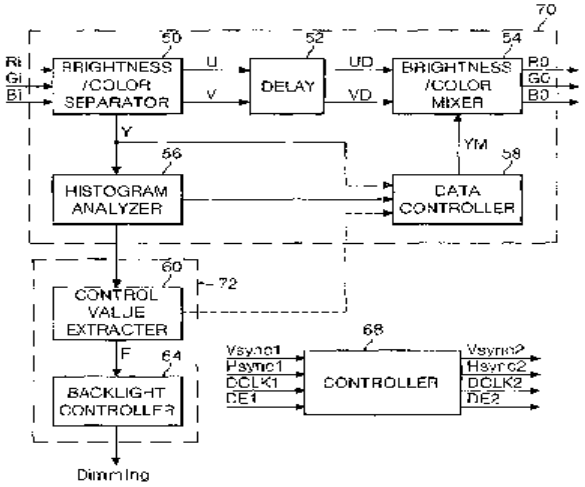
一种驱动液晶显示器的方法包括：将外部提供的第一数据布置成每帧的直方图，使用直方图产生具有扩展对比度的第二数据，通过在亮度分量是的位置处提取峰值来确定控制值。集中在分布中，并根据控制值的灰度级控制背光的亮度。