US 20080272998A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2008/0272998 A1**

(43) **Pub. Date: Nov. 6, 2008**

Yano et al.

(54) **IMAGE DISPLAY DEVICE AND IMAGE DISPLAY METHOD**

(76) Inventors: **Tomoya Yano**, Kanagawa (JP); **Yoshiki Shirochi**, Chiba (JP); **Toshinobu Isobe**, Chiba (JP); **Makio Iida**, Tokyo (JP)

Correspondence Address:
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER LLP
901 NEW YORK AVENUE, NW
WASHINGTON, DC 20001-4413 (US)

(21) Appl. No.: **10/571,911**

(22) PCT Filed: **Jul. 15, 2005**

(86) PCT No.: **PCT/JP2005/013144**

§ 371 (c)(1),
(2), (4) Date: **Mar. 14, 2006**

(30) **Foreign Application Priority Data**

Jul. 16, 2004 (JP) 2004-210347
Jun. 6, 2005 (JP) 2005-166014

Publication Classification

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

(52) **U.S. Cl.** **345/89**

(57) **ABSTRACT**

An image display device and an image display method able to display a middle gray-scale by using a plurality of pixels or fields and, at the same time, improve viewing angle characteristics are provided. When displaying an image via a direct view type liquid crystal display screen, a gray-scales of an input video signal is converted to characteristic values (transmittances) of pixels two-dimensionally arranged with respect to the display image, and the gray-scale is converted so as to include, among a plurality of pixels or fields expressing a middle gray-scale, at least one pixel or field converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal, and at least one pixel or field converted to a second characteristic value obtained by adding a negative correction value to the gray-scale of the input video signal.

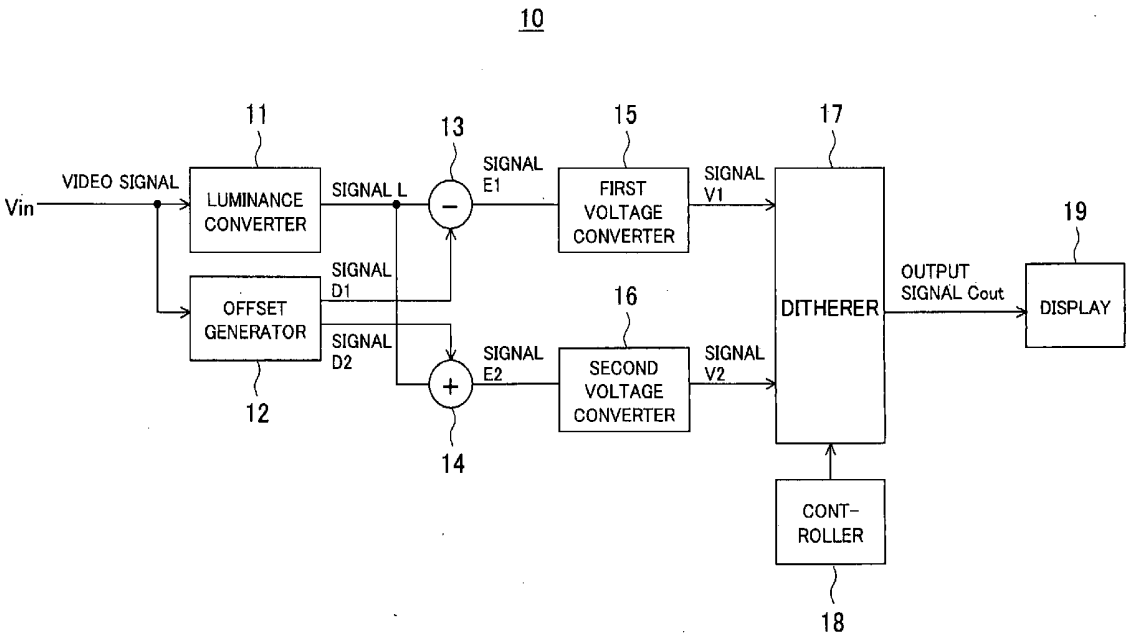


FIG. 1A

157	208	106	52
39	18	123	97
169	178	123	176
230	208	157	167

FIG. 1B

0	3	0	3
2	1	2	1
0	3	0	3
2	1	2	1

FIG. 1C

157	211	106	55
41	19	125	98
169	181	123	179
232	209	159	168

FIG. 1D

156	208	104	52
40	16	124	96
168	180	120	176
232	208	156	168

FIG. 2A

1	1	1	1
1	1	1	1
1	1	1	1
1	1	1	1

FIG. 2B

0	2	0	2
3	1	3	1
0	2	0	2
3	1	3	1

FIG. 2C

0	0	0	0
4	0	4	0
0	0	0	0
4	0	4	0

FIG. 3

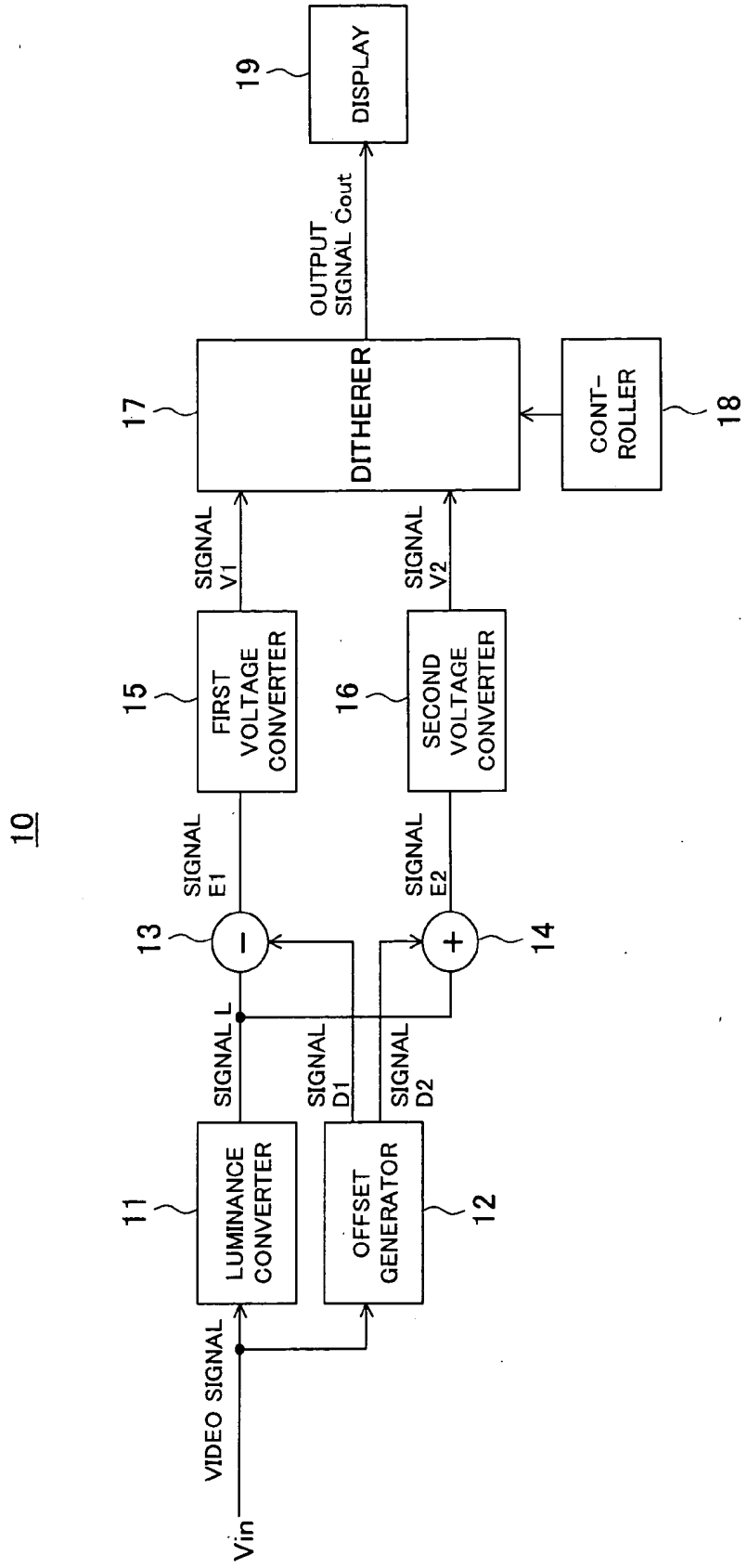

10
VIDEO SIGNAL
Vin
11
LUMINANCE CONVERTER
12
OFFSET GENERATOR
13
14
SIGNAL L
SIGNAL D1
SIGNAL D2
SIGNAL E1
SIGNAL E2
15
FIRST VOLTAGE CONVERTER
16
SECOND VOLTAGE CONVERTER
SIGNAL V1
SIGNAL V2
17
DITHERER
18
CONT-ROLLER
OUTPUT SIGNAL Cout
19
DISPLAY

FIG. 4A

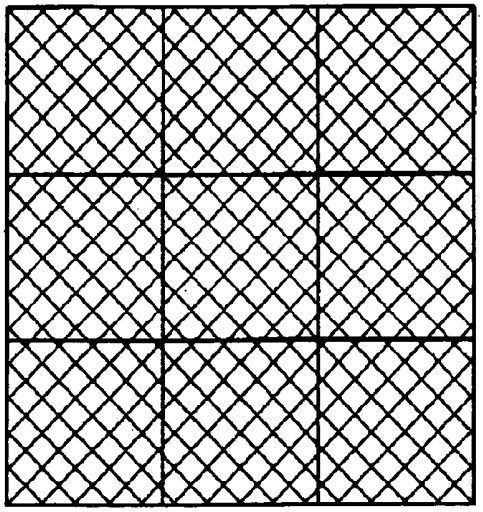


FIG. 4B

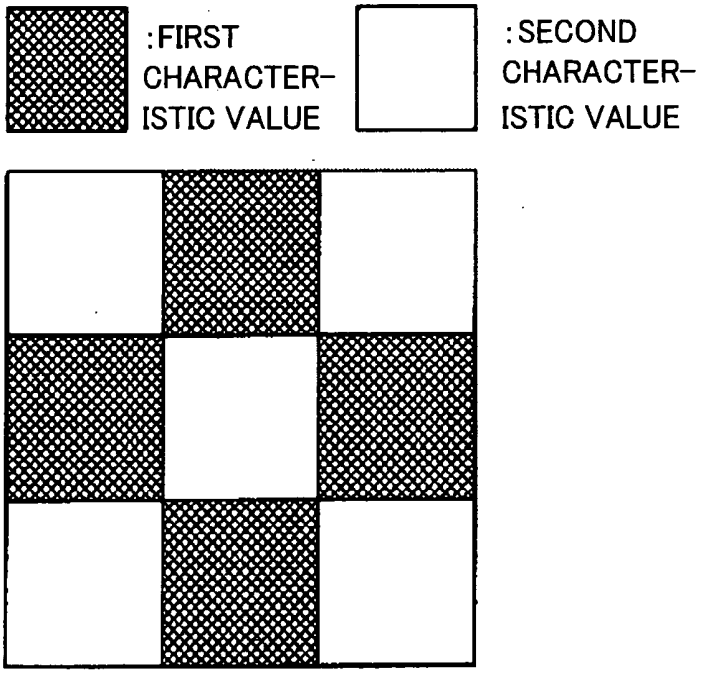

:FIRST CHARACTER-ISTIC VALUE
:SECOND CHARACTER-ISTIC VALUE
DITHER MATRIX

FIG. 5

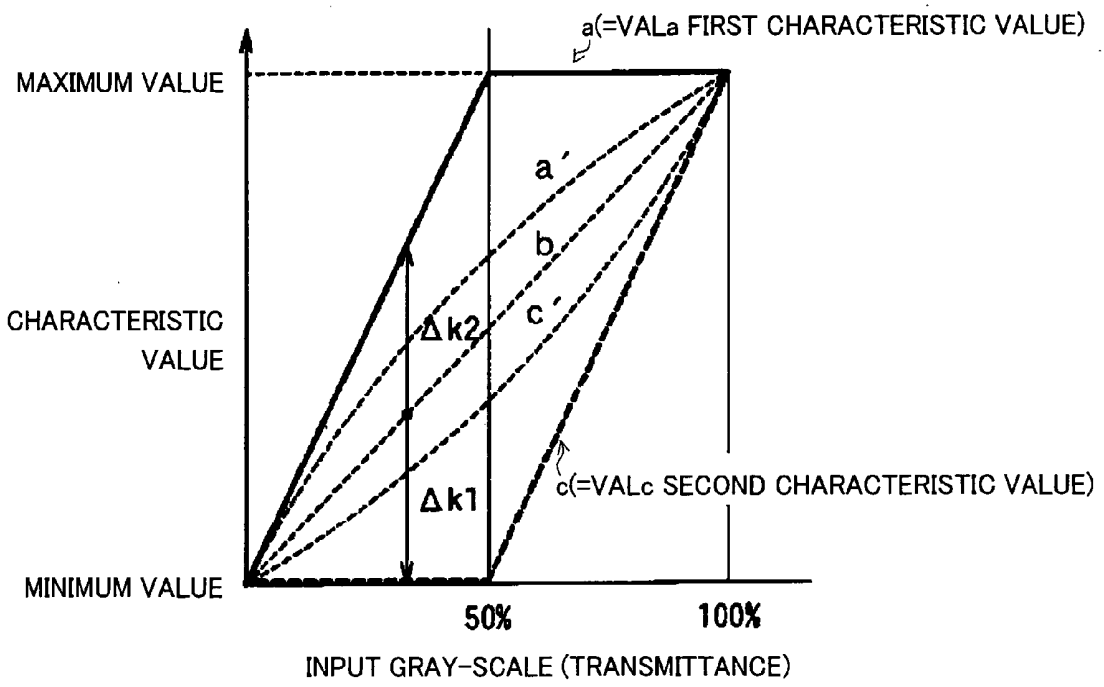

a(=VALa FIRST CHARACTERISTIC VALUE)
MAXIMUM VALUE
a'
b
c'
CHARACTERISTIC VALUE
Δk2
Δk1
c(=VALc SECOND CHARACTERISTIC VALUE)
MINIMUM VALUE
50%
100%
INPUT GRAY-SCALE (TRANSMITTANCE)

FIG. 6A

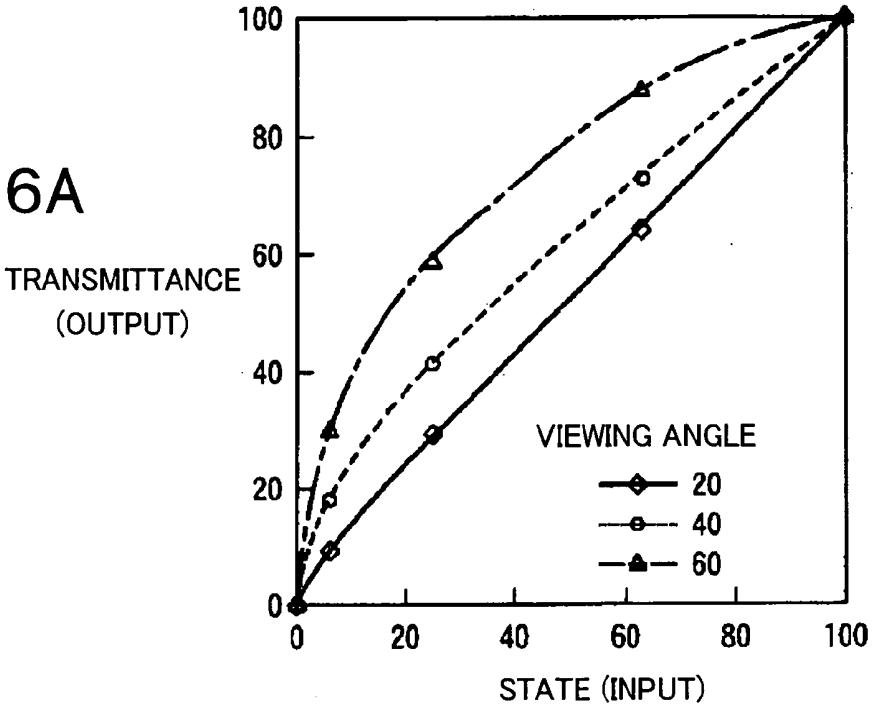

TRANSMITTANCE
(OUTPUT)
100
80
60
40
20
0
0
20
40
60
80
100
STATE (INPUT)
VIEWING ANGLE
20
40
60

FIG. 6B

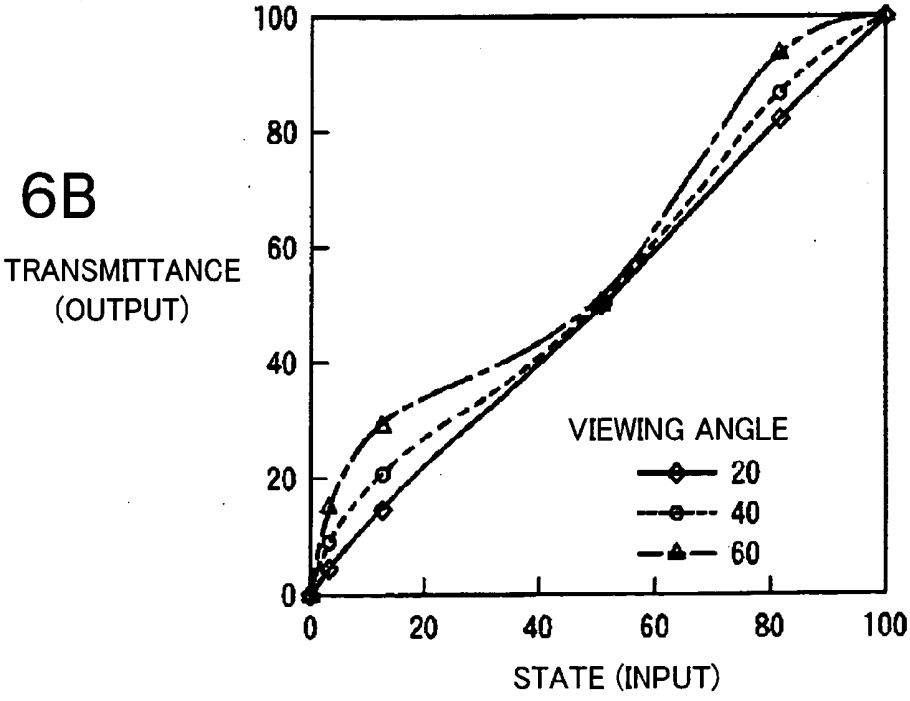

TRANSMITTANCE
(OUTPUT)
100
80
60
40
20
0
0
20
40
60
80
100
STATE (INPUT)
VIEWING ANGLE
20
40
60

FIG. 7A

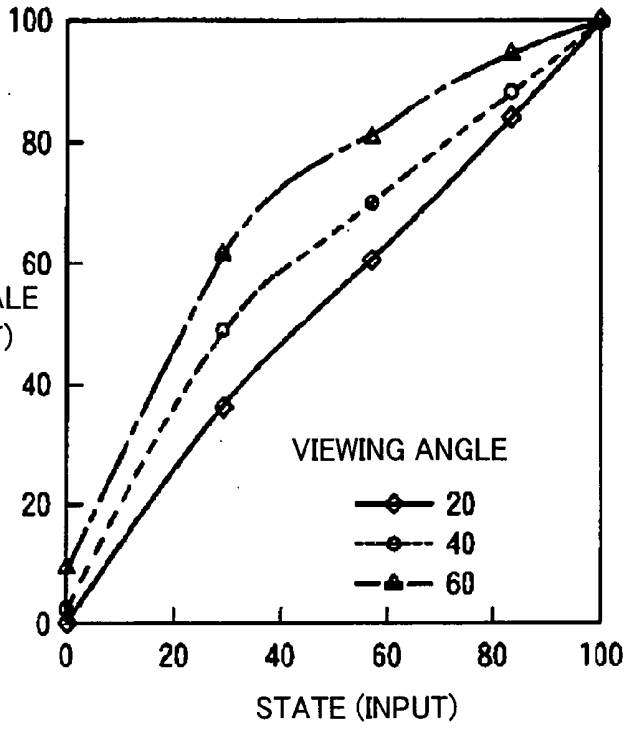

100
80
60
40
20
0
GRAY-SCALE
(OUTPUT)
VIEWING ANGLE
20
40
60
0
20
40
60
80
100
STATE (INPUT)

FIG. 7B

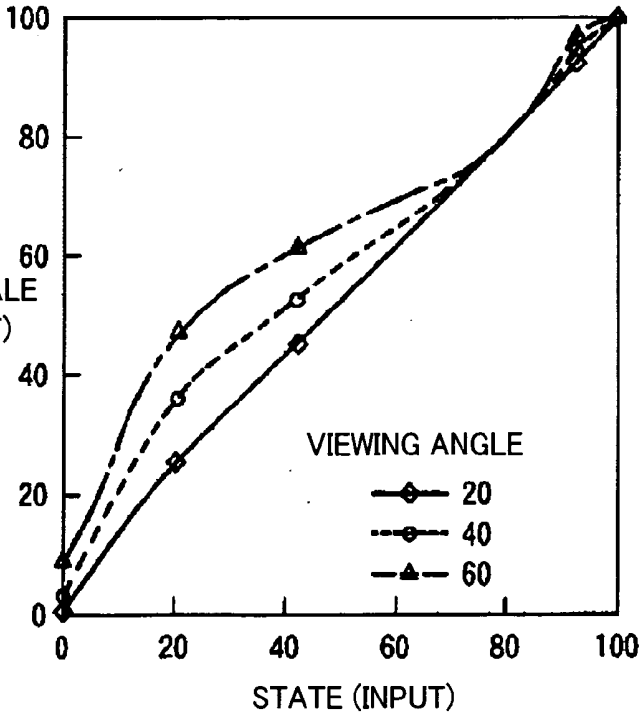

100
80
60
40
20
0
GRAY-SCALE
(OUTPUT)
VIEWING ANGLE
20
40
60
0
20
40
60
80
100
STATE (INPUT)

FIG. 8A

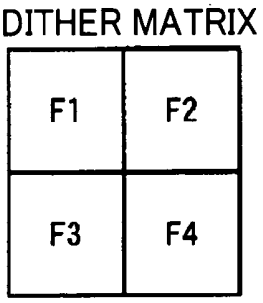

DITHER MATRIX
F1
F2
F3
F4

FIG. 8B

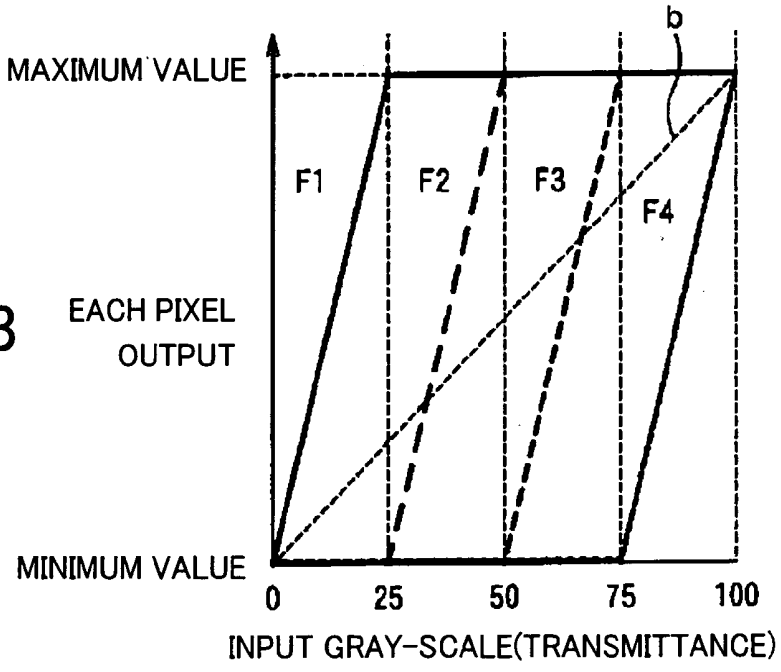

b
MAXIMUM VALUE
F1
F2
F3
F4
EACH PIXEL OUTPUT
MINIMUM VALUE
0
25
50
75
100
INPUT GRAY-SCALE(TRANSMITTANCE)

FIG. 9

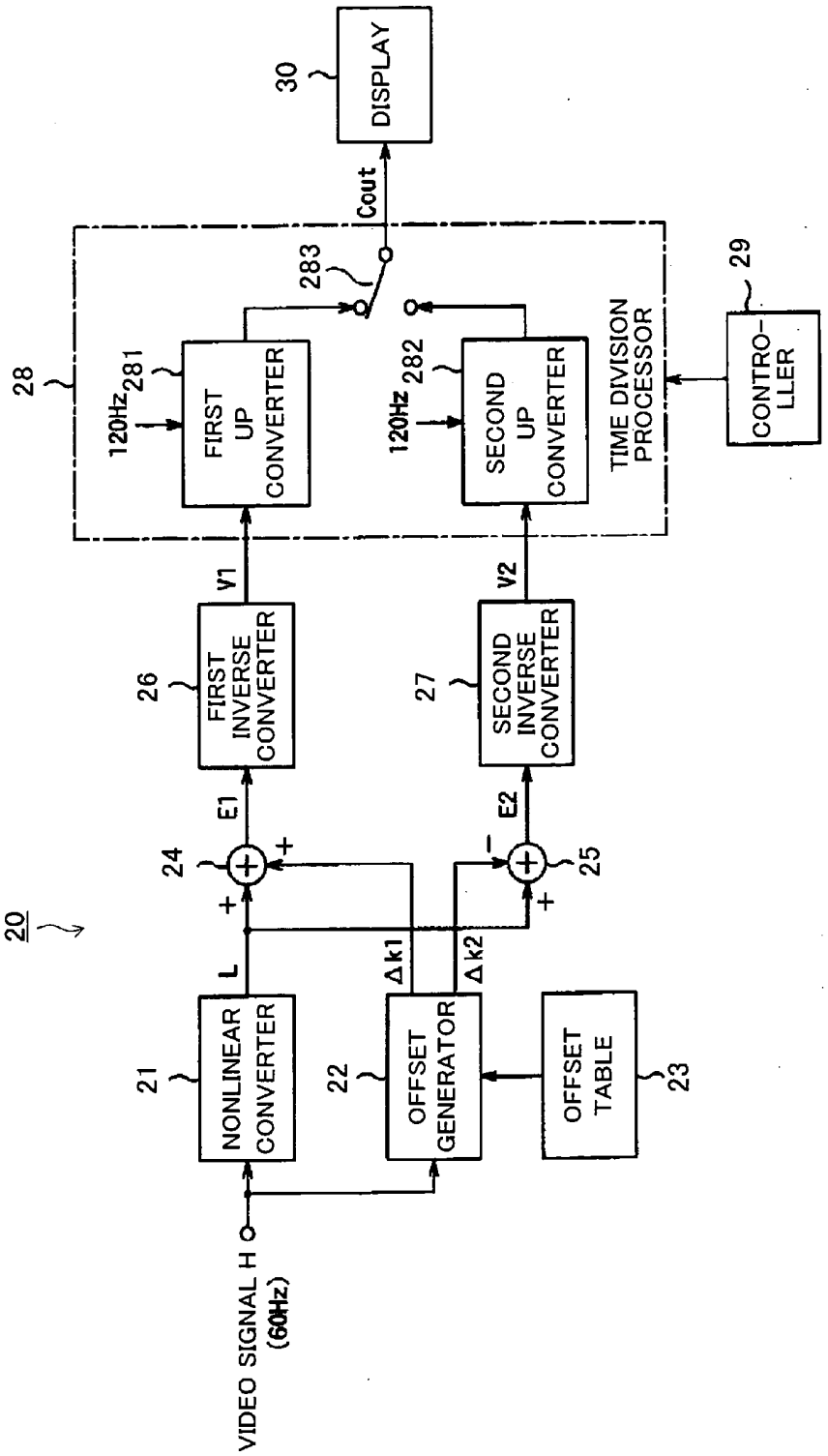

20
VIDEO SIGNAL H
(60Hz)
21
NONLINEAR CONVERTER
22
OFFSET GENERATOR
23
OFFSET TABLE
24
25
26
FIRST INVERSE CONVERTER
27
SECOND INVERSE CONVERTER
28
TIME DIVISION PROCESSOR
281
FIRST UP CONVERTER
282
SECOND UP CONVERTER
283
29
CONTRO-LLER
30
DISPLAY
L
Δk1
Δk2
E1
E2
V1
V2
Cout
120Hz
120Hz

FIG. 10

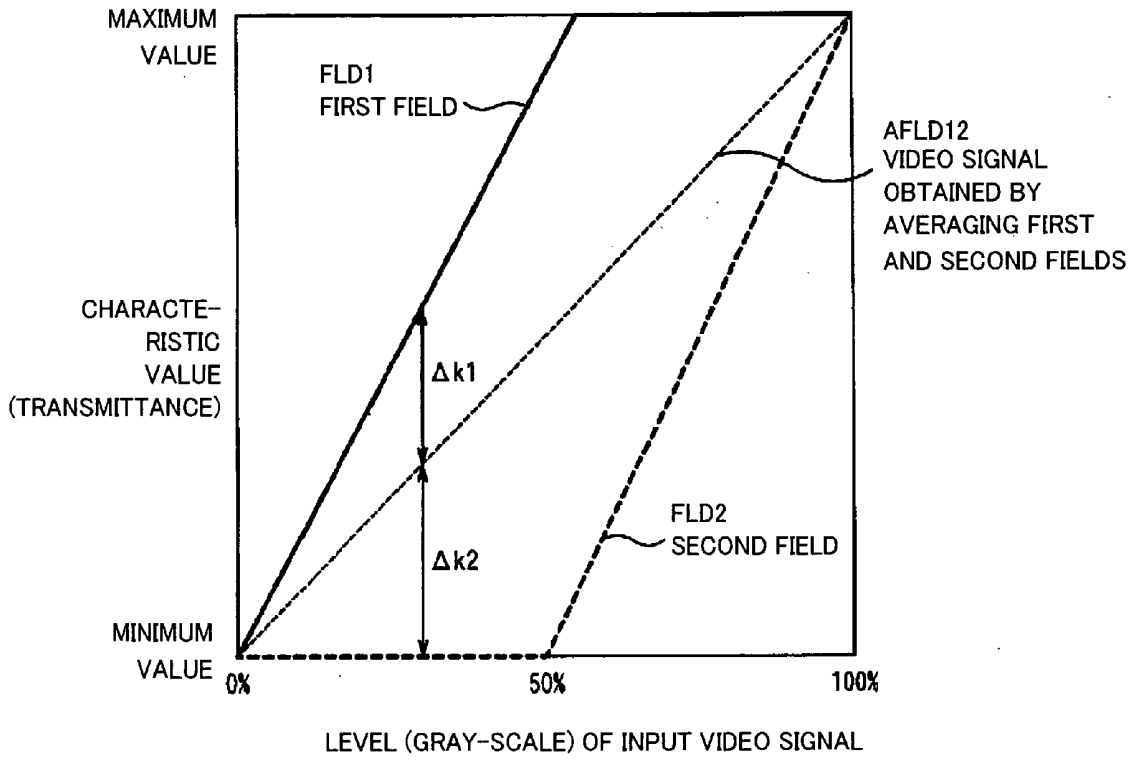

MAXIMUM VALUE
FLD1 FIRST FIELD
AFLD12 VIDEO SIGNAL OBTAINED BY AVERAGING FIRST AND SECOND FIELDS
CHARACTE-RISTIC VALUE (TRANSMITTANCE)
Δk1
Δk2
FLD2 SECOND FIELD
MINIMUM VALUE
0%
50%
100%
LEVEL (GRAY-SCALE) OF INPUT VIDEO SIGNAL

FIG. 11

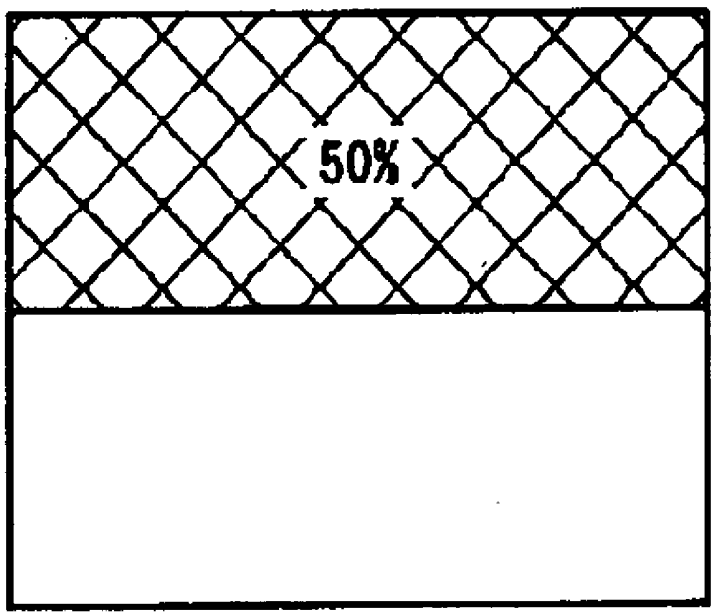


FIG. 12

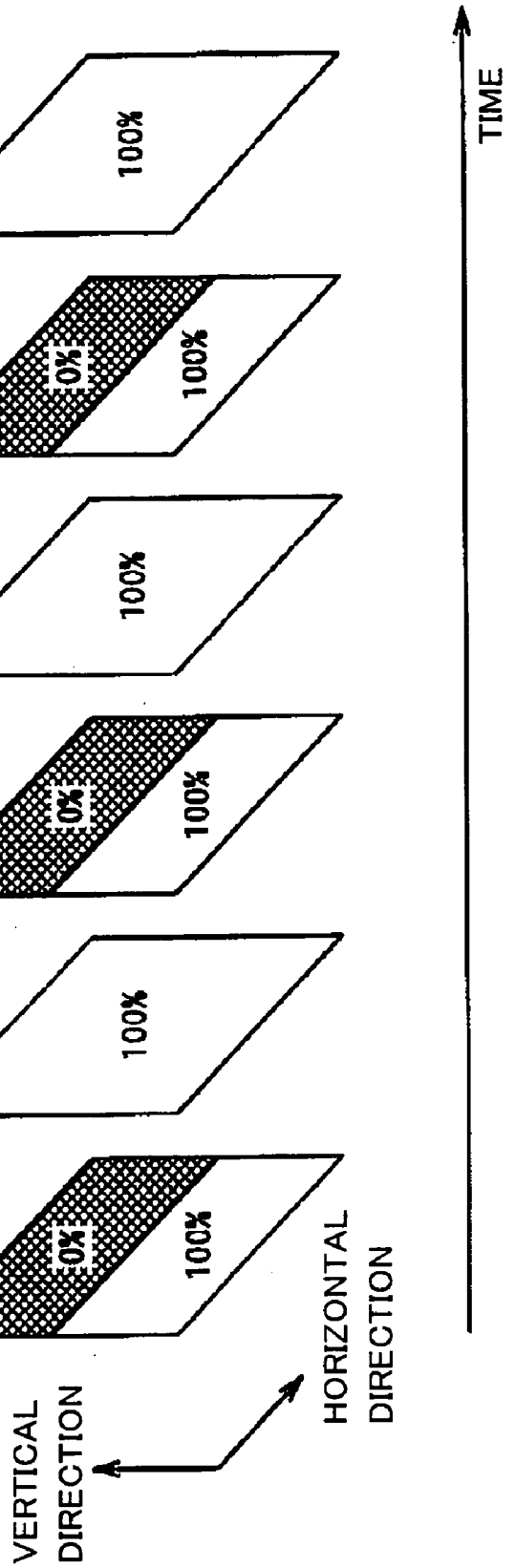

FIRST FIELD
FLD1
100%
SECOND
FIELD
FLD2
0%
100%
FIRST FIELD
FLD1
100%
SECOND
FIELD
FLD2
0%
100%
FIRST FIELD
FLD1
100%
SECOND
FIELD
FLD2
0%
100%
TIME
VERTICAL
DIRECTION
HORIZONTAL
DIRECTION

FIG. 13A

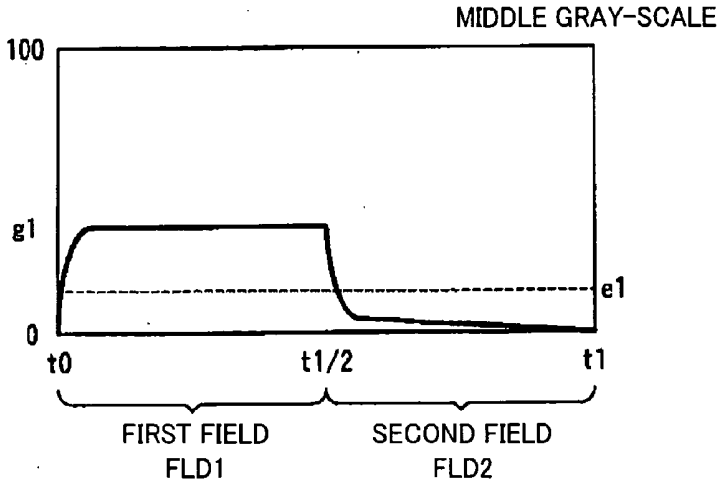


FIG. 13B

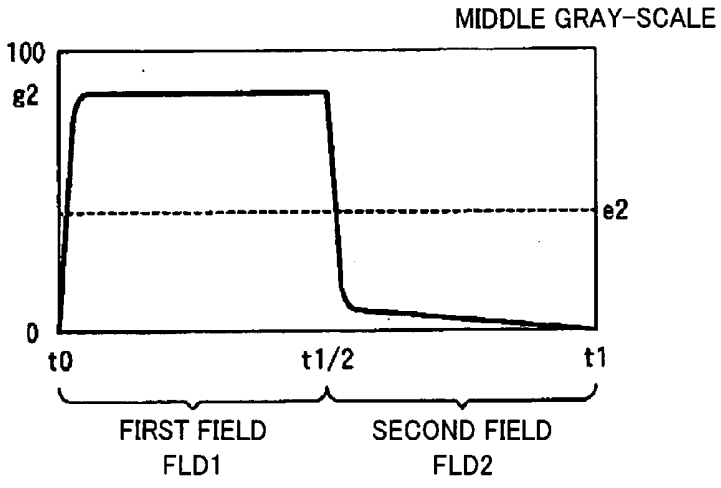


FIG. 13C

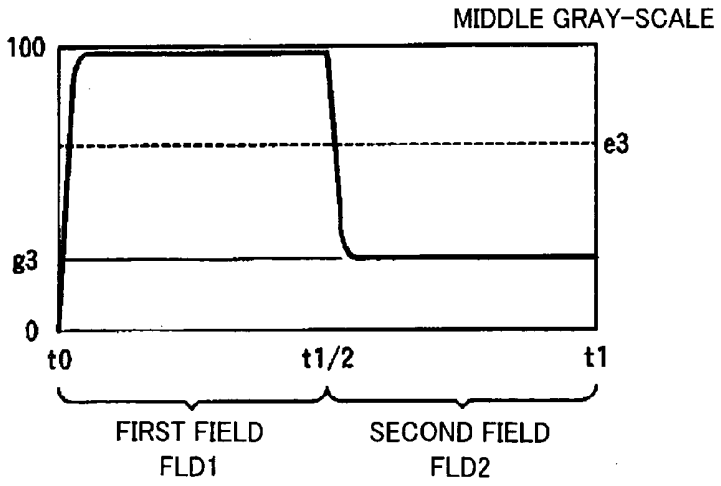


FIG. 14A

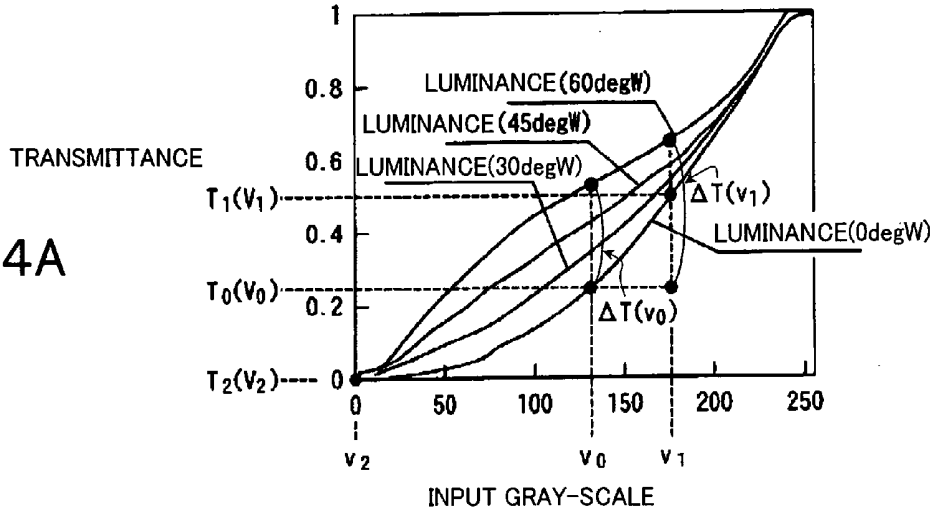


FIG. 14B

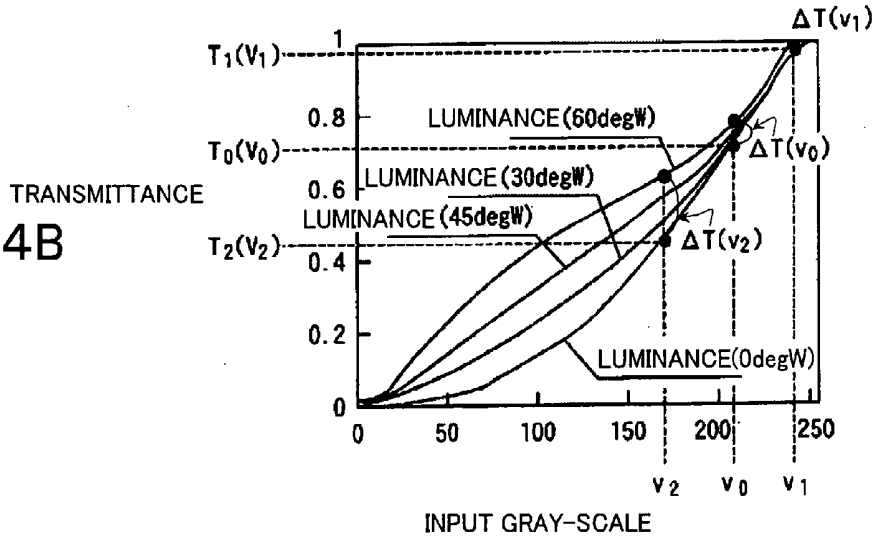


FIG. 15A

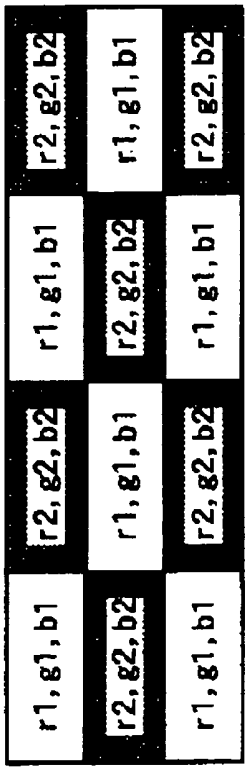


FIG. 15B

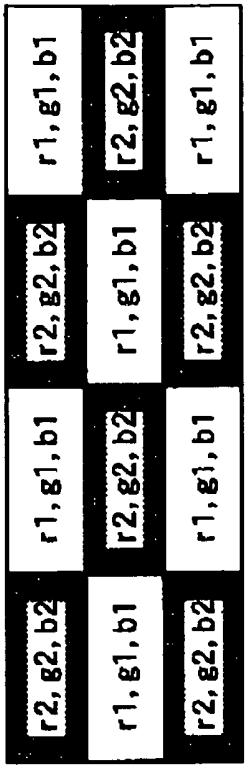


FIG. 16B

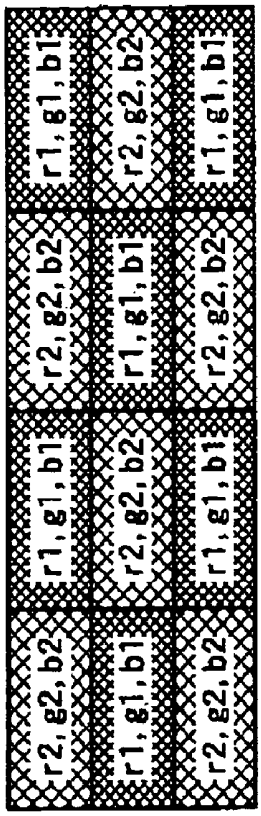


FIG. 16A

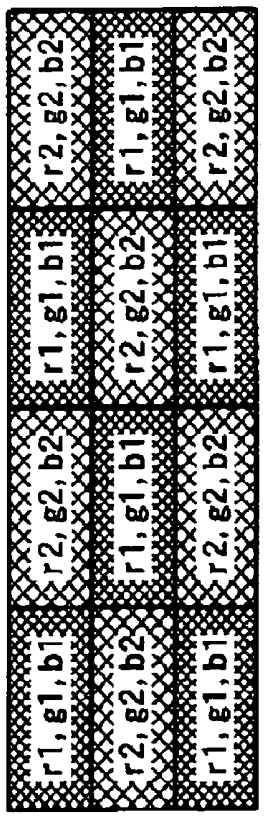


FIG. 17

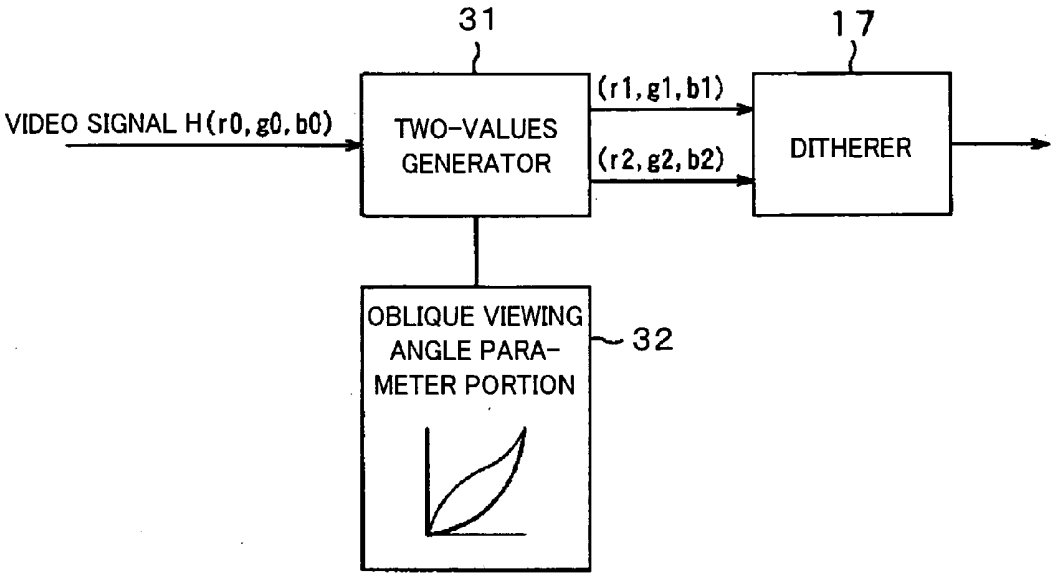

31
17
VIDEO SIGNAL H(r0, g0, b0)
TWO-VALUES GENERATOR
(r1, g1, b1)
(r2, g2, b2)
DITHERER
OBLIQUE VIEWING ANGLE PARA-METER PORTION
32

FIG. 18

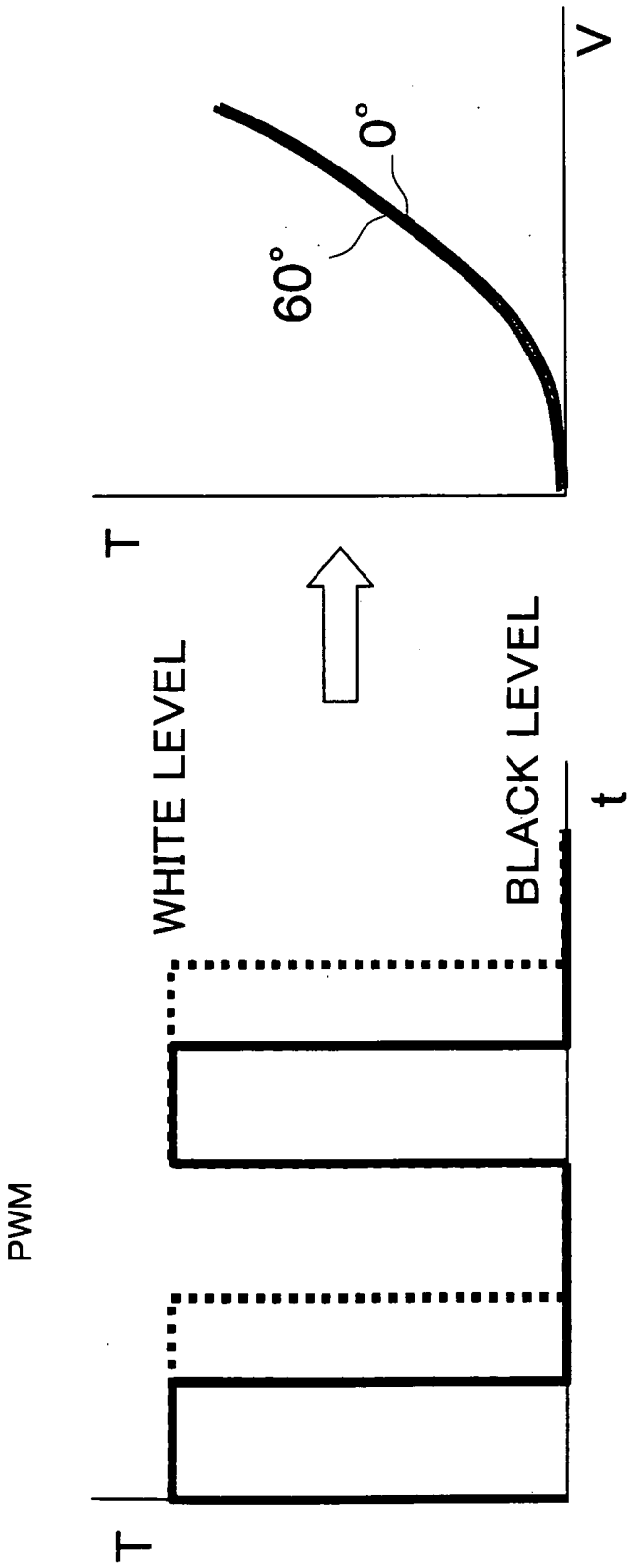


FIG. 19A

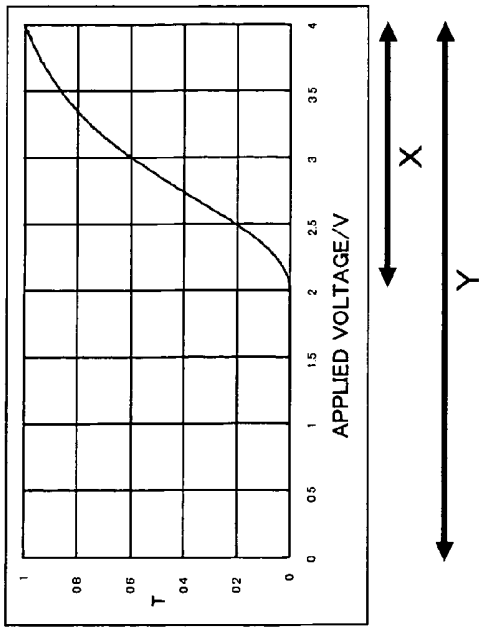
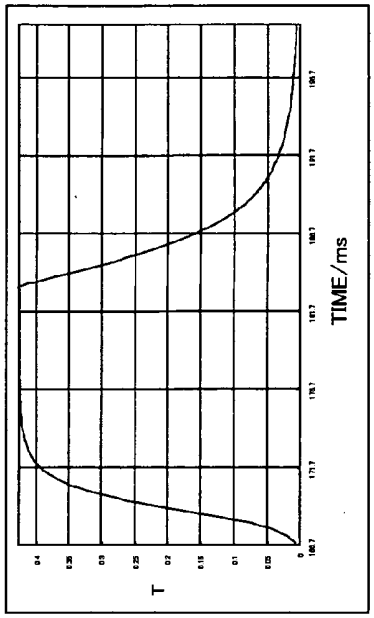


FIG. 19B



1.9V–4.0V

FIG. 19C

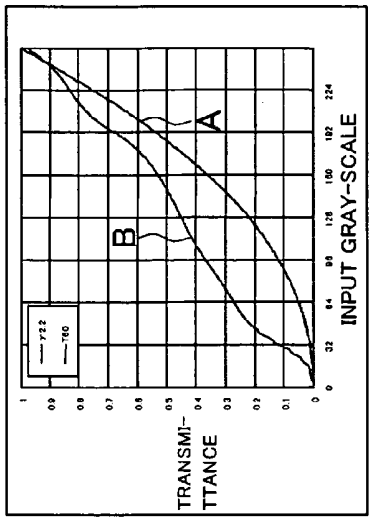
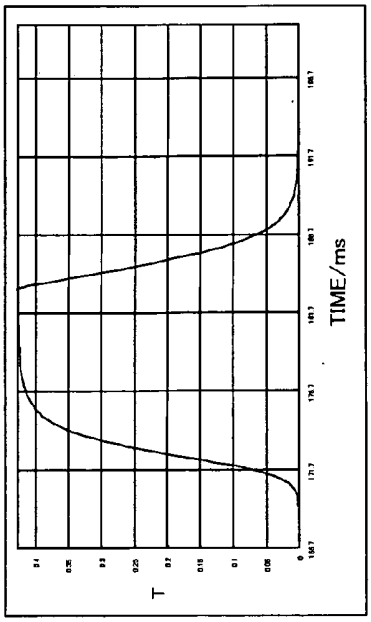


FIG. 19D



0V–4.0V

FIG. 19E

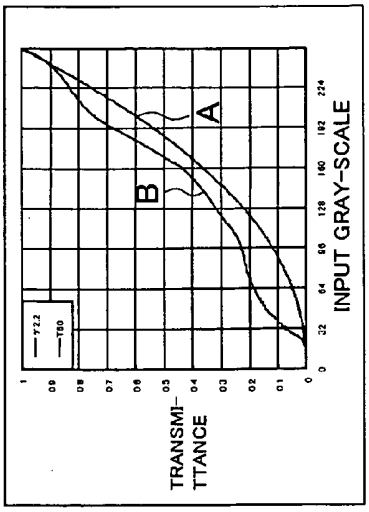


FIG. 20A

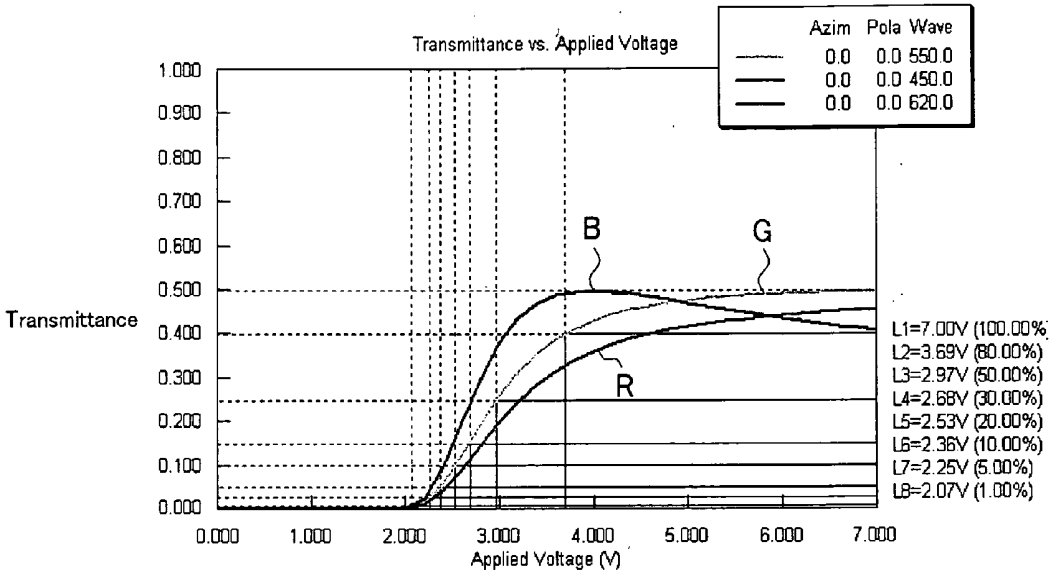


FIG. 20B

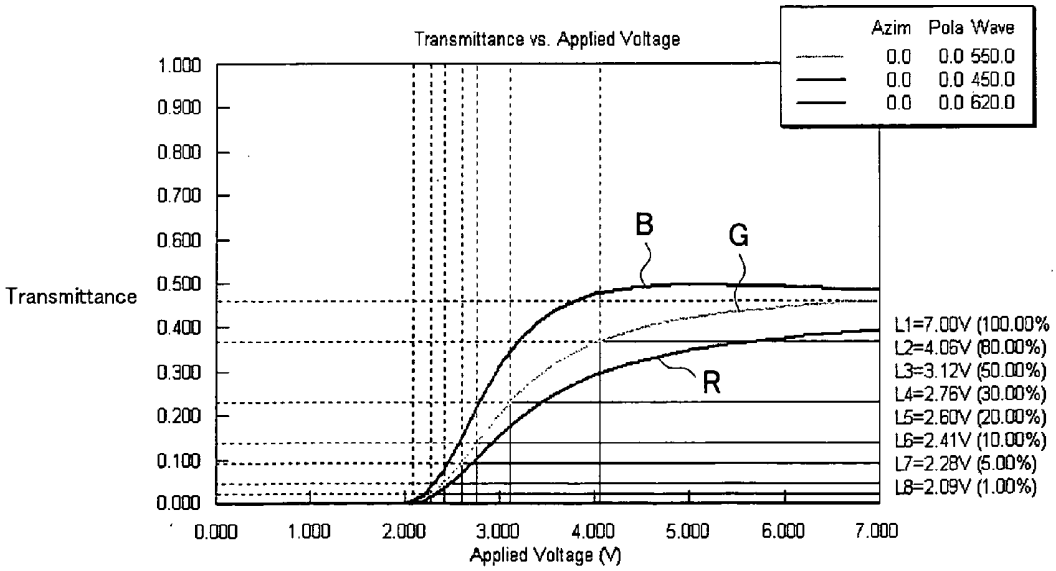


FIG. 21A

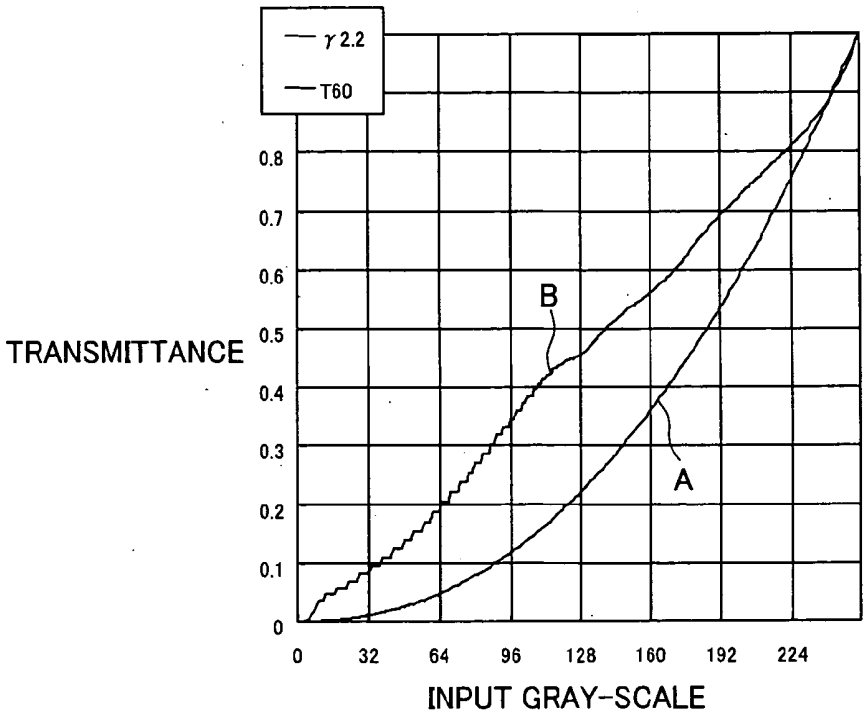


FIG. 21B

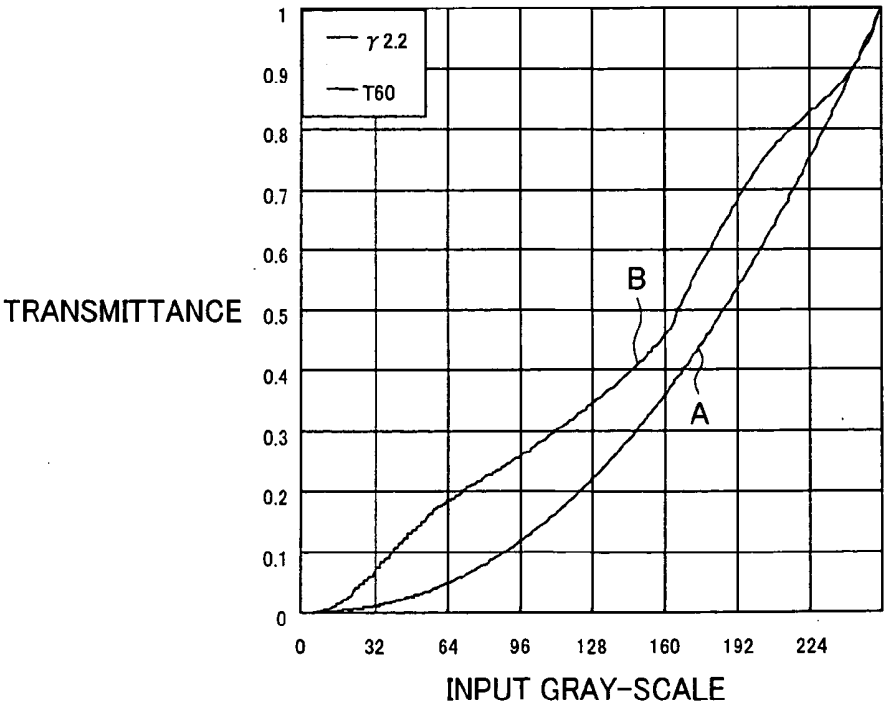


FIG. 22

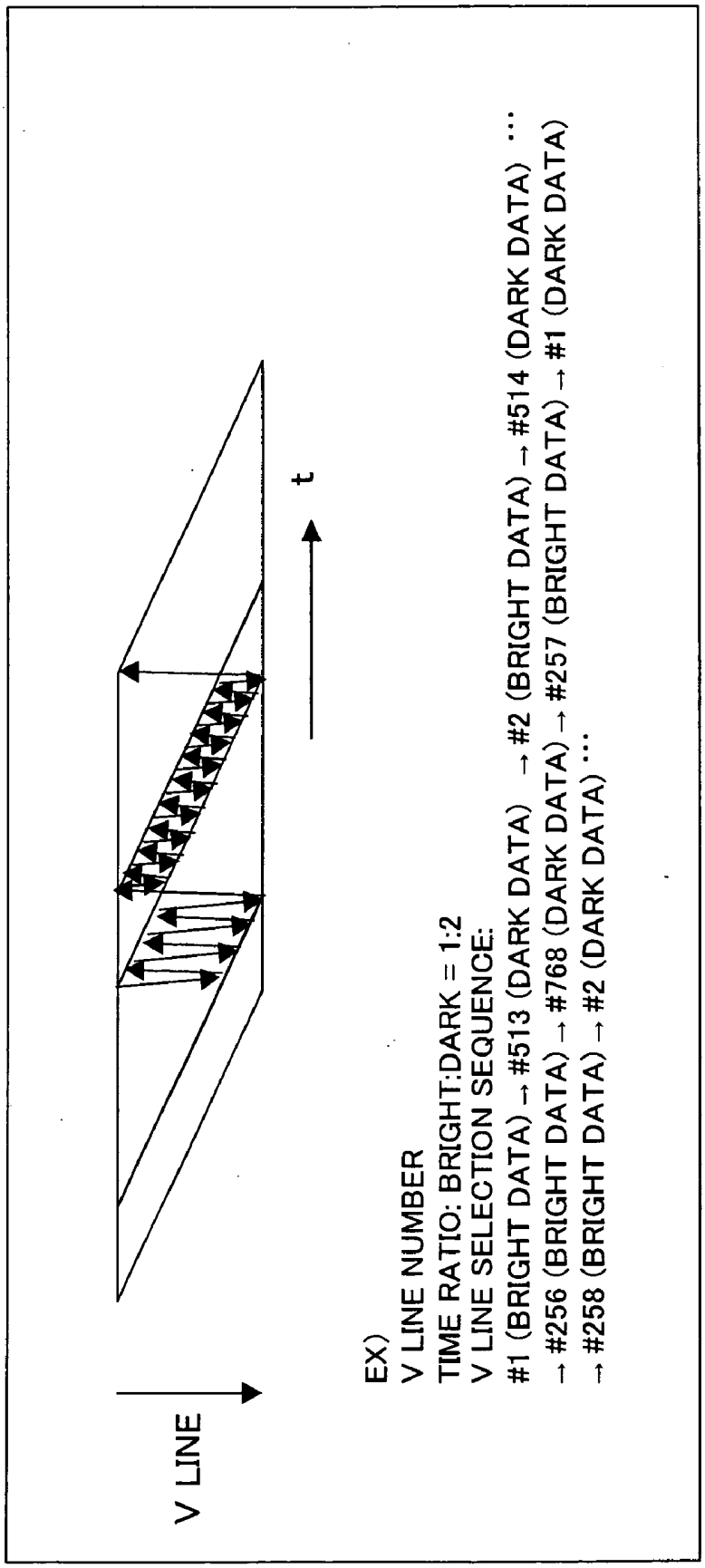
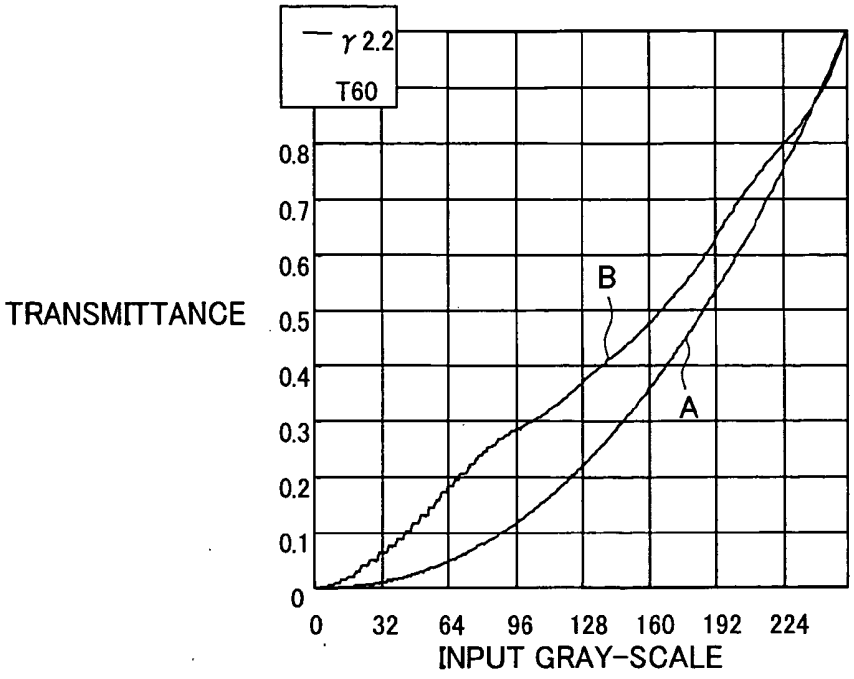
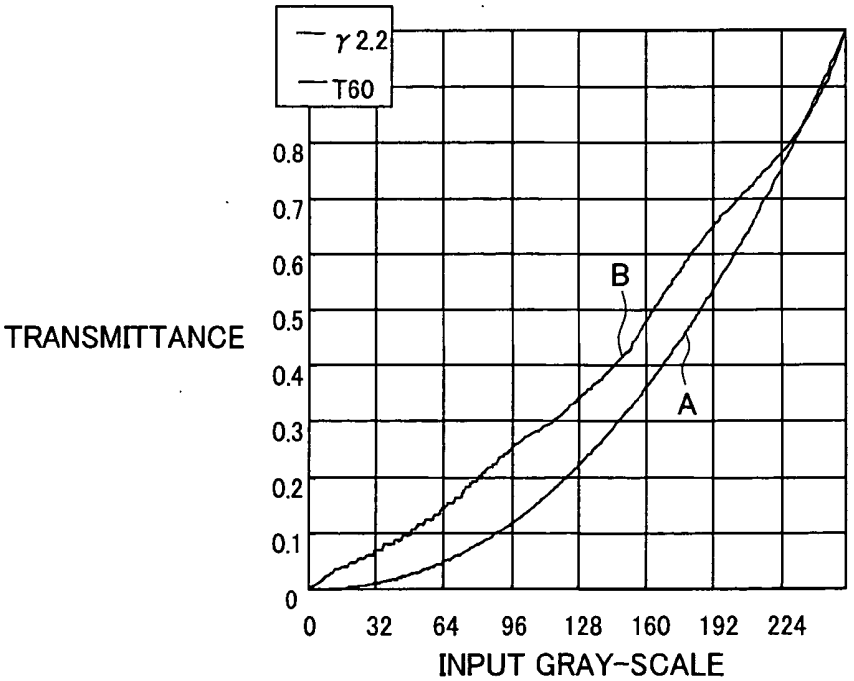

V LINE
t
EX)
V LINE NUMBER
TIME RATIO: BRIGHT:DARK = 1:2
V LINE SELECTION SEQUENCE:
#1 (BRIGHT DATA) → #513 (DARK DATA) → #2 (BRIGHT DATA) → #514 (DARK DATA) ···
→ #256 (BRIGHT DATA) → #768 (DARK DATA) → #257 (BRIGHT DATA) → #1 (DARK DATA)
→ #258 (BRIGHT DATA) → #2 (DARK DATA) ···

FIG. 23A



TIME RATIO: 1:1

FIG. 23B



TIME RATIO: 2 (DARK) :1 (BRIGHT)

FIG. 24A

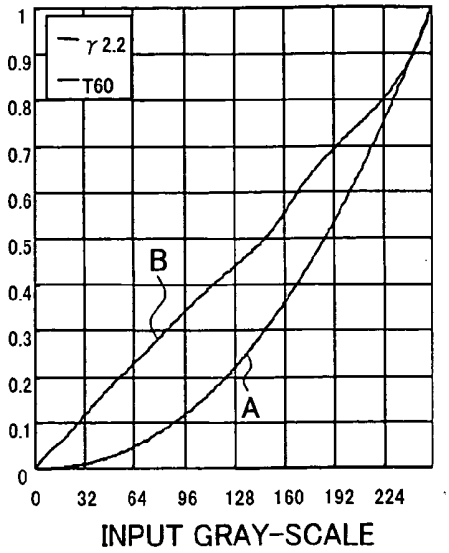


FIG. 24B

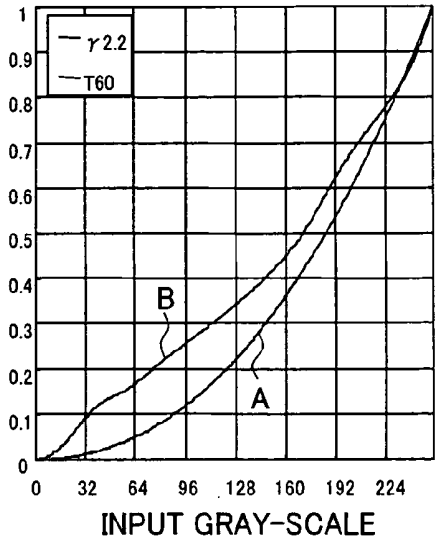


FIG. 24C

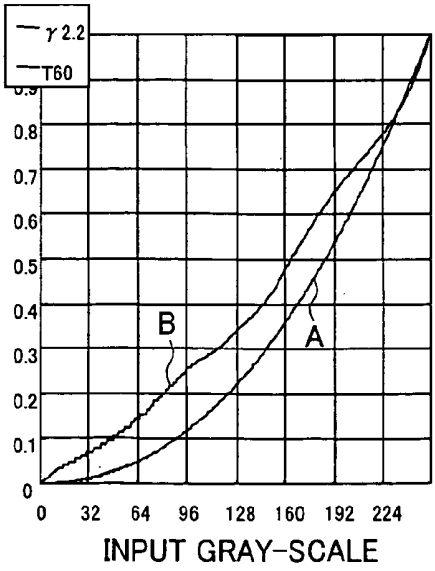


FIG. 25A

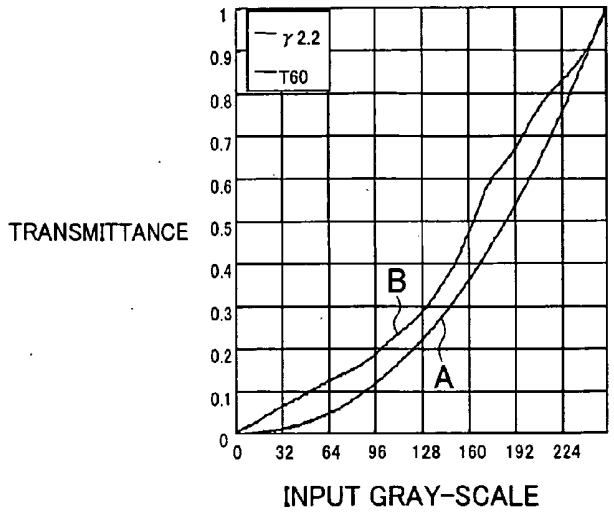


FIG. 25B

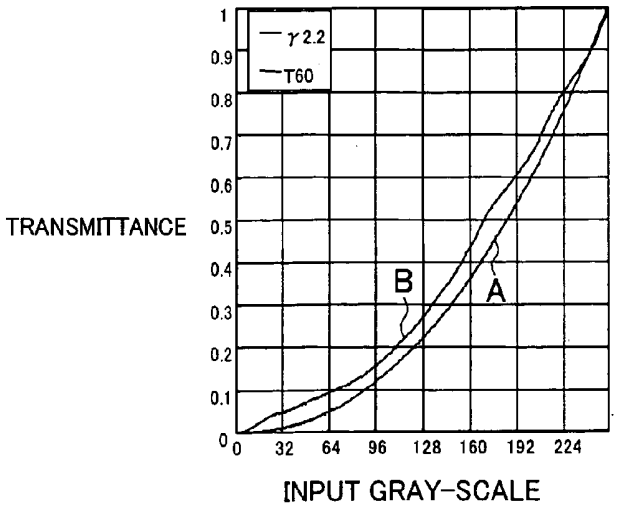


FIG. 26A

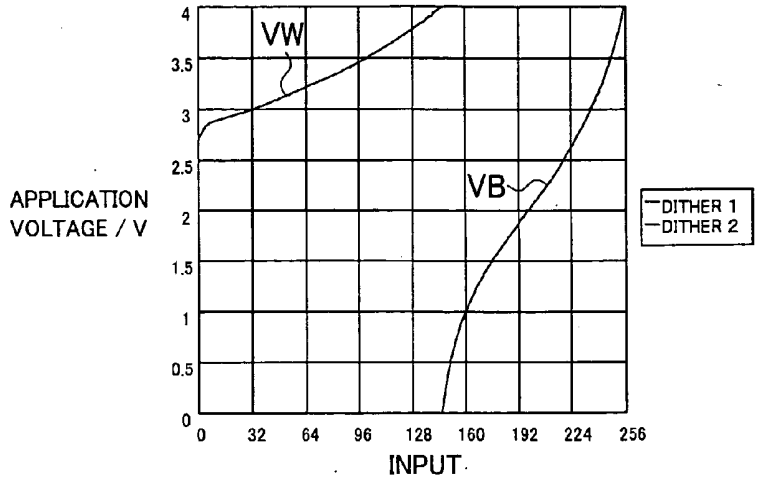


FIG. 26B

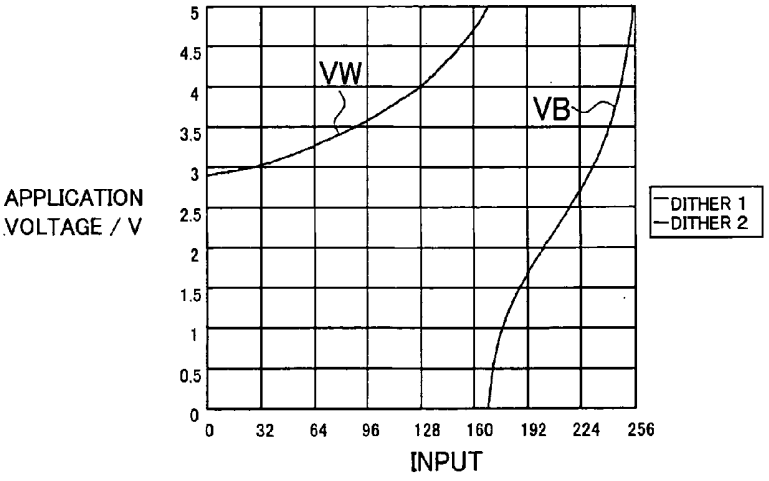


FIG. 26C

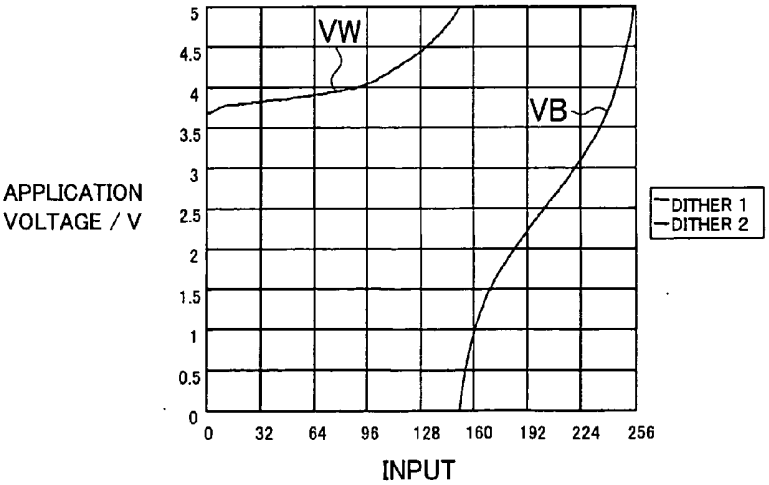


FIG. 27A

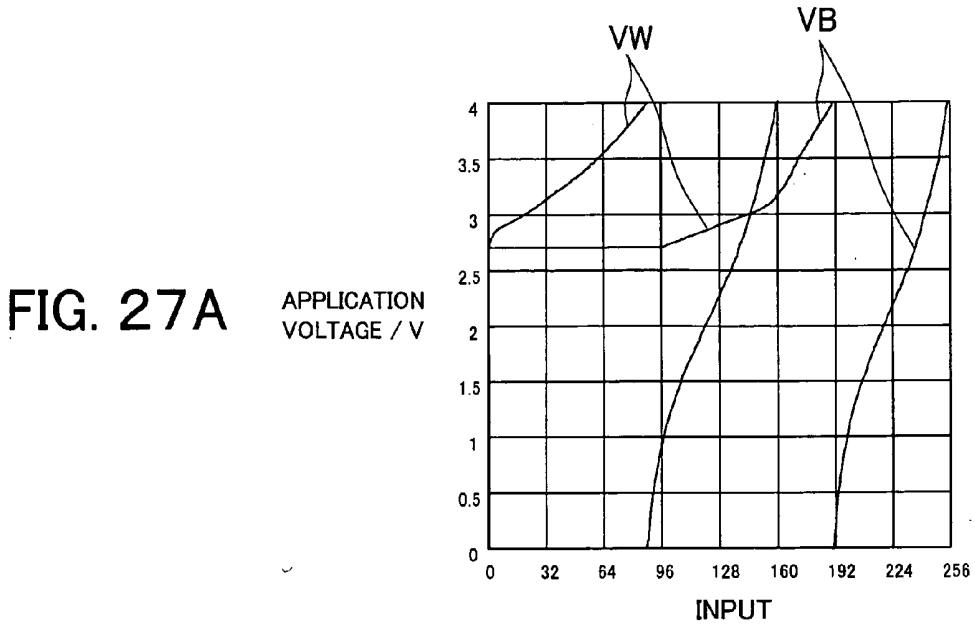


FIG. 27B

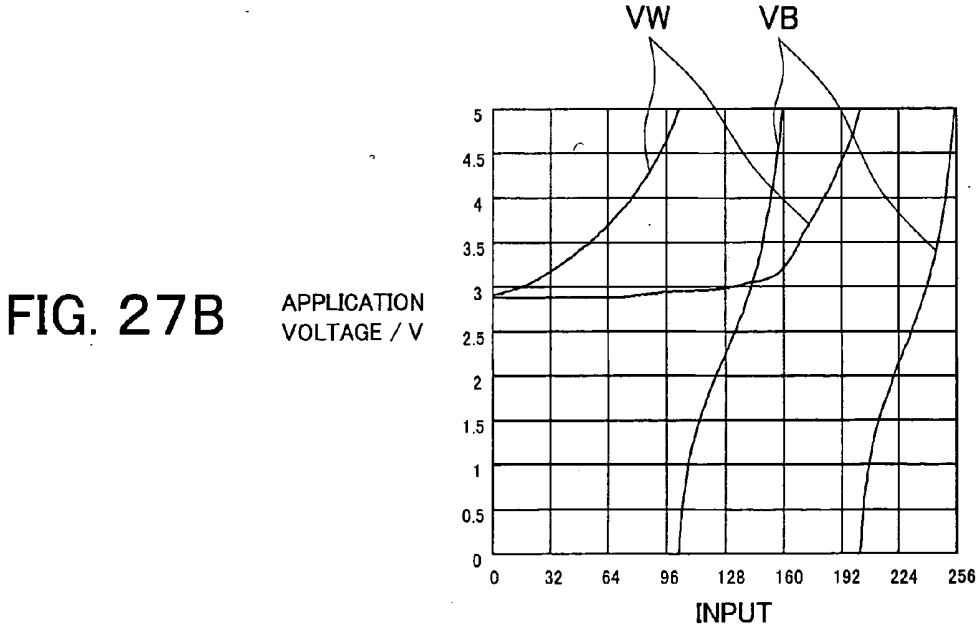


FIG. 28

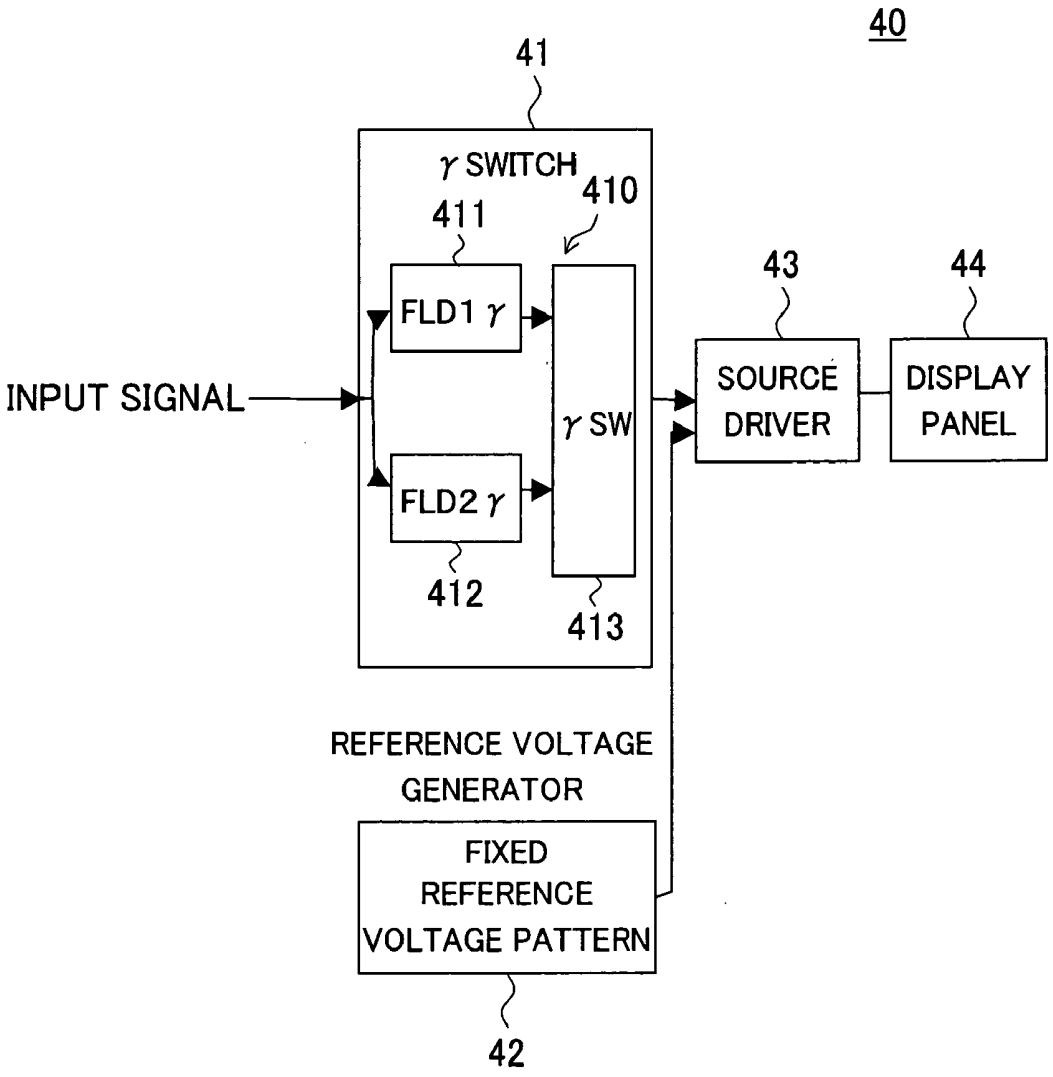

40
41
γ SWITCH
410
411
FLD1 γ
FLD2 γ
γ SW
412
413
INPUT SIGNAL
43
SOURCE DRIVER
44
DISPLAY PANEL
REFERENCE VOLTAGE GENERATOR
FIXED REFERENCE VOLTAGE PATTERN
42

FIG. 29

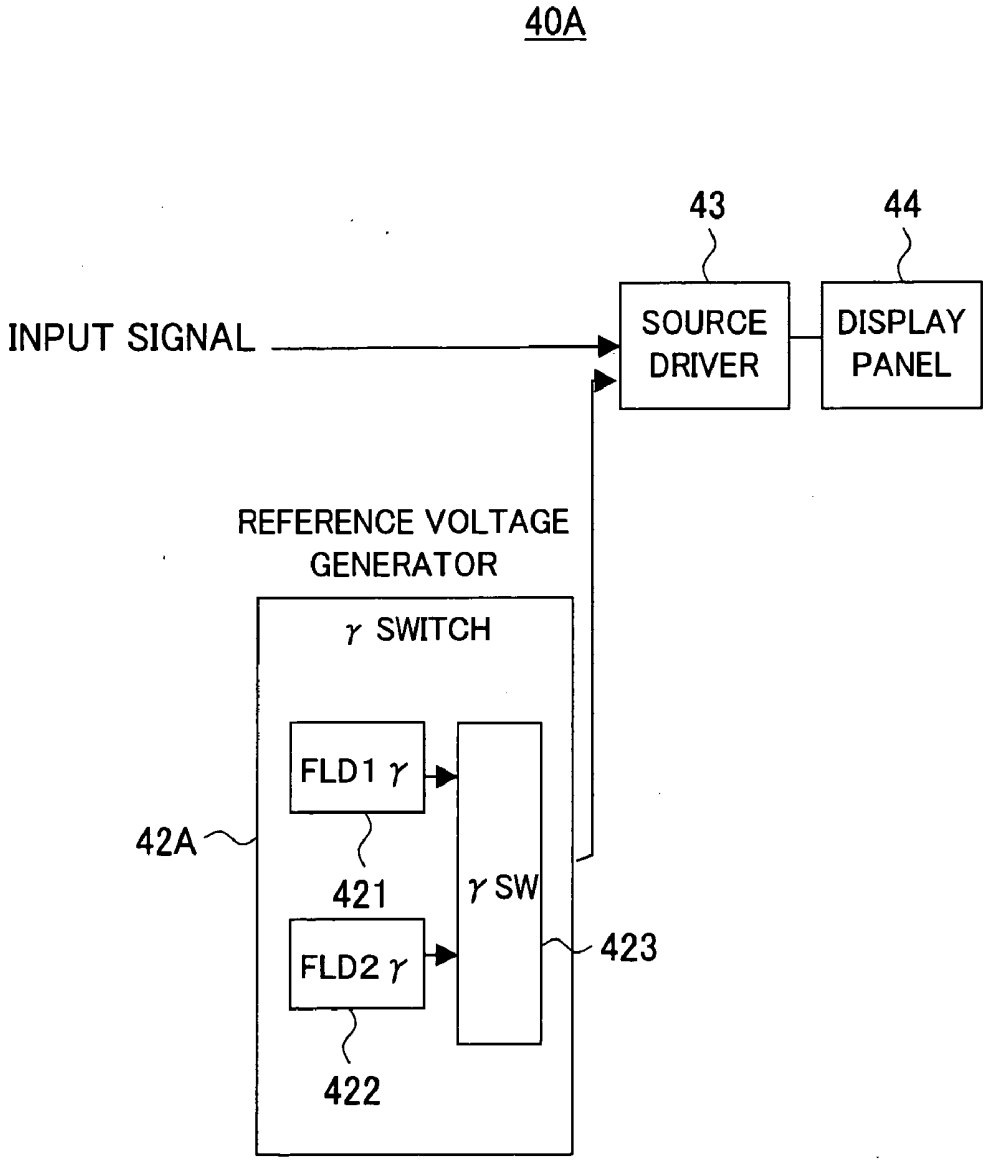

40A
43
44
INPUT SIGNAL
SOURCE DRIVER
DISPLAY PANEL
REFERENCE VOLTAGE GENERATOR
γ SWITCH
FLD1 γ
FLD2 γ
γ SW
42A
421
422
423

FIG. 30

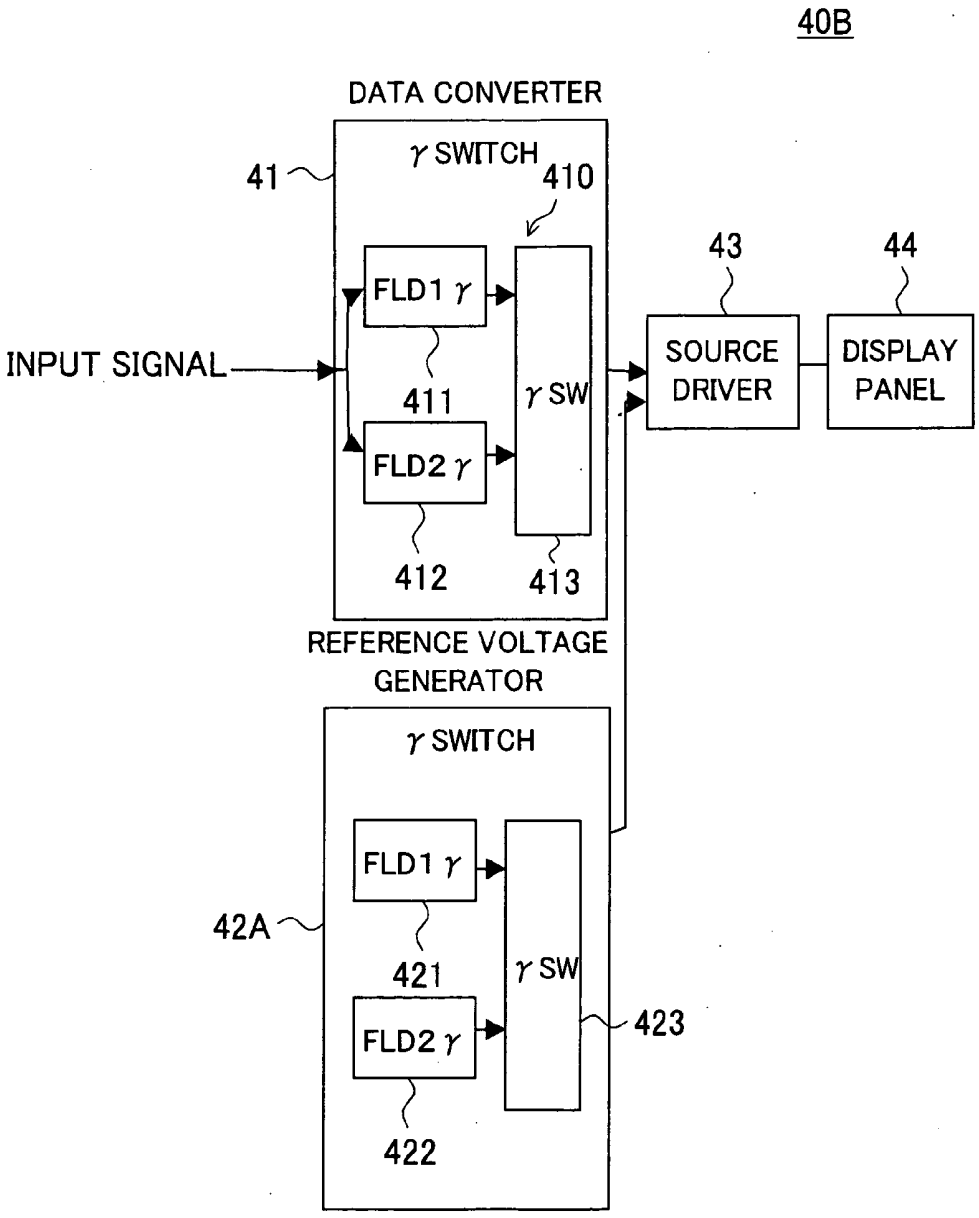

40B
DATA CONVERTER
41
γ SWITCH
410
FLD1 γ
411
FLD2 γ
412
γ SW
413
INPUT SIGNAL
43
SOURCE DRIVER
44
DISPLAY PANEL
REFERENCE VOLTAGE GENERATOR
γ SWITCH
42A
FLD1 γ
421
FLD2 γ
422
γ SW
423

FIG. 31A

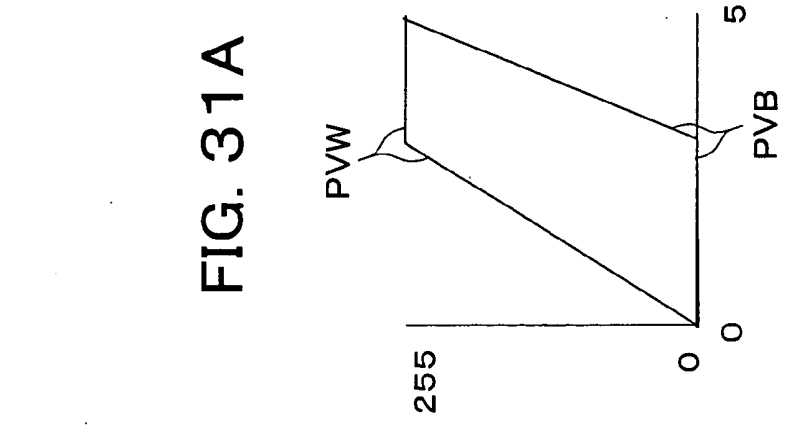


FIG. 31B

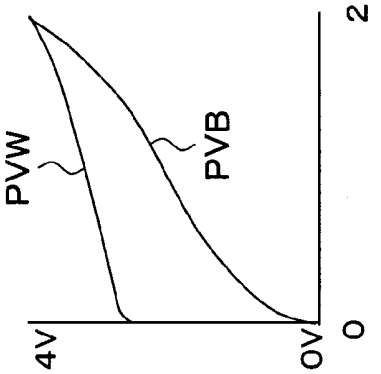


FIG. 31C

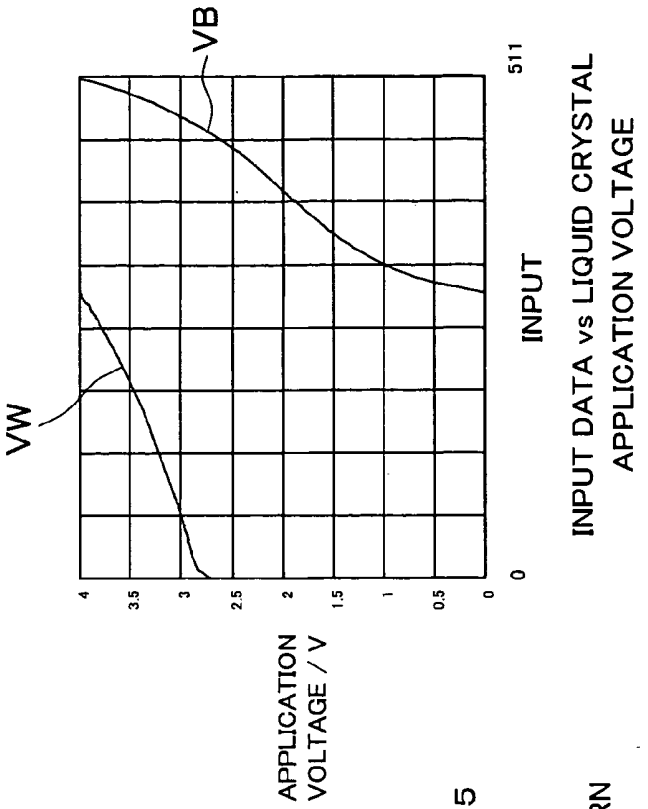
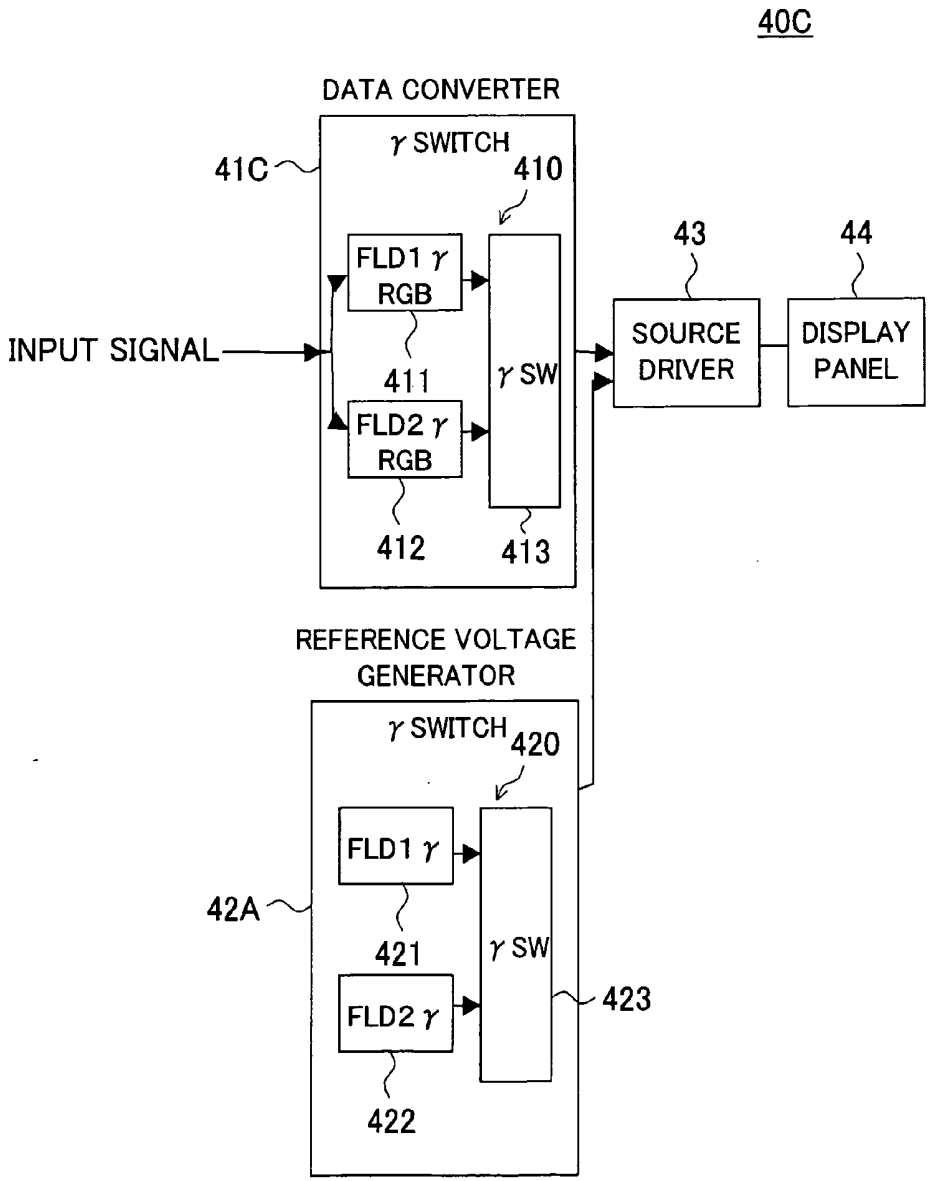


FIG. 32


40C
DATA CONVERTER
γ SWITCH
41C
410
FLD1 γ RGB
411
FLD2 γ RGB
412
γ SW
413
INPUT SIGNAL
43
SOURCE DRIVER
44
DISPLAY PANEL
REFERENCE VOLTAGE GENERATOR
γ SWITCH
420
FLD1 γ
421
FLD2 γ
422
γ SW
423
42A

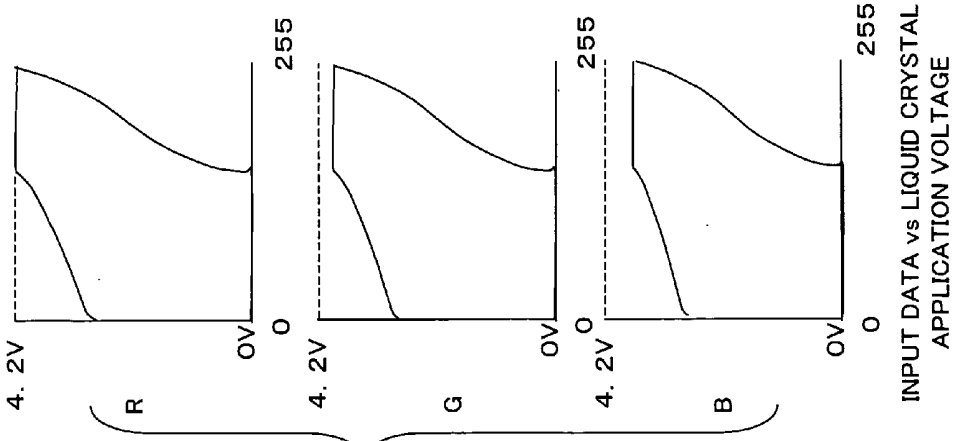


FIG. 33C

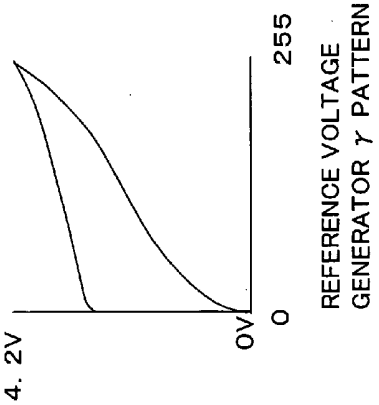


FIG. 33B

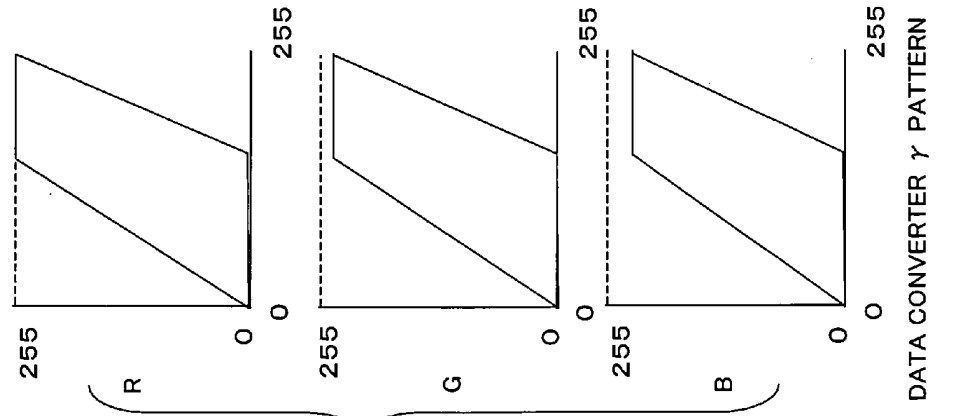


FIG. 33A

FIG. 34

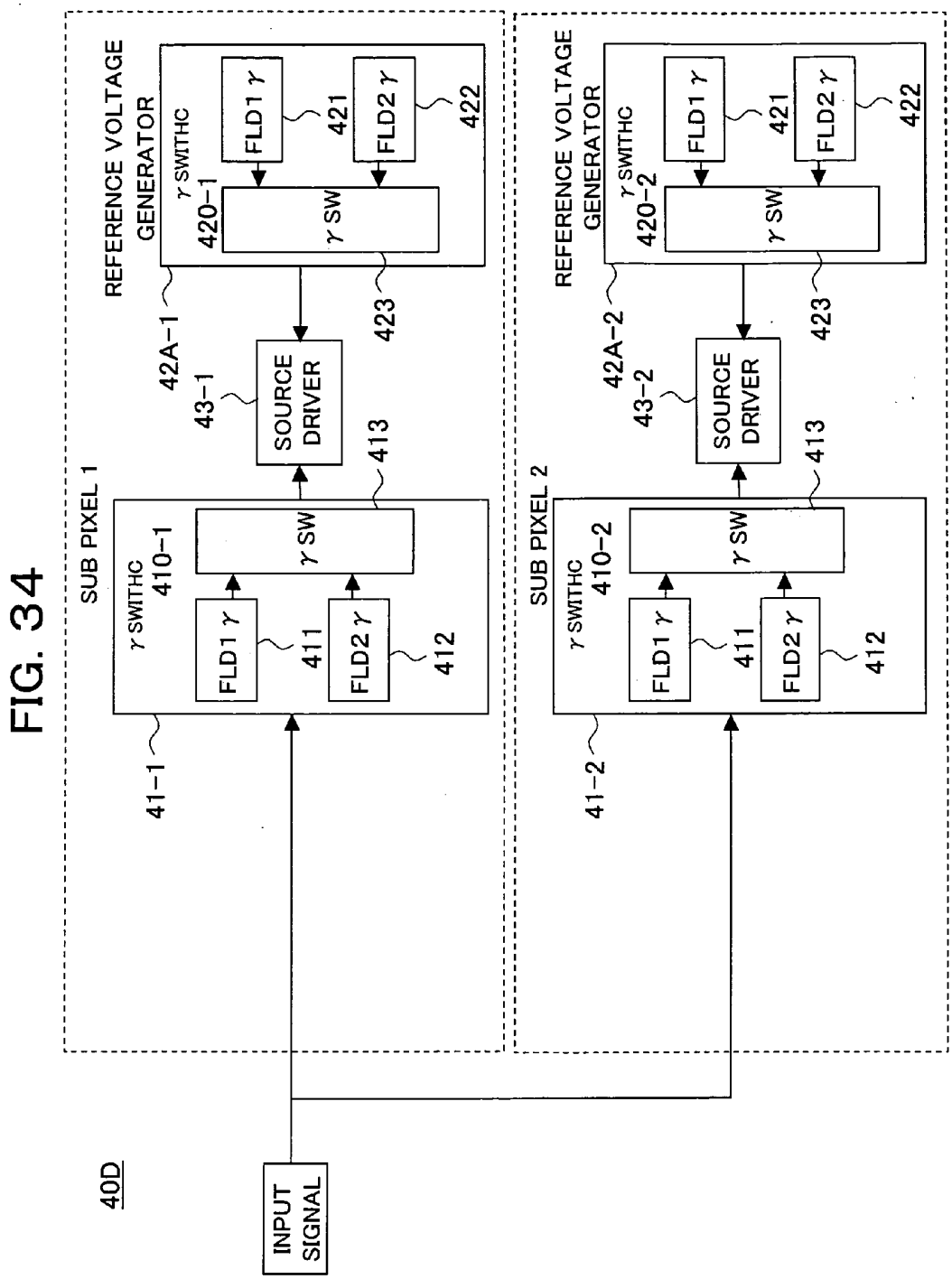

40D
INPUT SIGNAL
SUB PIXEL 1
SUB PIXEL 2
41-1
41-2
γ SWITHC
410-1
410-2
FLD1 γ
411
FLD2 γ
412
γ SW
413
SOURCE DRIVER
43-1
43-2
REFERENCE VOLTAGE GENERATOR
γ SWITHC
420-1
420-2
FLD1 γ
421
FLD2 γ
422
γ SW
423
42A-1
42A-2

FIG. 35A

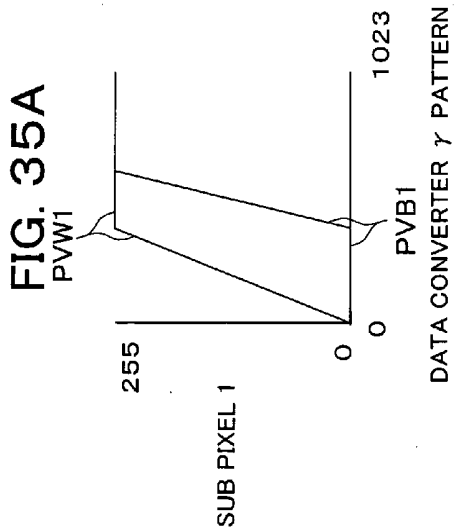


FIG. 35B

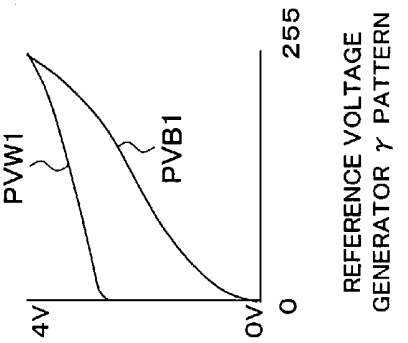


FIG. 35C

FIG. 35D

FIG. 35E

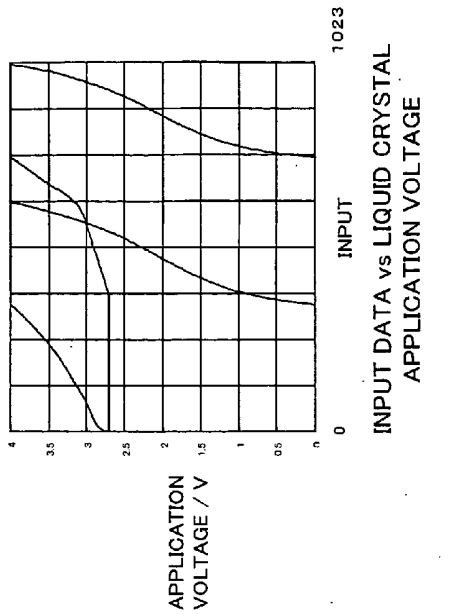
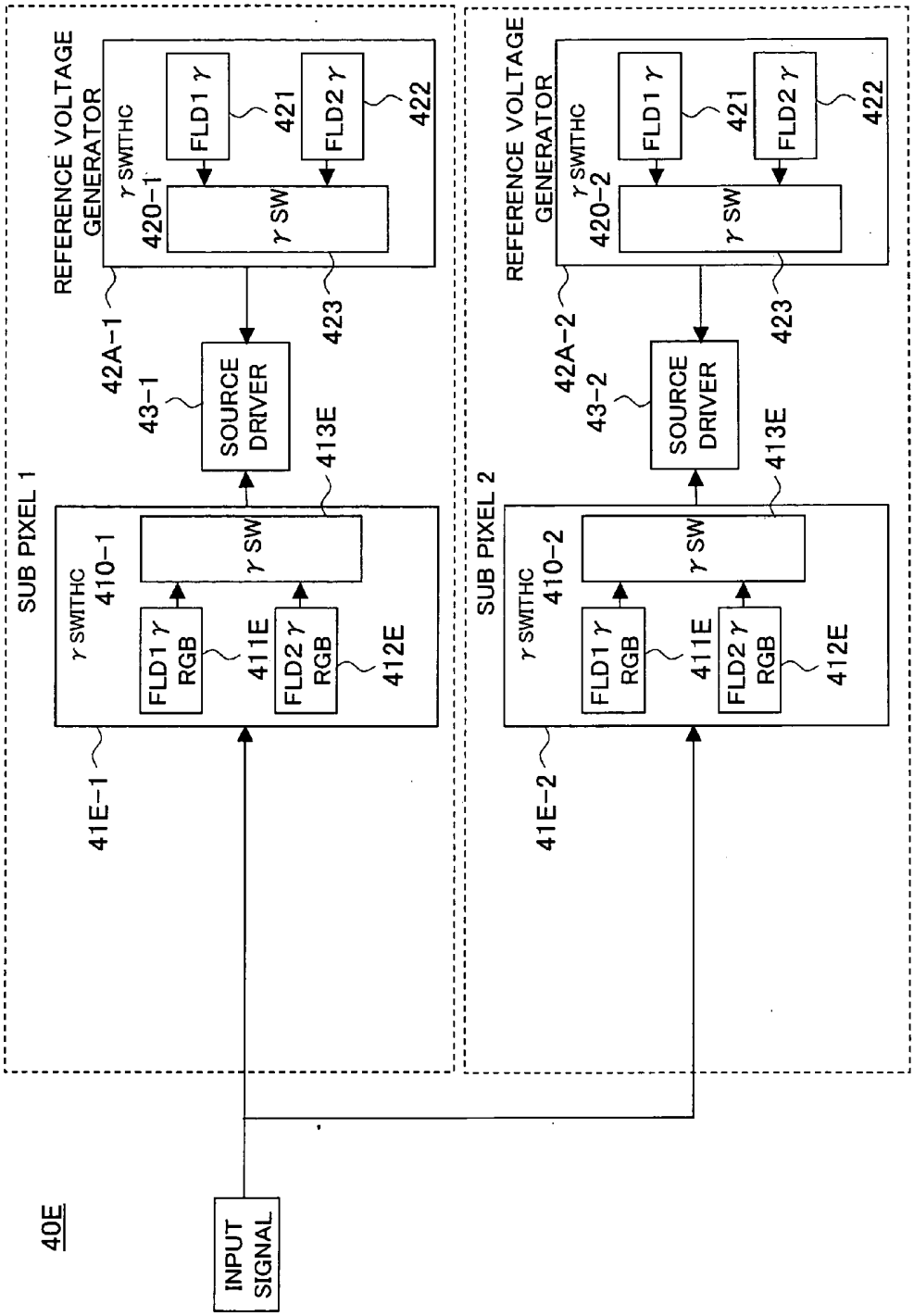


FIG. 36


40E
INPUT SIGNAL
SUB PIXEL 1
SUB PIXEL 2
41E-1
41E-2
γ SWITHC 410-1
γ SWITHC 410-2
FLD1 γ RGB
FLD2 γ RGB
411E
412E
γ SW
413E
SOURCE DRIVER
43-1
43-2
42A-1
42A-2
REFERENCE VOLTAGE GENERATOR
γ SWITHC 420-1
γ SWITHC 420-2
FLD1 γ
FLD2 γ
421
422
423

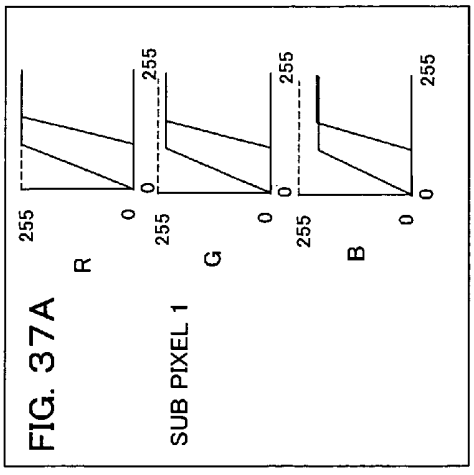


FIG. 37A
SUB PIXEL 1
R
G
B
255
0

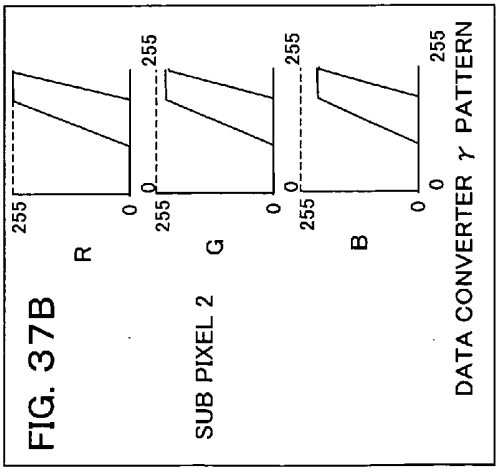


FIG. 37B
SUB PIXEL 2
R
G
B
255
0
DATA CONVERTER γ PATTERN

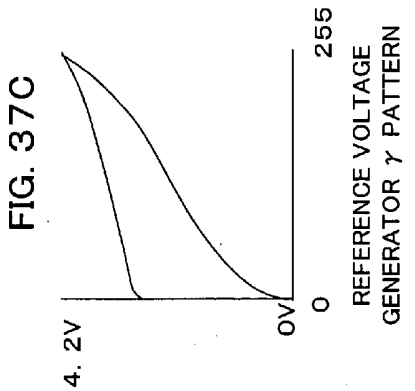


FIG. 37C
4. 2V
0V
0
255
REFERENCE VOLTAGE
GENERATOR γ PATTERN

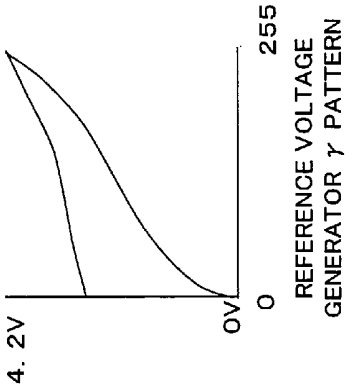


FIG. 37D
4. 2V
0V
0
255
REFERENCE VOLTAGE
GENERATOR γ PATTERN

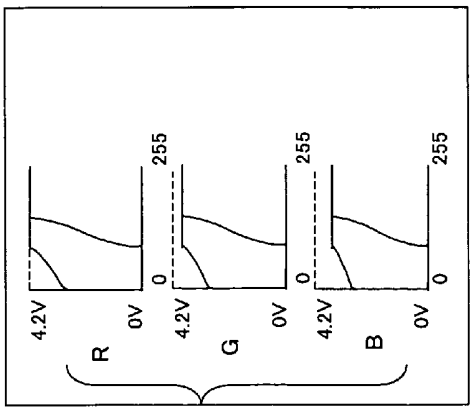


FIG. 37E
4.2V
0V
R
G
B
0
255

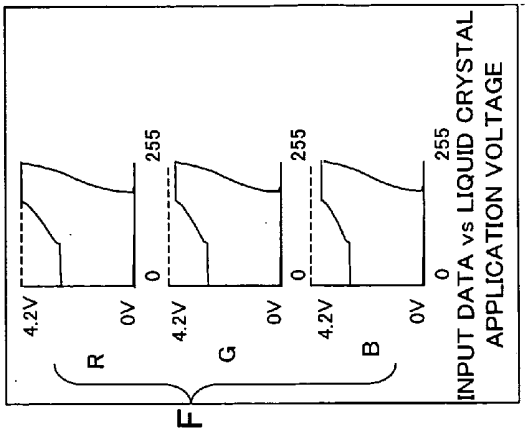


FIG. 37F
4.2V
0V
R
G
B
0
255
INPUT DATA vs LIQUID CRYSTAL
APPLICATION VOLTAGE

FIG. 38

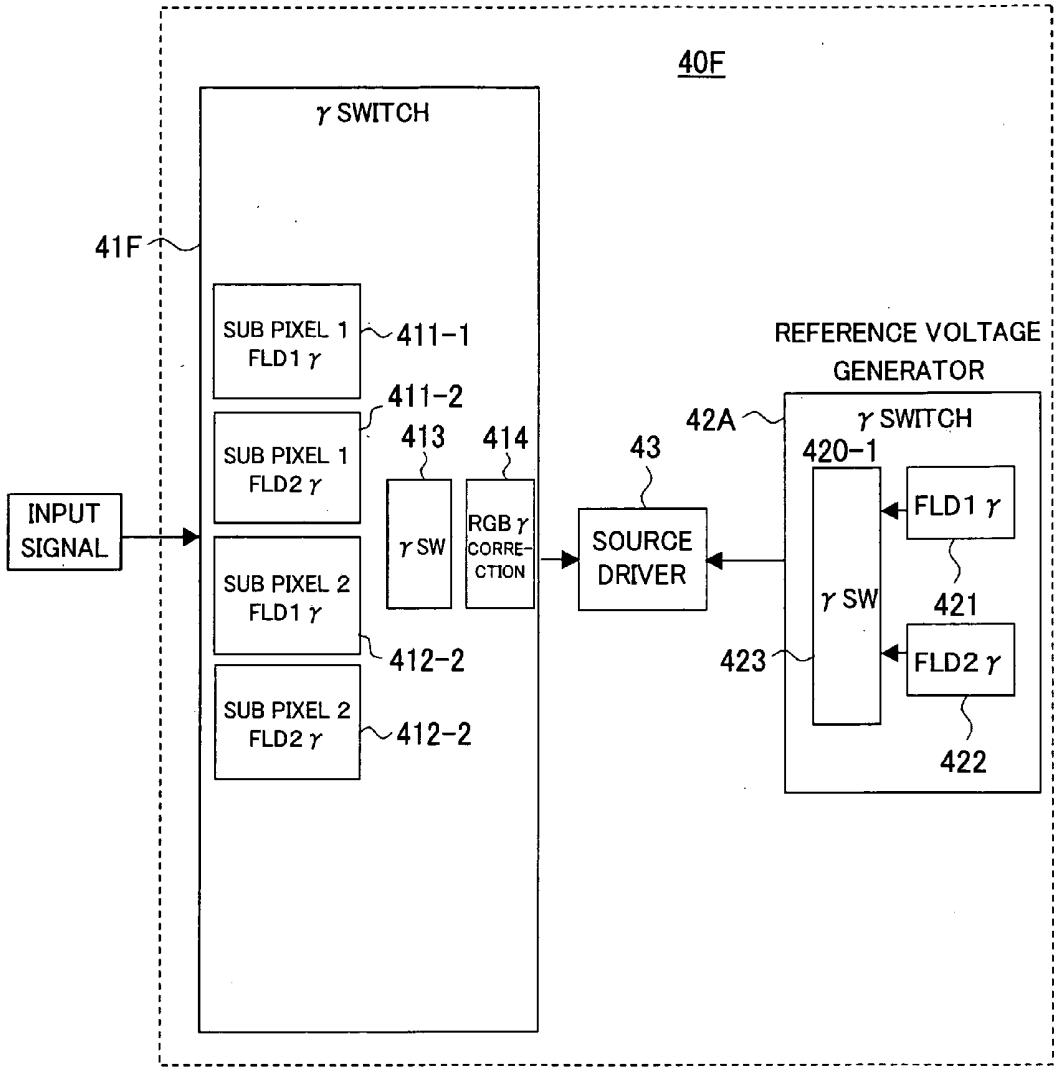

40F
γ SWITCH
41F
SUB PIXEL 1 FLD1 γ
411-1
SUB PIXEL 1 FLD2 γ
411-2
SUB PIXEL 2 FLD1 γ
412-2
SUB PIXEL 2 FLD2 γ
412-2
413
414
γ SW
RGB γ CORRE-CTION
INPUT SIGNAL
43
SOURCE DRIVER
REFERENCE VOLTAGE GENERATOR
42A
γ SWITCH
420-1
γ SW
FLD1 γ
421
FLD2 γ
422
423

IMAGE DISPLAY DEVICE AND IMAGE DISPLAY METHOD

TECHNICAL FIELD

[0001] The present invention relates to an image display device and an image display method enabling a gray-scale display in accordance with an input video signal as in for example a liquid crystal display device.

BACKGROUND ART

[0002] When the number of gray-scale which can be displayed on a display is small, the boundaries between gray-scales appear as patterns like contour lines of a map. These are called "pseudo contours" and greatly degrade the display performance.

[0003] In general, if each color can be displayed by about 8 bits (256 gray-scale), such pseudo contours become of levels which do not pose problems in the display performance.

[0004] In a liquid crystal display, a plasma display panel (PDP), an electroluminescence display (ELD), or other display device, however, it is relatively difficult to display each color by 8 bits (256 gray-scale).

[0005] For example, a liquid crystal display device mounting thin film transistors (TFT) for driving liquid crystals utilizes the characteristics of a liquid crystal material having a characteristic curve corresponding to an applied signal voltage, for example, a transmittance curve, and divides the voltage to match with the gray-scale levels to thereby obtain predetermined characteristic values, for example, transmittances, for middle gray-scale display.

[0006] When trying to express 8 bits of gray-scale (256 gray-scale) by such a method, however, the range of divided voltage becomes very narrow, the gray-scale levels overlap due to a variation of the liquid crystal material characteristics and the TFT characteristics in some cases, and 256 gray-scale cannot be sufficiently displayed.

[0007] Further, in a dot matrix drive system using STN liquid crystals, a color image is displayed by turning on/off the liquid crystals in units of red (R), green (G), and blue (B) dots, therefore basically only a two-value display is possible in dot units.

[0008] A plasma display panel (PDP) is also a display device emitting binary light by a dot matrix type display, therefore generally use is made of a sub field method for superposing a weighted plurality of binary images in terms of time so as to display a moving picture having a middle gray-scale. In this system, pseudo contours are sometimes generated depending on the drive format.

[0009] As a method of displaying middle gray-scale images in such a display device, dither using a plurality of pixels, error diffusion, and other methods of expressing pseudo gray-scale have been used for middle gray-scale display (see for example Patent Document 1).

[0010] For example, in a case where the input signal is formed by 8 bits (256 gray-scale) and the display performance of the display device is 6 bits (64 gray-scale), if simply discarding the lower 2 bits from the input signal of 8 bits (256 gray-scale) so as to display an image by 6 bits (64 gray-scale), patterns like contour lines of a map are produced. In order to make such patterns less visible, in dither, a small noise is deliberately added to the input signal.

[0011] The dither frequently used in general expression of pseudo gray-scale will be explained next with reference to FIGS. **1**A to **1**D.

[0012] Here, texture-based dither will be explained using as an example a case of a dither matrix comprised of n dots and m lines where n and m are 2. In this case, as will be explained below, 8 bits' worth of, 256, gray-scale (0, 1, 2, 3, . . . , 255) can be pseudo expressed by 6 bits' worth of, 64, gray-scale (0, 4, 8, 12, . . . , 252).

[0013] Assume that the input signal (8 bits) becomes as shown in FIG. **1**A. To this, a 2×2 dither matrix of dither coefficients such as shown in FIG. **1**B are added to the corresponding positions of the pixels.

[0014] The results of the addition are shown in FIG. **1**C. Since the input video signal is formed by 8 bits, the lower 2 bits are discarded (made 0) in order to enable the display of a display performance of 6 bits. The values when discarding the lower 2 bits are shown in FIG. **1**D.

[0015] For example, when an image data value after adding the dither coefficient in FIG. **1**C is "211", it is expressed as "11010011" in binary notation, therefore the value becomes "11010000" when the lower 2 bits are discarded and becomes "208" when it is returned to the decimal notation.

[0016] By performing such processing, 8 bits (256 gray-scale)' worth of the gray-scale can be pseudo expressed by 6 bits (64 gray-scale).

[0017] The principle of such dithering will be explained below.

[0018] When the lower 2 bits among the original 8 bits of the input video signal are "0", the higher 6 bits do not increase no matter what dither coefficient is added.

[0019] When the lower 2 bits among the original 8 bits of the input video signal are "1", the higher 6 bits are advanced by 1 only in a case where the dither coefficient is 3. For example, an image signal having a value of "109" is "01101101" in binary notation. The higher 6 bits are advanced by 1 when the dither coefficient 3 (00000011) is added.

[0020] In the dither matrix of FIG. **1**B, the probability of the dither coefficient being 3 is ¼, therefore the probability of the higher 6 bits being advanced by 1 is ¼ in the case where the lower 2 bits are "1".

[0021] When the lower 2 bits among the original 8 bits of the input video signal are "2", the higher 6 bits are advanced by 1 in the case where the dither coefficient is 3 or 2.

[0022] In the dither matrix of FIG. **1**B, the probability of the dither coefficient being 3 or 2 is ¾, therefore the probability of the higher 6 bits being advanced by 1 is ¾ in the case where the lower 2 bits are "2".

[0023] When the lower 2 bits among the original 8 bits of the input video signal are "3", the higher 6 bits are advanced by 1 in a case where the dither coefficient is 3, 2, or 1.

[0024] In the dither matrix of FIG. **1**B, the probability of the dither coefficient being 3, 2, or 1 is ¾, therefore the probability of the higher 6 bits being advanced by 1 is ¾ in the case where the lower 2 bits are "3".

[0025] For example, when the above dithering is applied to image data having an original value of 21 (lower 2 bits are 1), the value becomes 24 with a probability of 1 pixel per 4 pixels and becomes 20 with a probability of 3 pixels per 4 pixels.

[0026] Accordingly, an average gray-scale of the image after the dithering becomes 24×¼+20×¾=21, and the original 8 bits can be pseudo expressed by 6 bits (lower 2 bits

among 8 bits are 0). The input image data is pseudo expressed finally with 6 bits' worth of gray-scale as described above.

[0027] In such dither, the characteristic that the added value is cyclic and, further, a checkerboard like regular pattern is sometimes observed in the horizontal direction and vertical direction.

[0028] When for example all pixels are "1" in the input signal as in FIG. **2**A, if performing processing to add the dither coefficients of FIG. **2**B to the input signal and then make the lower 2 bits "0", an image pattern as shown in FIG. **2**C is obtained. In this pattern, "4" is displayed with a ratio of 1 pixel per 4 pixels, therefore "1" can be pseudo expressed in average.

[0029] However, as shown by this diagram, a fixed pattern in which "4" is regularly arranged is generated, so this is recognized as a degradation of image quality. In order to prevent the generation of such a fixed pattern, dither using a different dither matrix for each field is proposed.

[0030] Patent Document 1: Japanese Patent Publication (A) No. 2002-052758

DISCLOSURE OF THE INVENTION

Problem to be Solved by the Invention

[0031] In a direct view type display having for example a viewing angle dependency, a difference ends up appearing in the image birefringence phase difference (retardation) in accordance with the viewing direction, so the colors of an image displayed on the display end up appearing changed.

[0032] For this reason, even in a case where a middle gray-scale display using a plurality of pixels can be realized by the above dither, the effect is exhibited only in a case where the display is viewed from a specific direction. A middle gray-scale cannot typically be precisely displayed when the image is viewed from any other directions.

[0033] Namely, in a general liquid crystal display device etc., middle gray-scale expression can be realized, but there is the disadvantage that the viewing angle characteristic cannot be improved.

[0034] An object of the present invention is to provide an image display device and method enabling a middle gray-scale display by using a plurality of pixels and simultaneously improving the viewing angle characteristic.

Means for Solving the Invention

[0035] A first aspect of the present invention is an image display device enabling a gray-scale display in accordance with an input video signal, having: a gray-scale converter for converting a gray-scale of an input video signal to characteristic values of pixels two-dimensionally arranged with respect to the image to be displayed, wherein the gray-scale converter converts a gray-scale so as to include, among the plurality of pixels expressing a middle gray-scale, at least one pixel converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one pixel converted to a second characteristic value obtained by adding a negative correction value.

[0036] Preferably, the device further has a correction value setter for setting the correction values in accordance with a middle gray-scale to be expressed.

[0037] Preferably, the gray-scale converter converts a gray-scale for a video signal expressed by primary color luminance components.

[0038] Preferably, the gray-scale converter converts a gray-scale so that either one of the first characteristic value or second characteristic value to which the positive or negative correction value has been added becomes a maximum characteristic value or a minimum characteristic value.

[0039] A second aspect of the present invention is an image display device enabling a gray-scale display in accordance with an input video signal, having: a gray-scale expresser for expressing a middle gray-scale of the input video signal by a field train formed by a plurality of fields, wherein the gray-scale expresser expresses a gray-scale so as to include at least one field converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one field converted to a second characteristic value obtained by adding a negative correction value.

[0040] Preferably, the device further has a setter for setting the first characteristic value and the second characteristic value in accordance with a middle gray-scale to be displayed.

[0041] Preferably, the gray-scale expresser expresses by the field train a middle gray-scale of a video signal expressed by primary color luminance components.

[0042] Preferably, the gray-scale converter expresser expresses a gray-scale so that either one of the first characteristic value or second characteristic value becomes a maximum characteristic value or a minimum characteristic value.

[0043] A third aspect of the present invention is an image display device enabling a gray-scale display in accordance with an input video signal, having: a gray-scale converter for converting a gray-scale of an input video signal to characteristic values of pixels two-dimensionally arranged with respect to the image to be displayed and a gray-scale expresser for expressing a middle gray-scale of the input video signal by a field train formed by a plurality of fields, wherein the gray-scale converter converts a gray-scale so as to include, among the plurality of pixels expressing a middle gray-scale, at least one pixel converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one pixel converted to a second characteristic value obtained by adding a negative correction value, and the gray-scale expresser expresses a gray-scale so as to include at least one field converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one field converted to a second characteristic value obtained by adding a negative correction value.

[0044] Preferably, the device further has a controller for controlling the gray-scale converter to convert a gray-scale when the input video signal includes a moving picture and controlling the gray-scale expresser to express a middle gray-scale by a field train when the input video

[0045] A fourth aspect of the present invention is an image display device enabling an expression of a middle gray-scale of an input video signal by a field train formed by a plurality of fields and a gray-scale display in accordance with an input video signal, having: a display including liquid crystal pixel cells displaying an image by a in accordance with in accordance with drive voltages and a drive portion for generating drive voltages corresponding to effective voltages including a first voltage corresponding to a bright level and a second voltage corresponding to a dark level, wherein the second voltage is set at a voltage lower than a threshold voltage of a liquid crystal cell.

[0046] A fifth aspect of the present invention is an image display device enabling an expression of a middle gray-scale of an input video signal by a field train formed by a plurality of fields and a gray-scale display in accordance with an input video signal, having: a display including liquid crystal pixel cells displaying an image by a gray-scale in accordance with drive voltages and a drive portion for generating drive voltages corresponding to effective voltages including a first voltage corresponding to a bright level and a second voltage corresponding to a dark level, wherein the first voltage is set at a voltage higher than a voltage at which the characteristic value of a liquid crystal cell starts to become substantially the maximum.

[0047] Preferably, an optical thickness of each pixel cell is set in accordance with the first voltage value.

[0048] A sixth aspect of the present invention is an image display device enabling an expression of a middle gray-scale of an input video signal by a field train formed by a plurality of fields and a gray-scale display in accordance with an input video signal, having: a display including liquid crystal pixel cells displaying an image by a gray-scale in accordance with drive voltages, wherein the display is driven while changing a bright/dark ratio over time.

[0049] Preferably, the display is driven so that the dark ratio in the bright/dark ratio becomes larger.

[0050] Preferably, the device further has a drive for generating drive voltages corresponding to effective voltages including a first voltage corresponding to a bright level and a second voltage corresponding to a dark level, and the first voltage is set at a voltage higher than the voltage at which the characteristic value of a liquid crystal cell starts to become substantially the maximum.

[0051] A seventh aspect of the present invention is an image display method enabling a gray-scale display in accordance with an input video signal, having: a gray-scale conversion step of converting a gray-scale of an input video signal to characteristic values of pixels two-dimensionally arranged with respect to the image to be displayed, wherein the gray-scale conversion step converts a gray-scale so as to include, among the plurality of pixels expressing a middle gray-scale, at least one pixel converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one pixel converted to a second characteristic value obtained by adding a negative correction value.

[0052] An eighth aspect of the present invention is an image display method enabling a gray-scale display in accordance with an input video signal, having: a gray-scale expression step of expressing a middle gray-scale of the input video signal by a field train formed by a plurality of fields, wherein the gray-scale expressing step expresses a gray-scale so as to include at least one field converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one field converted to a second characteristic value obtained by adding a negative correction value.

[0053] A ninth aspect of the present invention is an image display method enabling a gray-scale display in accordance with an input video signal, having: a gray-scale conversion step of converting a gray-scale of an input video signal to characteristic values of pixels two-dimensionally arranged with respect to the image to be displayed and a gray-scale expression step of expressing a middle gray-scale of the input video signal by a field train formed by a plurality of fields, wherein the gray-scale conversion step converts a gray-scale so as to include, among the plurality of pixels expressing a middle gray-scale, at least one pixel converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one pixel converted to a second characteristic value obtained by adding a negative correction value, and the gray-scale expressing step expresses a gray-scale so as to include at least one field converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one field converted to a second characteristic value obtained by adding a negative correction value.

[0054] A 10th aspect of the present invention is an image display method enabling an expression of a middle gray-scale of an input video signal by a field train formed by a plurality of fields and a gray-scale display in accordance with an input video signal, having: a step of generating drive voltages corresponding to effective voltages including a first voltage corresponding to a bright level and a second voltage corresponding to a dark level and a step of applying the generated drive voltages to the liquid crystal cells, wherein the second voltage is set at a voltage lower than a threshold voltage of a liquid crystal cell.

[0055] An 11th aspect of the present invention is an image display method enabling an expression of a middle gray-scale of an input video signal by a field train formed by a plurality of fields and a gray-scale display in accordance with an input video signal, having: a step of generating drive voltages corresponding to effective voltages including a first voltage corresponding to a bright level and a second voltage corresponding to a dark level and a step of applying the generated drive voltages to the liquid crystal cells, wherein the first voltage is set at a voltage higher than a voltage at which the characteristic value of the liquid crystal cell starts to become substantially the maximum.

[0056] A 12th aspect of the present invention is an image display method enabling an expression of a middle gray-scale of an input video signal by a field train formed by a plurality of fields and a gray-scale display in accordance with an input video signal, having: driving a display including liquid crystal cells displaying an image by a gray-scale in accordance with drive voltages while changing a bright/dark ratio over time.

EFFECT OF THE INVENTION

[0057] According to the present invention, it is possible to use a plurality of pixels to display a middle gray-scale and, at the same time, improve the viewing angle characteristic.

BRIEF DESCRIPTION OF THE DRAWINGS

[0058] FIG. **1**A to FIG. **1**D are diagrams for explaining general dither.

[0059] FIG. **2**A to FIG. **2**C are other diagrams for explaining general dither.

[0060] FIG. **3** is a diagram showing an example of the configuration of an image display device of a first embodiment to which the present invention is applied.

[0061] FIG. **4**A and FIG. **4**B are diagrams for explaining a case where dithering is carried out by using a dither matrix.

[0062] FIG. **5** is a diagram showing a relationship of a pixel output to be corrected with respect to an input gray-scale.

[0063] FIG. **6**A and FIG. **6**B are diagrams for explaining a viewing angle characteristic improved by the image display device to which the present invention is applied.

[0064] FIG. **7**A and FIG. **7**B are other diagrams for explaining the viewing angle characteristic improved by the image display device to which the present invention is applied.

[0065] FIG. **8**A and FIG. **8**B are diagrams for explaining a case where one dither matrix is comprised of four pixels of F**1** to F**4**.

[0066] FIG. **9** is a diagram showing the configuration of an image display device of a second embodiment to which the present invention is applied.

[0067] FIG. **10** is a diagram showing the relationship of a density (transmittance) of a displayed video with respect to a level of an input video signal.

[0068] FIG. **11** is a diagram showing an image region with an upper half having a density of 50% and with a lower half having a density of 100%.

[0069] FIG. **12** is a diagram showing a field train comprised of a plurality of fields in a case where the image of FIG. **11** is displayed.

[0070] FIG. **13**A to FIG. **13**C are diagrams showing the density of a region P in the field train from a time t**0** until a time t**1**.

[0071] FIG. **14**A and FIG. **14**B are diagrams for explaining a case where a binary luminance is found based on an oblique viewing angle characteristic.

[0072] FIG. **15**A and FIG. **15**B are diagrams showing in a zigzag state an example of displaying a point T(v**1**) brighter than the brightness of an original pixel and a point T(v**2**) darker than that of the original pixel in the found binary values.

[0073] FIG. **16**A and FIG. **16**B are diagrams showing an example where a dither matrix is comprised by replacing only G among R, G, and B.

[0074] FIG. **17** is a diagram showing a configuration optimizing the dithering based on a measured oblique viewing angle.

[0075] FIG. **18** is a diagram for explaining a first method of optimizing a voltage selection of a black level of a drive voltage applied to a liquid crystal so as to make a liquid crystal response waveform approach a pulse width modulation (PWM) waveform and improve the viewing angle characteristic.

[0076] FIG. **19**A to FIG. **19**E are diagrams for explaining a first method of optimizing a voltage selection of a black level of a drive voltage applied to a liquid crystal so as to make a liquid crystal response waveform approach a pulse width modulation (PWM) waveform.

[0077] FIG. **20**A and FIG. **20**B are diagrams for explaining a second method of optimizing the voltage selection of a white level and optimizing a refractive index anisotropy And (d is a panel thickness) to improve the viewing angle characteristic.

[0078] FIG. **21**A and FIG. **21**B are diagrams showing transmittance characteristics with respect to input gray-scale of a general liquid crystal display device and a liquid crystal display device employing the second method of the present embodiment corresponding to FIG. **20**B.

[0079] FIG. **22** is a diagram for explaining an example of a drive method so that a bright/dark ratio over time becomes 1:2 according to a third method.

[0080] FIG. **23**A and FIG. **23**B are diagrams showing transmittance characteristics with respect to input gray-scale of a general liquid crystal display device and a liquid crystal display device employing the third method of the present embodiment corresponding to FIG. **20**B.

[0081] FIG. **24**A to FIG. **24**C are diagrams showing transmittance characteristics with respect to input gray-scale of a general liquid crystal display device and liquid crystal display devices employing the second method and a fourth method of the present embodiment.

[0082] FIG. **25**A and FIG. **25**B are diagrams showing transmittance characteristics with respect to input gray-scale of a general liquid crystal display device and a liquid crystal display device employing a fifth method of the present embodiment.

[0083] FIG. **26**A to FIG. **26**C are diagrams showing drive voltage waveforms at bright and dark times of a general liquid crystal display device and liquid crystal display devices employing the second method and the fourth method of the present embodiment.

[0084] FIG. **27**A and FIG. **27**B are diagrams showing drive voltage waveforms at bright and dark times of a general liquid crystal display device and a liquid crystal display device employing the fifth method of the present embodiment.

[0085] FIG. **28** is a diagram showing a first example of the configuration of a liquid crystal display device (image display device) which can be applied to the drive method of the present embodiment.

[0086] FIG. **29** is a diagram showing a second example of the configuration of a liquid crystal display device (image display device) which can be applied to the drive method of the present embodiment.

[0087] FIG. **30** is a diagram showing a third example of the configuration of a liquid crystal display device (image display device) which can be applied to the drive method of the present embodiment.

[0088] FIG. **31**A to FIG. **31**C are diagrams showing a γ pattern of a data converter set in the device of FIG. **30**, a γ pattern of a reference voltage generator, and a liquid crystal application voltage with respect to the input data.

[0089] FIG. **32** is a diagram showing a fourth example of the configuration of a liquid crystal display device (image display device) which can be applied to the drive method of the present embodiment.

[0090] FIG. **33**A to FIG. **33**C are diagrams showing a γ pattern of a data converter set in the device of FIG. **32**, a γ pattern of a reference voltage generator, and a liquid crystal application voltage with respect to the input data.

[0091] FIG. **34** is a diagram showing a fifth example of the configuration of a liquid crystal display device (image display device) which can be applied to the drive method of the present embodiment.

[0092] FIG. **35**A to FIG. **35**E are diagrams showing γ patterns of data converters set in the device of FIG. **32**, γ patterns of reference voltage generators, and a liquid crystal application voltage with respect to the input data.

[0093] FIG. **36** is a diagram showing a sixth example of the configuration of a liquid crystal display device (image display device) which can be applied to the drive method of the present embodiment.

[0094] FIG. **37**A to FIG. **37**F are diagrams showing γ patterns of data converters set in the device of FIG. **32**, γ patterns of reference voltage generators, and liquid crystal application voltages with respect to the input data.

[0095] FIG. **38** is a diagram showing a seventh example of the configuration of a liquid crystal display device (image display device) which can be applied to the drive method of the present embodiment.

DESCRIPTION OF NOTATIONS

[0096] **10** . . . image display device, **11** . . . luminance converter, **12** . . . offset generator, **13** . . . first adder circuit, **14** . . . second adder circuit, **15** . . . first voltage converter, **16** . . . second voltage converter, **17** . . . ditherer, **18** . . . controller, **21** . . . display, **20** . . . image display device, **21** . . . nonlinear converter, **22** . . . offset generator, **23** . . . offset table, **24** . . . first adder circuit, **25** . . . second adder circuit, **26** . . . first inverse converter, **27** . . . second inverse converter, **28** . . . time division processor, **29** . . . controller, **30** . . . display, **40**, **40**A to **40**F . . . liquid crystal display devices (image display devices), **41**, **41**C, **41**F . . . data converter, **42**, **42**A . . . reference voltage generator, **43** . . . source driver, **44** . . . display panel.

BEST MODE FOR WORKING THE INVENTION

[0097] Below, embodiments of the present invention will be explained with reference to the drawings.

[0098] In the embodiments, the explanation will be given by taking as an example an image display device for displaying an image in response to an input video signal via a direct view type liquid crystal display screen.

[0099] First, an image display device **10** according to a first embodiment will be explained

[0100] FIG. **3** is a diagram showing an example of the configuration of an image display device according to a first embodiment of the present invention.

[0101] The image display device **10** is provided with, as shown in FIG. **1**, a luminance converter **11** for converting a video signal H given as an applied signal voltage to a luminance signal based on a predetermined nonlinear characteristic, an offset generator **12** supplied with the input video signal H, a first adder circuit **13** and a second adder circuit **14** for adding and subtracting output signals from the luminance converter **11** and an offset table, a first voltage converter **15** supplied with a computation result of the first adder circuit **13**, a second voltage converter **16** supplied with a computation result of the second adder circuit **14**, a ditherer **17** supplied with signals V**1** and V**2** output from the first and second voltage converters **15** and **16**, a controller **18** for controlling the ditherer **17**, and a display **19** for displaying an image in response to the input video signal H based on an output signal Cout from the ditherer **17**.

[0102] The luminance converter **11** converts the supplied video signal H to a luminance signal L based on a previously set nonlinear characteristic.

[0103] The nonlinear characteristic set in the luminance converter **11** can be freely set and may be expressed by for example a nonlinear curve having a gradient becoming more gentle as the voltage becomes lower.

[0104] The signal L converted from voltage to luminance in the luminance converter **11** is supplied to the first adder circuit **13** and the second adder circuit **14**.

[0105] The offset generator **12** generates a signal D**1** and a signal D**2** expressed as pixel outputs correcting the gray-scale of the supplied video signal H (hereinafter, referred to as an input gray-scale).

[0106] The offset generator **12** generates signals D**1** and D**2** for offsetting the luminance signal L from the luminance converter **11** with reference to a previously set offset table in accordance with the applied signal voltage of the supplied video signal H.

[0107] The signal D**1** generated at the offset generator **12** is output to the first adder circuit **13**, and the signal D**2** is output to the second adder circuit **14**.

[0108] Note that, details of the offset table in the offset generator **12** and the signals D**1** and D**2** to be generated will be explained later.

[0109] The first adder circuit **13** is supplied with the signal L from the luminance converter **11** and supplied with the signal D**1** from the offset generator **12**.

[0110] The first adder circuit **13** subtracts the signal D**1** from the signal L and supplies a signal E**1** obtained as a result to the first voltage converter **15**.

[0111] The second adder circuit **14** is supplied with the signal L from the luminance converter **11** and supplied with the signal D**2** from the offset generator **12**.

[0112] The second adder circuit **14** adds the signal D**2** to the signal L and supplies a signal E**2** obtained as a result to the second voltage converter **16**.

[0113] The first voltage converter **15** converts the signal E**1** supplied from the first adder circuit **13** to the γ characteristic again based on the previously set nonlinear characteristic.

[0114] This nonlinear characteristic set in the first voltage converter **15** is expressed as an inverse characteristic to the nonlinear characteristic set in the luminance converter **11**. For this reason, when updating the nonlinear characteristic set in the luminance converter **11**, the nonlinear characteristic set in the first voltage converter **15** will also be updated linked with this.

[0115] The signal V**1** converted by the first voltage converter **15** is output to the ditherer **17**.

[0116] The second voltage converter **16** converts the signal E**2** supplied from the second adder circuit **14** to the γ characteristic again based on the previously set nonlinear characteristic.

[0117] This nonlinear characteristic set in the second voltage converter **16** is expressed as an inverse characteristic to the nonlinear characteristic set in the luminance converter **11**. For this reason, when updating the nonlinear characteristic set in the luminance converter **11**, the nonlinear characteristic set in the second voltage converter **16** will also be updated linked with this.

[0118] The signal V**2** converted by the second voltage converter **16** is output to the ditherer **17**.

[0119] The ditherer **17** performs dithering based on dither under the control of the controller **18** from the signals V**1** and V**2** supplied from the first voltage converter **15** and the second voltage converter **16**.

[0120] FIG. **4** are diagrams for explaining a case where the ditherer **17** of the present embodiment uses a dither matrix to perform the dithering.

[0121] This dither, as shown in FIG. **4**A, pseudo expresses an image region expressed by a middle gray-scale comprised of a plurality of pixels by a two-dimensional dither matrix comprised of two types of pixels of pixels having a first characteristic value (transmittance in the present embodiment) and pixels having a second characteristic value (transmittance in the present embodiment) expressed by a checkerboard like regular pattern in the horizontal direction and the vertical direction as shown in FIG. **4**B.

[0122] The ditherer **17** outputs an output signal Cout expressed by such a dither matrix to the display **19**.

[0123] The display **19** for example displays the output image of the ditherer **17** via the direct view type liquid crystal display screen mounting thin film transistors (TFT) for driving liquid crystals

[0124] The display **19** obtains the predetermined transmittances (characteristic values) and displays the middle gray-scale by utilizing for example the liquid crystal material characteristic having a transmittance curve corresponding to the output signal Cout defined as the voltage value.

[0125] Next, the operation up until the image display device **10** according to the first embodiment of the present invention generates the two-dimensional dither matrix explained above will be explained.

[0126] FIG. **5** is a diagram showing the relationship of the pixel output to be corrected with respect to the input gray-scale.

[0127] In FIG. **5**, an abscissa indicates the input gray-scale (transmittance), and an ordinate indicates the characteristic value (transmittance).

[0128] In the usual dither, predetermined dither coefficients are added to corresponding positions of a plurality of pixels. The input signal is corrected so that an average output obtained by addition by the plurality of pixels exhibits a linear relationship as shown by a straight line b in FIG. **5** with respect to the input gray-scale, whereby the resultant pixel output is obtained.

[0129] As opposed to this, in the image display device **10** of the present embodiment, for example a pair of pixels (sub pixels) are corrected based on the relationships of pixel outputs shown by a and c in FIG. **5** with respect to the input gray-scale and controlled so as to obtain a first characteristic value VALa and a second characteristic value VALc.

[0130] Specifically, in this correction, a plus correction value Δk**2** is added to the straight line b as shown in FIG. **5** to find the first characteristic value VALa, while a minus correction value Δk**1** is subtracted from the straight line b to find the second characteristic value VALc.

[0131] In other words, the positive correction value Δk**2** and the negative correction value Δk**1** are generated with respect to the input gray-scale. These correction values are added to the input gray-scale to thereby obtain the pixel output b.

[0132] The ditherer **17** is supplied with a signal V**1** indicating the pixel output having the relationship of a with respect to the input gray-scale and a signal V**2** indicating the pixel output having the relationship of c with respect to the input gray-scale.

[0133] The ditherer **17** determines the first characteristic value VALa based on the signal V**1**, determines the second characteristic value VALc based on the signal V**2**, and expresses the middle gray-scale via the dither matrix.

[0134] As a result, the middle gray-scale obtained by adding the first characteristic value VALa and the second characteristic value VALb and dividing the result by 2 is expressed by the dither matrix.

[0135] This corresponds to the expression of the relationship obtained by adding pixel outputs (transmittances) expressed by the relationships of a and c shown in FIG. **5** and dividing the result by 2 via a dither matrix.

[0136] Incidentally, the offset generator **12** stores in advance the relationships a and c of pixel outputs with respect to the input gray-scale in an offset table to refers to this offset table whenever the drive signal H is input so as to specify the correction values Δk**1** and Δk**2**.

[0137] The relationships a and c of the pixel outputs previously stored in the offset table are set to a format including at least one pixel converted to the first characteristic value VALa obtained by adding the negative correction value Δk**1** to the input gray-scale and at least one pixel converted to the second density obtained by adding the positive correction value Δk**2** to the input gray-scale in the dither matrix as shown in FIG. **5**.

[0138] For example, the relationships a and c of the pixel outputs are stored in the offset table so that either of the first characteristic value or second characteristic value obtained as a result of adding the negative correction value Δk**1** and the positive correction value Δk**2** becomes the maximum characteristic value (transmittance: 100%) or the minimum characteristic value (transmittance: 0%).

[0139] In FIG. **5**, the negative correction value Δk**1** is set so that the second characteristic value becomes the minimum characteristic value from the transmittance 0% to 50%, while the positive correction value Δk**2** is set so that the first characteristic value becomes the maximum characteristic value from the transmittance 50% to 100%.

[0140] FIG. **6**A and FIG. **6**B are diagrams showing the relationships of the transmittance with respect to viewing angles (0 degree, 20 degrees, 40 degrees, 60 degrees) with respect to the liquid crystal display screen of the display **19** in the case where the correction values are set as explained above, in which FIG. **6**A shows the relationship of the transmittance with respect to the viewing angle in the case based on the usual dither, and FIG. **6**B shows the relationship of the transmittance with respect to the viewing angle in the present embodiment.

[0141] In FIG. **6**A and FIG. **6**B, the abscissa indicates the transmittance (input) based on the output signal Cout supplied from the ditherer **17** in accordance with the gray-scale to be displayed in the display **19**, and the ordinate indicates the transmittance (output) of the gray-scale actually displayed on the display **19**.

[0142] When correcting the input gray-scale to obtain the pixel output based on the linear relationship shown by the straight line b in FIG. **5** based on the usual dither, as shown in FIG. **6**A, it is seen that the viewing angle characteristic is remarkably deteriorated as the viewing angle becomes larger, in other words, in the case where the liquid crystal display screen is viewed obliquely.

[0143] As opposed to this, when determining the first characteristic value and the second characteristic value so as to obtain the relationships a and c of pixel outputs as in the present embodiment, as shown in FIG. **6**B, it is seen that the viewing angle characteristic is improved even in the case where the liquid crystal display screen is viewed obliquely.

[0144] FIG. **7**A and FIG. **7**B are diagrams showing results expressing the relationships of transmittances shown in FIG. **6**A and FIG. **6**B by the γ corrected gray-scale. In FIG. **7**A and FIG. **7**B, the abscissas indicate input gray-scale, and the ordinates indicate output gray-scale.

[0145] In the case of a gray-scale where the input gray-scale can be actually viewed by the human eye via the liquid crystal display screen (hereinafter, referred to as an "output gray-scale"), when correcting this to obtain the pixel output based on the linear relationship shown by the straight line b in FIG. **5** with respect to the input gray-scale based on the usual dither, as shown in FIG. **7**A, the linearity between the input gray-scale and the output gray-scale gradually deviates as the viewing angle becomes larger. This suggests that the viewing

angle characteristic remarkably deteriorates in the case where the liquid crystal display screen is obliquely viewed.

[0146] As opposed to this, when, as in the present embodiment, determining the first characteristic value and the second characteristic value so as to obtain the relationships a and c of pixel outputs, as shown in FIG. **7**B, it is seen that the viewing angle characteristic is improved even in the case where the liquid crystal display screen is obliquely viewed.

[0147] As the reason why the viewing angle is improved in this way, in the case where the transmittance is for example 50%, as shown in FIG. **5**, the dither matrix is formed so that the first characteristic value becomes the transmittance of 100% and the second characteristic value becomes the transmittance of 0% in the relationships a and c of pixel outputs.

[0148] The viewing angle characteristic does not deteriorate when the transmittances are 0% and 100%, therefore a middle gray-scale of a dither matrix expressed by adding the first characteristic value and the second characteristic value and dividing the result by 2 does not deteriorate in the viewing angle characteristic when the transmittance is 50%.

[0149] It is seen that deviation in accordance with the viewing angle does not occur in the case of a transmittance of 50% as shown in FIG. **6**B.

[0150] Further, even from the transmittance 0% to the transmittance 50%, in the present embodiment, as shown in FIG. **5**, since the second characteristic value is fixed to the transmittance 0% and the transmittance is changed only for the first characteristic value, the viewing angle characteristic no longer deteriorates at least in regard to the second characteristic value.

[0151] For this reason, when displaying a middle gray-scale of a dither matrix expressed by adding these first characteristic value and second characteristic value and dividing the result by 2, the viewing angle characteristic can be improved in comparison with the usual dither.

[0152] In the same way, even from the transmittance 50% to the transmittance 100%, in the present embodiment, as shown in FIG. **5**, since the first characteristic value is fixed at the transmittance 100% and the transmittance is changed only for the second characteristic value, the viewing angle characteristic no longer deteriorates at least in regard to the first characteristic value.

[0153] For this reason, when displaying a middle gray-scale of a dither matrix expressed by adding these first characteristic value and second characteristic value and dividing the result by 2, the viewing angle characteristic can be improved in comparison with the usual dither.

[0154] In this way, in the image display device **10** of the present embodiment, when expressing a middle gray-scale of a dither matrix by the first characteristic value and the second characteristic value, since the density of either is fixed to 0% or 100%, it becomes possible to improve the viewing angle characteristic by that amount.

[0155] Note that the present embodiment is not limited to the case where the relationships a and c of pixel outputs where either of the first characteristic value or second characteristic value becomes the maximum characteristic value or the minimum characteristic value are stored in the offset table.

[0156] If at least one pixel converted to the first characteristic value (transmittance) obtained by adding the negative correction value $\Delta k1$ to the input gray-scale and at least one pixel converted to the second characteristic value (transmittance) obtained by adding the positive correction value $\Delta k2$ to the input gray-scale are included in the dither matrix, the same effect can be obtained. For example, curves where the relationships of pixel outputs shown in FIG. **5** are defined by a' and c' may be stored in the offset table as well.

[0157] Further, in the above embodiment, the case where the dither matrix was comprised of two pixels was explained, but the present invention is not limited to such a case. Any format may be employed so far as the dither matrix is comprised of a plurality of pixels.

[0158] For example, when forming one dither matrix by 4 pixels of F**1** to F**4** as shown in FIG. **8**A, in the relationships of pixel outputs to be corrected with respect to the input gray-scale, as shown in FIG. **8**B, when the transmittance is 0% to 25%, the characteristic value (transmittance) of the pixel output of the pixel F**1** is shifted to a large extent, while the pixels F**2**, F**3**, and F**4** are fixed to the minimum characteristic value.

[0159] When the transmittance is 25% to 50%, the characteristic value of the pixel output of the pixel F**2** is shifted to a large extent, while the transmittance of the pixel F**1** is fixed at the maximum value (characteristic value) and further the transmittances of the pixels F**3** and F**4** are fixed at the minimum characteristic value.

[0160] When the transmittance is 50% to 75%, the characteristic value of the pixel output of the pixel F**3** is shifted to a large extent, while the pixels F**1** and F**2** are fixed at the maximum characteristic value and further the pixel F**4** is fixed at the minimum characteristic value.

[0161] When the transmittance is 75% to 100%, the characteristic value of the pixel output of the pixel F**4** is shifted to a large extent, while the pixels F**1**, F**2**, and F**3** are fixed at the maximum characteristic value.

[0162] As a result, it becomes possible to pseudo create the pixel output as shown by the straight line b in FIG. **8**B. Further, in such case, since at least three pixels among the pixels F**1** to F**4** will be typically fixed at the minimum characteristic value (transmittance: 0%) or the maximum characteristic value (transmittance: 100%), it also becomes possible to prevent the deterioration of the viewing angle characteristic.

[0163] In this way, in the image display device **10** of the first embodiment, when expressing a middle gray-scale of a dither matrix by a first characteristic value and a second characteristic value, only the characteristic value of one pixel composing this dither matrix is shifted. The characteristic values of the other pixels are typically fixed in characteristic values (transmittances) at 0% or 100%. Therefore it becomes possible to improve the viewing angle characteristic by that amount.

[0164] Next, an image processing apparatus **20** according to a second embodiment expressing a middle gray-scale of an input video signal by a field train comprised of a plurality of fields so as to improve the viewing angle characteristic will be explained.

[0165] The image display device **10** of the first embodiment used the technique of dithering in the spatial direction to express one gray-scale by a plurality of pixels so as to improve the viewing angle characteristic.

[0166] As opposed to this, the image display device **20** of the second embodiment expresses one gray-scale by pixels of a plurality of screens arranged in the time direction to improve the viewing angle characteristic.

[0167] Below, one screen will be also referred to as a "field" and a train comprised of a plurality of fields will be referred to

as a "field train". Note that the term "field" in the present description is not limited to the field in so-called interlaced scan.

[0168] FIG. **9** is a block diagram showing an example of the configuration of the image display device **20** according to the second embodiment.

[0169] The image display device **20** is provided with, as shown in FIG. **9**, a nonlinear converter **21**, an offset generator **22**, an offset table **23**, a first adder circuit **24**, a second adder circuit **25**, a first inverse converter **26**, a second inverse converter **27**, a time division processor **28**, a controller **29** for controlling the time division processor **28**, and a display **30**.

[0170] The nonlinear converter **21**, for example, receives as input a video signal H having a screen display rate of 60 Hz from the outside.

[0171] The nonlinear converter **21** converts the level of the input video signal H according to the predetermined nonlinear input/output characteristic set in advance.

[0172] The nonlinear input/output characteristic set in the nonlinear converter **21** is a nonlinear curve expressed by a so-called gamma function where the gradient becomes gentler as the level becomes lower. Note that this nonlinear input/output characteristic can be freely set.

[0173] The video signal L after the level conversion output from the nonlinear converter **21** is supplied to the first adder circuit **24** and the second adder circuit **25**.

[0174] The offset generator **22** receives as input the video signal H. The offset generator **22** refers to the offset table **23** and generates the first offset signal Δk**1** and the second offset signal Δk**2**.

[0175] The offset table **23** is a table showing values of corresponding offset signals Δk**1** and Δk**2** with respect to the signal level of the input video signal H.

[0176] The offset generator **22** retrieves the corresponding Δk**1** and Δk**2** from the offset table in accordance with the input video signal H and outputs them as offset signals.

[0177] Note that details for the first offset signal Δk**1** and the second offset signal Δk**2** output from the offset generator **22** will be explained later.

[0178] The first offset signal Δk**1** output from the offset generator **22** is supplied to the first adder circuit **24**. The second offset signal Δk**2** output from the offset generator **22** is supplied to the second adder circuit **25**.

[0179] The first adder circuit **24** receives as input the video signal L output from the nonlinear converter **21** and the first offset signal Δk**1** output from the offset generator **22**.

[0180] The first adder circuit **24** adds the video signal L and the first offset signal Δk**1** to generate a video signal E**1**.

[0181] The video signal E**1** generated by the first adder circuit **24** is supplied to the first inverse converter **26**.

[0182] The second adder circuit **25** receives as input the video signal L output from the nonlinear converter **21** and the second offset signal Δk**2** output from the offset generator **22**.

[0183] The second adder circuit **25** subtracts the first offset signal Δk**1** from the video signal L to generate a video signal E**2**.

[0184] The video signal E**2** generated by the second adder circuit **24** is supplied to the second inverse converter **27**. The first inverse converter **26** receives as input the video signal E**1** output from the first adder circuit **24**. The first inverse converter **26** converts the level of the input video signal E**1** according to the predetermined nonlinear input/output characteristic set in advance.

[0185] The second inverse converter **27** receives as input the video signal E**2** output from the second adder circuit **25**. The second inverse converter **27** converts the level of the input video signal E**2** according to the predetermined nonlinear input/output characteristic set in advance.

[0186] The nonlinear input/output characteristics set in the first inverse converter **26** and the second inverse converter **27** are inverse characteristics to the nonlinear input/output characteristics set in the nonlinear converter **21**.

[0187] For example, if input/output characteristics in accordance with the gamma function are set in the nonlinear converter **21**, this means that inverse gamma characteristics are set in the first inverse converter **26** and the second inverse converter **27**.

[0188] For this reason, when updating the nonlinear characteristics set in the nonlinear converter **21**, the nonlinear characteristics set in the first inverse converter **26** and the second inverse converter **27** will also be updated linked with this.

[0189] The video signal V**1** after the level conversion by the first inverse converter **26** is supplied to the time division processor **28**. Further, the video signal V**2** after the level conversion by the second inverse converter **27** is supplied to the time division processor **28**.

[0190] Note that the nonlinear converter **21** has the same components as those of the luminance converter **11** of the image display device **10** of the first embodiment, the offset generator **22** and the offset table **23** have the same components as those of the offset generator **12** of the image display device **10** of the first embodiment, the first adder circuit **24** has the same components as those of the first adder circuit **13** of the image display device **10** of the first embodiment, and the second adder circuit **25** has the same components as those of the second adder circuit **14** of the image display device **10** of the first embodiment. Further, the first inverse converter **16** has the same components as those of the first voltage converter **15** of the image display device **10** of the first embodiment, and the second inverse converter **27** has the same components as those of the second voltage converter **26** of the image display device **10** of the first embodiment.

[0191] Further, the connections of the components described above are the same as those of the image display device **10** of the first embodiment.

[0192] The time division processor **28** has a first up convert unit **281**, a second up convert unit **282**, and a switch output unit **283**.

[0193] The first up convert unit **281** receives as input the video signal V**1** after the level conversion by the first inverse converter **26**. The video signal V**1** has a screen display rate (60 Hz) the same as that of the original video signal H.

[0194] The first up convert unit **281** converts the screen display rate of the input video signal V**1** from 60 Hz to 120 Hz. The first up convert unit **281** performs the up conversion by repeatedly outputting for example the same screen two times.

[0195] The second up convert unit **282** receives as input the video signal V**2** after the level conversion by the second inverse converter **27**. The video signal V**2** has a screen display rate (60 Hz) the same as that of the original video signal H.

[0196] The second up convert unit **282** converts the screen display rate of the input video signal V**2** from 60 Hz to 120 Hz. The second up convert unit **282** performs the up conversion by repeatedly outputting for example the same screen two times.

[0197] The switch output unit **283** alternately selects and outputs the video signal output from the first up convert unit **281** and the video signal output from the second up convert unit **282** for each screen.

[0198] For this reason, the switch output unit **283** outputs a video signal Cout having a screen display rate of 120 Hz in which a screen generated by the addition of the first offset signal Δk**1** and a screen generated by the addition of the second offset signal Δk**2** are alternately repeated.

[0199] The video signal Cout output from the switch output unit **283** is supplied to the display **30**.

[0200] The display **30** displays the output image of the time division processor **28** via a direct view type liquid crystal display screen mounting for example thin film transistors (TFT) for driving the liquid crystals.

[0201] In the display **30**, the liquid crystal display screen changes in the transmittance at the pixel positions corresponding to the video signal Cout to display different screens of the video signal. Here, even when the screen display rate is 120 Hz, the alternating current of the liquid crystals is set at 60 Hz. This is so as to prevent the application of DC current to the liquid crystals and subsequent burn-in or flickering.

[0202] Next, the processing operation of the image display device **20** according to the second embodiment will be explained.

[0203] The image display device **20** expresses one gray-scale by two consecutive screens arranged in the time direction so as to improve the viewing angle characteristic. Specifically, the following processing is carried out.

[0204] The image display device **20** converts the screen display rate of the video signal from 60 Hz to 120 Hz.

[0205] Here, between two consecutive screens of a video signal after up converting the screen display rate, a preceding screen will be called the "first field", and the following screen will be called the "second field".

[0206] Note that while the term "field" is used, this has no relation to the "field" of an interlaced scan.

[0207] FIG. **10** is a diagram showing a characteristic value (transmittance of liquid crystal) displayed on the display **30** with respect to the signal level (gray-scale) of an input video signal H.

[0208] In the image display device **20**, as shown in FIG. **10**, the first offset signal Δk**1** is added to the first field FLD**1**, and the second offset signal Δk**2** is subtracted from the second field FLD**2**.

[0209] For this reason, in the image display device **20**, an output video signal Cout in which a field corrected in level to the plus side (first field) and a field corrected in level to the minus side are alternately repeated is supplied to the display **30**.

[0210] Here, human vision has an integrating characteristic with respect to the time direction, therefore, when a field corrected to the plus side and a field corrected to the minus side are alternately displayed, a user perceives an image having a level of the average value of the same.

[0211] For this reason, a user pseudo viewing the video image displayed on the display **30** sees a video signal AFDL**12** represented by the average level of the first field FLD**1** and the second field FLD**2**.

[0212] Accordingly, in the image display device **20**, the offset signals Δk**1** and Δk**2** are determined so that the video image becomes the same as the ordinary video image seen in the case where the offset signals Δk**1** and Δk**2** are not added when averaging the first field FLD**1** and the second field FLD**2**.

[0213] The offset generator **22** of the image display device **20** generates the first offset signal Δk**1** and the second offset signal Δk**2** by referring to the offset table **23**.

[0214] The offset table **23** stores in advance the relationship of the pixel output level with respect to the level of the original video signal (input gray-scale). The offset generator **22** specifies Δk**1** and Δk**2** by referring to the offset table **23** whenever a video signal H is input.

[0215] For example, consider the case as shown in FIG. **11** where a screen w in which the region of the upper half of the screen is a region displayed by a gray-scale having a transmittance of 50% and the region of the lower half of the screen is a region displayed by a gray-scale having a transmittance of 100% is displayed.

[0216] In this case, as shown in FIG. **12**, the first field FLD**1** becomes an image in which the entire screen is displayed by a gray-scale having the transmittance of 100%. Further, in the second field FLD**2**, the region of the upper half of the screen is displayed by a gray-scale having a transmittance of 0%, and the region of the lower half of the screen is displayed by a gray-scale having a transmittance of 100%.

[0217] When displaying the screen w, such a first field FLD**1** and second field FLD**2** are alternately displayed, therefore an image in which the density of the upper half region is viewed as a combined density of 0% and 100% can be pseudo displayed.

[0218] Further, in the image display device **20**, Δk**1** and Δk**2** are stored in the offset table **23** so that either of the resultant value obtained by adding the first offset signal Δk**1** or the resultant value by subtracting the second offset signal Δk**2** becomes the maximum characteristic value (transmittance of 100%) or the minimum characteristic value (transmittance of 0%).

[0219] In FIG. **10** described above, the second offset signal Δk**2** is set so that the characteristic value (transmittance) of the second field FLD**2** becomes the minimum value (minimum transmittance) from the level of the input video signal of 0% to 50%, while the first offset signal Δk**1** is set so that the characteristic value (transmittance) of the first field FLD**1** becomes the maximum value (maximum transmittance) from the level of the input video signal of 50% to 100%.

[0220] For this reason, when for example expressing a middle gray-scale e**1**, as shown in FIG. **13**A, the first field FLD**1** of a time t**0** to a time t**1**/**2** is based on a transmittance g**1**, and the second field FLD**2** of a time t**1**/**2** to a time t**1** is set at the transmittance 0%.

[0221] Due to this, it becomes possible to pseudo project the middle gray-scale e**1** for the image region to a user viewing the array of consecutive fields (hereinafter referred to as a "field train") from the time t**0** to the time t**1**.

[0222] Further, for example, when expressing a middle gray-scale e**2**, as shown in FIG. **13**B, the first field FLD**1** of a time t**0** to a time t**1**/**2** is based on a transmittance g**2**, and the second field FLD**2** of a time t**1**/**2** to a time t**1** is set at the transmittance 0%.

[0223] Due to this, it becomes possible to pseudo project the middle gray-scale e**2** for the image region to a user continuously viewing the field train from the time t**0** to the time t**1**.

[0224] Further, for example, when expressing a middle gray-scale e**3** having a high transmittance, as shown in FIG.

13C, the first field FLD1 of a time t0 to a time t1/2 is based on the transmittance 100%, and the second field FLD2 of a time t1/2 to a time t1 is set at a transmittance g3.

[0225] Due to this, it becomes possible to pseudo project the middle gray-scale e3 for the image region to a user continuously viewing the field train from the time t0 to the time t1.

[0226] In this way, in the image display device 20 to which the present invention is applied, when expressing a middle gray-scale of a dither matrix by a first characteristic value (transmittance) and a second characteristic value (transmittance), either characteristic value is fixed to the minimum characteristic value (transmittance: 0%) or the maximum characteristic value (transmittance: 100%).

[0227] Both of these characteristic values (transmittances) 0% and 100% give good viewing angle characteristics, therefore, by setting either characteristic value at the minimum characteristic value and the maximum characteristic value, it becomes possible to improve the viewing angle characteristic by that amount.

[0228] The relationship of the transmittance with respect to the viewing angles of the liquid crystal display screen of the display 30 in the case where such offset signals Δk1 and Δk2 are set is improved in the same way as the case of the spatial dither.

[0229] Note that, in the second embodiment, one gray-scale is displayed by two consecutive fields, but the present invention is not limited to this. Gray-scales may be displayed in any way so long as the gray-scales are expressed including at lease one field converted to a characteristic value obtained by adding a positive correction value (offset value) to the gray-scale of the video signal and at least one field converted to a characteristic value obtained by adding a negative correction value (offset value) to the gray-scale of the video signal in a field train comprised of two or more consecutive fields.

[0230] Note that the present invention is not limited to the first embodiment and the second embodiment explained above. When for example the input video signal H is formed by a moving picture, the ditherer 17 may also be controlled to use the dither matrix as the two-dimensional image to express a middle gray-scale, while when the input video signal H is formed by a still image, it may be controlled to use a field train to express a middle gray-scale.

[0231] Further, the image display device according to the present embodiment may be provided with both of the configuration expressing a middle gray-scale by a dither matrix and the configuration expressing the same by a field train or may be provided with only one of the same.

[0232] Further, this image display device is not limited to the case where a middle gray-scale of a monochrome image is expressed. A middle gray-scale of a video signal expressed by the primary color luminance components of R, G, and B may be expressed based on the same technique as well.

[0233] Further, in this image display device 10, naturally the correction values Δk1 and Δk2 set in the offset generator 12 may be freely set in advance by the user.

[0234] Further, in this image display device 10, it is also possible to measure the so-called oblique viewing angle in the case where the liquid crystal display screen is obliquely viewed and optimize the dithering in the ditherer 17 based on the measured oblique viewing angle.

[0235] In general, the reason why black dot defects do not occur with an oblique viewing angle is the mostly the provision of the viewing angle compensation film. Further, in a middle gray-scale, when the deviation of the gamma characteristic becomes large, there is a noticeable phenomenon of fading of the skin color in the colors stored as gray-scale having different R, G, and B. In order to solve this it is necessary to reduce the change of the gamma characteristic with respect to the oblique viewing angle.

[0236] For this reason, two values whose original levels give the same luminance (transmittance) when averaged but separate from each other by ΔT are found.

[0237] FIG. 14A and FIG. 14B show transmittance characteristics with respect to the input gray-scale in cases where the viewing angle is 0 degree, 30 degrees, 45 degrees, and 60 degrees. For example, the luminance obtained as a result of averaging T1(v1) and T2(v2) is defined as T0(v0) as shown in FIG. 14A. Further, when the actually measured gamma characteristic has shifted to the dark direction as shown in FIG. 14A,

$$T60_org=T0(v0)+\Delta T(v0) \quad (1)$$

$$T60_dither=(T0(v1)+\Delta T(v1)+T0(v2)+\Delta T(v2))/2=T0(v1)/2+\Delta T(v1)/2+T0(v2)/2+\Delta T(v2)/2 \quad (2)$$

$$T0(v0)=(T1(v1)+T2(v2))/2 \quad (3)$$

Therefore,

$$T60_dither=T0(v0)+\Delta T(v1)/2+T0(v2)/2 \quad (4)$$

[0238] Note that above variables show the following values.

[0239] v0: normal drive voltage for displaying the intended middle gray-scale;

[0240] v1: drive voltage for obtaining characteristic value obtained by adding positive correction value in present invention;

[0241] v2: drive voltage for obtaining characteristic value obtained by adding negative correction value in present invention;

[0242] T0(v0): targeted middle gray-scale transmittance;

[0243] T1(v1): characteristic value obtained by adding positive characteristic value in present invention;

[0244] T2(v2): characteristic value obtained by subtracting negative characteristic value in present invention;

[0245] ΔT(v0): difference between transmittance of viewing angle 60° and transmittance of viewing angle 0° at v0;

[0246] ΔT(v1): difference between transmittance of viewing angle 60° and transmittance of viewing angle 0° at v1;

[0247] ΔT(v2): difference between transmittance of viewing angle 60° and transmittance of viewing angle 0° at v2;

[0248] T60_org: transmittance of viewing angle 60° at normal drive; and

[0249] T60_dither: transmittance of viewing angle 60° in present invention

[0250] Further, ΔT(v1)/2+ΔT(v2)/2<ΔT(v0), therefore A T60_dither becomes smaller than ΔT60_org, and the fluctuation of luminance depending on the viewing angle becomes small. The condition that the ΔT's be separate from each other in such a case until one side is clipped to 0 is most improved. The change of the gamma characteristic due to the oblique viewing angle becomes small.

[0251] Further, when the actually measured gamma characteristic has shifted to the bright direction as shown in FIG. 14B, ΔT(v1)/2+ΔT(v2)/2>ΔT(v0), therefore A T60 dither becomes larger than ΔT60_org, therefore the fluctuation in

luminance depending on the viewing angle becomes worse. In this case, the optimum point is found by using the original value T(V**0**) or changing ΔT.

[0252] Next, the found two values are utilized for spatial dither. At this time, the two values are found in accordance with the gamma characteristic for each pixel as explained above, and the point T(v**1**) brighter than the brightness of the original pixel and the point T(v**2**) darker than that between the two found values are displayed in a zigzag state as shown in FIG. **15**A.

[0253] Incidentally, for RGB as well, when displaying the pixels in a zigzag state in the same way, they will be expressed by the two values of the luminance comprised of (r1,g1,b1) and the luminance comprised of (r2,g2,b2).

[0254] After spatial dither is applied in this way, time dither is further applied. FIG. **15**B shows an example where a zigzag state of patterns found in FIG. **15**A is reversed along with the elapse of time and these patterns are alternately displayed.

[0255] By superposing the spatial dither and the time dither in this way, it becomes possible to create a good quality combined image in which no flickering exists, the mesh is not noticeable, and the viewing angle is spread.

[0256] Note that, for R, G, and B, in the case where pixels are displayed in a zigzag state as explained above, any primary color luminance component may be replaced.

[0257] FIG. **16**A and FIG. **16**B show an example where only G among R, G, and B is replaced. In the example shown in FIGS. **16**A and **16**B, the two values of the luminance comprised of (r1,g2,b1) and the luminance comprised of (r2, g1,b2) are spatially arranged in a zigzag state. This arrangement is reversed by applying a time dither.

[0258] In such case, not a zigzag arrangement of white and black, but an impression like a complementary color checkers' arrangement of G will be given to the user.

[0259] Namely, in the example of FIGS. **16**A and **16**B, the luminance difference between adjacent pixels is small, the mesh is hard to see, the edges are more smoothly seen, and the dither value is found for each pixel, therefore the deterioration of the resolution is small.

[0260] FIG. **17** shows an example of installing a configuration optimizing the dithering based on the measured oblique viewing angle into the image display device **10**.

[0261] Pixels are arranged in a zigzag state as shown in FIG. **15**A. When the dither matrix is comprised of two values of a luminance comprised of (r1,g1,b1) and a luminance comprised of (r2,g2,b2), this means that the device is configured by a two-values generator **31** to which the video signal H comprised of the input luminance (r0,g0,b0) is input, an oblique viewing angle parameter portion **32** connected to this two-values generator **31**, and a ditherer **17**A.

[0262] The two-values generator **31** finds the luminance (r1,g1,b1) and the luminance (r2,g2,b2) based on the above Equation (1) to Equation (4) with respect to the input video signal H. The two values of the luminances found in this two-values generator **31** are transmitted to the ditherer **17**A.

[0263] Incidentally, the two-values generator **31** refers to the oblique viewing angle parameter unit **32** managing the measured oblique viewing angles in the form of parameters when finding these two values of luminances.

[0264] When these luminance (r1,g1,b1) and luminance (r2,g2,b2) are sent from the two-values generator **31**, the ditherer **17**A executes the dithering as explained above based on this.

[0265] As explained above, as the second embodiment, temporal dither expressing one gray-scale by two consecutive screens arranged continuously in the time direction so as to improve the viewing angle characteristic was explained.

[0266] Below, a drive method expressing a middle gray-scale of an input video signal by a field train comprised of a plurality of fields explained below, including in the concept of the second embodiment, will be explained.

[0267] Below, an explanation will be given in sequence of a first method of optimizing the voltage selection of the black level of the drive voltage applied to the liquid crystals, optimizing the panel thickness, and making the liquid crystal response waveform approach a so-called pulse width modulation (PWM) waveform to improve the viewing angle characteristic, a second method of optimizing the voltage selection of the white level and optimizing the panel thickness to improve the viewing angle characteristic, and a third method of driving the panel by changing the bright/dark time ratio to improve the viewing angle characteristic.

[0268] First, the first method of optimizing the voltage selection of the black level of the drive voltage applied to the liquid crystals and making the liquid crystal response waveform approach a so-called pulse width modulation (PWM) waveform to improve the viewing angle characteristic as shown in FIG. **18** will be explained.

[0269] In a general liquid crystal display device, the drive voltage is set within a range shown by for example X of FIG. **19**A, that is, the black level is set at a value substantially the same as the threshold voltage, for example 1.9V, and the white level is set at 4.0V.

[0270] The drive voltage waveform in this case is shown in FIG. **19**B, and the transmittance characteristic with respect to the input gray-scale is shown in FIG. **19**C.

[0271] In this case, a sufficient sharpness is not obtained in rising and falling portions of the effective drive voltage waveform (sufficient response characteristic is not obtained). In the γ characteristic at the viewing angle of 60 degrees, an actual characteristic shown by B tends to give a waveform different from an ideal curve shown by A.

[0272] As opposed to this, in the first embodiment according to the present embodiment, the drive voltage is set within the range shown by Y of FIG. **19**A, that is, the black level is set at a voltage lower than the threshold voltage, for example 1.9V, i.e., 0V in the example of FIG. **19**A, and the white level is set at 4.0V.

[0273] The drive voltage waveform in this case is shown in FIG. **19**D, and the transmittance characteristic with respect to the input gray-scale is shown in FIG. **19**E.

[0274] In this case, a sufficient sharpness is obtained in rising and falling portions of the effective drive voltage waveform (sufficient response characteristic is obtained), and the control can be made so as to efficaciously narrower the pulse width, and in the γ characteristic at the viewing angle of 60 degrees, also the actual characteristic shown by B tends to give a waveform approximating the ideal curve shown by A.

[0275] Namely, by setting the voltage value of the black level at a value lower than the threshold value (as this value is lower (nearer 0V), it is possible to form a drive voltage waveform able to give a better response characteristic), as shown in FIG. **18**, there is the advantage that it becomes possible to make the liquid crystal response waveform approach a so-called pulse width modulation (PWM) waveform and thereby improve the viewing angle characteristic of the middle gray-scale.

[0276] Further, the liquid crystal response characteristic is improved, therefore there is the advantage that the response with respect to a moving picture is improved.

[0277] Next, a second method of optimizing the voltage selection of the white level and optimizing an optical cell thickness Δnd represented by a product of the refractive index anisotropy Δn and the thickness d of the liquid crystal layer so as to improve the viewing angle characteristic will be explained.

[0278] In the second method, basically, the voltage of the white level is set not a 4V exhibiting the maximum transmittance, but a value larger than 4V, for example 5V.

[0279] As shown in FIG. **20**A, when individually observing the R, G, and B signals, even when 4V is applied as the drive voltage at the white level for R and G, it is possible to hold the transmittance at the maximum level, but the B signal tends to become lower in transmittance.

[0280] Therefore, in the present embodiment, as shown in FIG. **20**B, the voltage of the white level is set not at 4V exhibiting the maximum transmittance, but a value larger than 4V, for example 5V. By setting 5V as the white level, it becomes possible to hold the transmittance at the time of white display at the level at the time of 4V or more.

[0281] Further, in the second method of the present embodiment, the optical cell thickness Δnd of a pixel cell which was 310 nm with respect to a wavelength 546 nm (vicinity of wavelength of G) in the usual liquid crystal display device is set at 270 nm, and the optical cell thickness Δnd of a pixel cell which was 330 nm with respect to a wavelength 450 nm (vicinity of wavelength of B) in the usual liquid crystal display device is set at 285 nm.

[0282] Namely, the liquid crystal panel employing the second method is constituted so that the optical cell thickness becomes thin.

[0283] Note that, in the second method, the black level is set at a value in the vicinity of the threshold value in the same way as the usual liquid crystal display device or lower than the threshold value in the same way as the first method.

[0284] FIG. **21**A shows the transmittance characteristic with respect to the input gray-scale of a general liquid crystal display device corresponding to FIG. **20**A, and FIG. **21**B shows the transmittance characteristic with respect to an input gray-scale of a liquid crystal display device employing the second method of the present embodiment corresponding to FIG. **20**B.

[0285] In a general liquid crystal display device, as shown in FIG. **21**A, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to give a waveform different from the ideal curve shown by A.

[0286] As opposed to this, in the second method according to the present embodiment, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to give a waveform approximating the ideal curve shown by A.

[0287] Namely, by setting the value of the white level of the drive voltage of the liquid crystal not at 4V at which the transmittance starts to become substantially the maximum, but at a voltage higher than 4V, for example 5V, and constituting the liquid crystal panel so that the optical thickness of the pixel cells becomes thin with respect to the predetermined wavelength corresponding to this, there is the advantage that improvement of the viewing angle characteristic of the middle gray-scale becomes possible.

[0288] Note that, in the present embodiment, the drive voltage (application voltage) of the white level is made higher by 25% and the optical cell thickness is set thinner, i.e., about 86%, in comparison with the general display device, but the present invention is not limited to this. Various aspects are possible. Further, by further using a material having a low viscosity as the liquid crystal material, a response speed of the liquid crystals becomes fast. By applying this to the above second embodiment, the viewing angle characteristic can be improved.

[0289] Next, a third method of driving a panel by changing the bright/dark time ratio so as to improve the viewing angle characteristic will be explained.

[0290] The third method basically employs a drive method giving a bright/dark ratio in time of 1:2.

[0291] In this case, for example as shown in FIG. **22**, the lines in the vertical direction (V) are accessed not in line sequence, but alternately for bright and dark lines. A method of access where the dark data becomes 2 times the bright data is employed.

[0292] For example, in a case where the number of V lines is 768, when driving the panel so that the bright/dark ratio in time becomes 1:2, the following drive control is carried out. Note that, in the following explanation, the numbers of the lines are shown by attaching numerals to the # mark.

[0293] First, a line #**1** is accessed as the bright data, a line #**513** is accessed as the dark data next, a line #**2** is accessed as the bright data next, a line #**514** is accessed as the dark data next, this is sequentially repeated thereafter, a line #**256** is accessed as the bright data, a line #**768** (last line) is accessed as the dark data next, and a line #**257** is accessed as the bright data next.

[0294] Lines are generally accessed in the above sequence, then a line #**1** is accessed as the dark data, a line #**258** is accessed as the bright data next, the line #**2** is accessed as the dark data next, and this is sequentially repeated thereafter.

[0295] By the above drive method, it is possible to drive the liquid crystal panel while setting the bright/dark time ratio to not 1:1, but 1:2.

[0296] FIG. **23**A shows the transmittance characteristic with respect to the input gray-scale of a general liquid crystal display device, and FIG. **23**B shows the transmittance characteristic with respect to the input gray-scale of a liquid crystal display device employing the third method of the present embodiment.

[0297] In a general liquid crystal display device, as shown in FIG. **23**A, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to give a waveform different from the ideal curve shown by A.

[0298] As opposed to this, in the third method according to the present embodiment, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to give a waveform approximating (approaching) the ideal curve shown by A.

[0299] Namely, by driving the liquid crystal panel so that the bright/dark ratio in time becomes 1:2, there is the advantage that the improvement of the viewing angle characteristic of the middle gray-scale becomes possible. Further, this ratio is not limited to 1:2. By driving the liquid crystal panel by changing the bright/dark ratio in time, particularly so that the dark ratio in the bright/dark ratio becomes large, it becomes possible to improve the viewing angle characteristic of the middle gray-scale.

[0300] Above, the explanation was given by taking as an example the first to third methods as the preferred method for driving a liquid crystal panel so that the bright/dark ratio in time becomes 1:2.

[0301] It is also possible to employ these methods in combination. For example, it is also possible to employ a fourth method combining the second method (the method of setting the white level at 5V and making the optical-cell thickness thin) and the third method (the method of changing the bright/dark ratio in time) or a fifth method combining so-called spatial sub pixels (an area ratio is for example 2:1) and the second method.

[0302] FIG. **24**A shows the transmittance characteristic with respect to the input gray-scale of a general liquid crystal device, FIG. **24**B shows the transmittance characteristic with respect to the input gray-scale of a liquid crystal display device employing the second method, and FIG. **24**C shows the transmittance characteristic with respect to the input gray-scale of a liquid crystal display device employing the fourth method combining the second method and the third method.

[0303] As previously explained, in a general liquid crystal display device, as shown in FIG. **24**A, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to given a waveform different from the ideal curve shown by A.

[0304] As opposed to this, in the second method of the present embodiment, as shown in FIG. **24**B, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to give a waveform approximating the ideal curve shown by A.

[0305] Further, in the fourth embodiment of the present embodiment, as shown in FIG. **24**C, in comparison with the second method, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to give a waveform further approximating the ideal curve shown by A.

[0306] Accordingly, even when the fourth method is employed, there is the advantage that improvement of the viewing angle characteristic of the middle gray-scale is possible.

[0307] FIG. **25**A shows the transmittance characteristic with respect to the input gray-scale of a liquid crystal display device corresponding to the general spatial sub pixel processing, and FIG. **25**B shows the transmittance characteristic with respect to the input gray-scale of a liquid crystal display device employing the fifth method combining the second method of the present embodiment and spatial sub pixel processing.

[0308] As previously explained, in a general liquid crystal display device, as shown in FIG. **25**A, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to give a waveform different from the ideal curve shown by A.

[0309] As opposed to this, in the fifth method according to the present embodiment, as shown in FIG. **25**B, in the γ characteristic at the viewing angle of 60 degrees, the actual characteristic shown by B tends to give a waveform approximating the ideal curve shown by A.

[0310] Accordingly, even when the fifth method is employed, there is the advantage that improvement of the viewing angle characteristic of the middle gray-scale is possible.

[0311] Next, drive voltages of the liquid crystal cell at bright and dark times will be explained.

[0312] FIG. **26**A shows voltage characteristic waveforms applied to a liquid crystal cell at bright and dark times with respect to the input of a general liquid crystal display device, FIG. **26**B shows voltage characteristic waveforms applied to a liquid crystal cell at bright and dark times with respect to the input of a liquid crystal display device employing the second method of the present embodiment, and FIG. **26**C shows voltage characteristic waveforms applied to a liquid crystal cell at bright and dark times with respect to the input of a liquid crystal display device employing the fourth method combining the second method and the third method.

[0313] In each diagram, a curve shown by VW shows the voltage waveform applied to the liquid crystal cell at the bright time, and a curve shown by VB shows the voltage waveform applied to the liquid crystal cell at the dark time.

[0314] As shown in the diagrams, in the liquid crystal display device employing the method of the present embodiment, the range of expression of the black level becomes wide, so it is possible to effectively improve the viewing angle characteristic of the middle gray-scale.

[0315] FIG. **27**A shows voltage characteristic waveforms applied to a liquid crystal cell at bright and dark times with respect to the input of a general liquid crystal display device corresponding to the spatial sub pixel processing, and FIG. **27**B shows voltage characteristic waveforms applied to a liquid crystal cell at bright and dark times with respect to the input of a liquid crystal display device employing the fifth method combining the second method of the present embodiment and spatial sub pixel processing.

[0316] In each diagram, the curve shown by VW shows the voltage waveform applied to a liquid crystal cell at the bright time, and the curve shown by VB shows the voltage waveform applied to a liquid crystal cell at the dark time.

[0317] As shown in the diagrams, in the liquid crystal display device employing the method of the present embodiment, the range of expression of the black level becomes wide, so it is possible to effectively improve the viewing angle characteristic of the middle gray-scale.

[0318] In the liquid crystal display devices employing the first to fifth methods of the present embodiment, bright application voltages VW and dark application voltages VB shown in FIG. **26**A to FIG. **26**C and FIGS. **27**A and **27**B are switched for each field and supplied to a so-called source driver at a stage in front of the liquid crystal panel.

[0319] Below, examples of the configuration of liquid crystal display devices corresponding to these methods will be explained.

[0320] FIG. **28** is a diagram showing a first example of the configuration of a liquid crystal display device (image display device) which can be applied to the drive method of the present embodiment.

[0321] This liquid crystal display device **40** has a data converter **41**, a reference voltage generator **42**, a source driver **43**, and a display panel **44** as the display. The drive portion is configured by the data converter **41**, the reference voltage generator **42**, and the source driver **43**. In the example of the configuration of the display device shown below, even when the input signal is a usual signal having an image display rate of 60 Hz, a signal obtained by raising the image display rate to 120 Hz and interpolating or a signal further subjected to overdrive processing, the drive method of the present embodiment can be applied.

[0322] The data converter **41** has a γ switch **410**. The γ switch **410** has a first field γ characteristic holder **411**, a second field γ characteristic holder **412**, and a γ switching switch **413**.

[0323] The first field γ characteristic holder **411** holds for example the characteristic voltage γ pattern of the bright voltage VW set corresponding to the above γ characteristic in a form of for example a LookUp Table.

[0324] The second field γ characteristic holder **412** holds for example the characteristic voltage γ pattern of the dark voltage VB set corresponding to the above γ characteristic in the form of for example a LookUp Table.

[0325] The γ switching switch **413** switches output data of the first field γ characteristic holder **411** and the second field γ characteristic holder **412** for each field and selectively outputs the same as the source driver signal to the source driver **43**.

[0326] The reference voltage generator **42** supplies a fixed reference voltage pattern to the source driver **43**.

[0327] The source driver **43** compares the source driver signal selectively supplied by the γ switch **410** with the reference voltage pattern and outputs a predetermined drive signal to the display panel **44**.

[0328] The above drive method is employed with respect to this device **40**, whereby the gray-scale performance is improved.

[0329] FIG. **29** is a diagram showing a second example of the configuration of a liquid crystal display device which can be applied to the drive method of the present embodiment.

[0330] This liquid crystal display device **40**A has a reference voltage generator **42**A, a source driver **43**, and a display panel **44**.

[0331] The difference of the device **40**A of FIG. **29** from the device of FIG. **28** resides in that the function of the γ switch is imparted to the reference voltage generator **42**A, and the original data is input to the source driver **43**.

[0332] The reference voltage generator **42**A has a first field γ characteristic holder **41**, a second field γ characteristic holder **422**, and a γ switch **423**.

[0333] The first field γ characteristic holder **421** holds for example the characteristic voltage γ pattern at the bright time set corresponding to the above γ characteristic in the form of for example a LookUp Table.

[0334] The second field γ characteristic holder **422** holds for example the characteristic voltage γ pattern at the dark time set corresponding to the above γ characteristic in the form of for example a LookUp Table.

[0335] The γ switching switch **423** switches output data of the first field γ characteristic holder **421** and the second field γ characteristic holder **422** for each field and selectively outputs the same as the reference voltage to the source driver **43**.

[0336] The source driver **43** compares the supplied source driver signal with the reference voltage pattern and outputs a predetermined drive signal to the display panel **44**.

[0337] The above drive method is employed with respect to this device **40**A, whereby the gray-scale performance is improved.

[0338] FIG. **30** is a diagram showing a third example of the configuration of a liquid crystal display device which can be applied to the drive method of the present embodiment.

[0339] This liquid crystal display device **40**B has a configuration provided with the γ switch **41** of FIG. **28** and the reference voltage generator **42**A having the switch function of FIG. **29** together.

[0340] Accordingly, the explanation of basic functions of the components will be omitted.

[0341] FIG. **31**A shows data conversion γ patterns PVW and PVB held in the first field γ characteristic holder **411** and the second field γ characteristic holder **412** of the γ switch **410**, FIG. **31**B shows data conversion γ patterns PVW and PVB held in the first field γ characteristic holder **421** and the second field γ characteristic holder **422** of the reference voltage generator **42**A, and FIG. **31**C shows the output (liquid crystal application voltage) characteristic of the source driver **43** with respect to the input data.

[0342] In the device **40**B of FIG. **30**, the source driver **43** compares the γ pattern selectively supplied from the γ switch **410** for each field and the γ pattern selectively supplied from the reference voltage generator **42**A for each field to generate the bright voltage VW and dark voltage VB as shown in FIG. **31**C and supplies the same to the display panel **44**.

[0343] The above method is employed with respect to this device **40**B, whereby the gray-scale performance is improved.

[0344] FIG. **32** is a diagram showing a fourth example of the configuration of a liquid crystal display device which can be applied to the drive method of the present embodiment.

[0345] The difference of this liquid crystal display device **40**C from the device **40**B of FIG. **30** resides in the configuration of performing γ corrections of R, G, and B. The basic function of the γ switch **410**C of the data converter **41**C is the same. Further, the reference voltage generator **42**A has the same configuration as that of the device **40**B of FIG. **30**.

[0346] Accordingly, the explanation of basic functions of the components will be omitted.

[0347] FIG. **33**A shows data conversion γ patterns PVW and PVB corresponding to R, G, and B held in a first field γ characteristic holder **411**C and a second field γ characteristic holder **412**C of a γ switch **410**C, FIG. **33**B shows data conversion γ patterns PVW and PVB held in the first field γ characteristic holder **421** and the second field γ characteristic holder **422** of the reference voltage generator **42**A, and FIG. **33**C shows the output (liquid crystal application voltage) characteristics of the source driver **43** corresponding to R, G, and B with respect to the input data.

[0348] In the device **40**C of FIG. **33**, the source driver **43** compares the γ patterns corresponding to R, G, and B selectively supplied from the γ switch **410**C of the data converter **41**C for each field and the γ pattern selectively supplied from the reference voltage generator **42**A for each field to generate the bright voltage VW and dark voltage VB as shown in FIG. **31**C and supplies the same to the display panel **44**.

[0349] The above method is employed with respect to this device **40**C, whereby the gray-scale performance is improved.

[0350] FIG. **34** is a diagram showing a fifth example of the configuration of a liquid crystal display device which can be applied to the drive method of the present embodiment.

[0351] The difference of this liquid crystal display device **40**D from the device **40**B of FIG. **30** resides in the configuration corresponding to the sub pixel conversion processing, that is, the parallel arrangement of a sub pixel **1** system and a sub pixel **2** system with respect to the input signal.

[0352] The functions of the components are the same as those in FIG. **30**, so the explanation of the basic functions of the components will be omitted.

[0353] FIG. **35**A shows data conversion γ patterns PVW**1** and PVB**1** held in the first field γ characteristic holder **411** and

the second field γ characteristic holder **412** of a γ switch **410-1**, FIG. **33**B shows data conversion γ patterns PVW**2** and PVB**2** held in the first field γ characteristic holder **411** and the second field γ characteristic holder **412** of a γ switch **410-2**, FIG. **35**C shows data conversion γ patterns PVW**1** and PVB**1** held in the first field γ characteristic holder **421** and the second field γ characteristic holder **422** of a reference voltage generator **42**A-**1**, FIG. **35**D shows data conversion patterns PVW**2** and PVB**2** held in the first field γ characteristic holder **421** and the second field γ characteristic holder **422** of the reference voltage generator **42**A-**2**, and FIG. **35**E shows the output (liquid crystal application voltage) characteristic of the source driver **43** with respect to the input data.

[0354] The above method is employed with respect to this device **40**D, whereby the gray-scale performance is improved.

[0355] FIG. **36** is a diagram showing a sixth example of the configuration of a liquid crystal display device which can be applied to the drive method of the present embodiment.

[0356] The difference of this liquid crystal display device **40**E from the device **40**D of FIG. **34** resides in the configuration for performing γ corrections of R, G, and B. The rest of the configuration is the same as that of the device **40**D.

[0357] Accordingly, the explanation of basic functions of the components will be omitted.

[0358] FIG. **37**A shows the data conversion γ patterns PVW**1** and PVB**1** held in the first field γ characteristic holder **411** and the second field γ characteristic holder **412** of the γ switch **410-1**, FIG. **37**B shows the data conversion γ patterns PVW**2** and PVB**2** corresponding to R, G, and B held in the first field γ characteristic holder **411** and the second field γ characteristic holder **412** of the γ switch **410-2**, FIG. **37**C shows data conversion γ patterns PVW**1** and PVB**1** held in the first field γ characteristic holder **421** and the second field γ characteristic holder **422** of the reference voltage generator **42**A-**1**, FIG. **37**D shows data conversion γ patterns PVW**2** and PVB**2** held in the first field γ characteristic holder **421** and the second field γ characteristic holder **422** of the reference voltage generator **42**A-**2**, and FIG. **37**E and FIG. **37**F show the output (liquid crystal application voltage) characteristics corresponding to R, G, and B of the source driver **43** with respect to the input data.

[0359] The above method is employed with respect to this device **40**E, whereby the gray-scale performance is improved.

[0360] FIG. **38** is a diagram showing a seventh example of the configuration of a liquid crystal display device which can be applied to the drive method of the present embodiment.

[0361] The difference of this liquid crystal display device **40**F from the device **40**D of FIG. **34** resides in that, in the γ switch **410**E of the data converter **41**E, the first and second field γ holders of the sub pixel **1** and the first and second field γ holders of the sub pixel **2** are arranged in parallel and selectively switched by one γ switch **413**F to output the signal and in that the signal is corrected at the RGB γ correction unit **414** and then output to the source driver **43**.

[0362] Accordingly, the device **40**F of FIG. **38** can cope with sub pixel modulation processing by providing only one source driver **43** and reference voltage generator **42**A. The above drive method is employed with respect to this device **40**E, whereby the gray-scale performance is improved.

INDUSTRIAL APPLICABILITY

[0363] The present image display device and image display method can display a middle gray-scale by using a plurality of pixels and, at the same time, can improve the viewing angle characteristics, so can be applied to the direct view type liquid crystal display devices etc.

1. An image display device enabling an expression of a middle gray-scale of an input video signal by effective voltages of a field train formed by a plurality of fields with a display rate higher than the video signal and a gray-scale display in accordance with the input video signal, comprising:

a display including liquid crystal pixel cells displaying an image by a gray-scale in accordance with drive voltages and

a drive portion generating drive voltages corresponding to a first voltage corresponding to a level brighter than the input video signal and a second voltage corresponding to a level darker than the input video signal, wherein

the second voltage is set at a voltage lower than a threshold voltage of a liquid crystal cell.

2. An image display device as set forth in claim **1**, further comprising a setter for setting the first characteristic value and second characteristic value in accordance with a middle gray-scale to be displayed.

3. An image display device as set forth in claim **1**, wherein the gray-scale expresser expresses a gray-scale for a video signal expressed by primary color luminance components by the field train.

4. An image display device as set forth in claim **1**, wherein the gray-scale expresser converts a gray-scale so that either one of the first characteristic value or second characteristic value becomes a maximum characteristic value or a minimum characteristic value.

5. An image display device enabling an expression of a middle gray-scale of an input video signal by effective voltages of a field train formed by a plurality of fields with a display rate higher than the video signal and a gray-scale display in accordance with the input video signal, comprising:

a display including liquid crystal pixel cells displaying an image by a gray-scale in accordance with drive voltages and

a drive portion for generating drive voltages corresponding to a first voltage corresponding to a level brighter than the input video signal and a second voltage corresponding to a level darker than the input video signal, wherein

a maximum value of the first characteristic is set to a voltage higher than a voltage at which a characteristic value of a liquid crystal cell starts to become substantially maximum.

6. An image display device as set forth in claim **5**, wherein an optical thickness of each pixel cell is set thinner than a predetermined wavelength of each of the three primary colors displayed.

7. An image display device enabling an expression of a middle gray-scale of an input video signal by effective voltages of a field train formed by a plurality of fields with a display rate higher than the video signal and a gray-scale display in accordance with the input video signal, comprising:

a display including liquid crystal pixel cells displaying an image by a gray-scale in accordance with drive voltages, wherein

the display is driven while changing a time ratio displayed by a bright level brighter than the input video signal and a dark level darker than the input video signal.

8. An image display device as set forth in claim **7**, wherein the display device is driven so that the time ratio of display by the dark level becomes greater in the time ratio of the bright level and the dark level.

9. An image display device as set forth in claim **8**, further comprising:

a drive portion for generating drive voltages corresponding to a first voltage corresponding to the bright level and a second voltage corresponding to the dark level, wherein

the maximum value of the first voltage is set at a voltage higher than a voltage at which a characteristic value of a liquid crystal cell starts to becomes substantially maximum.

10. An image display device having a display enabling a gray-scale display in accordance with an input video signal, comprising:

a gray-scale converter for converting a gray-scale of an input video signal to characteristic values of pixels two-dimensionally arranged with respect to the image to be displayed and

a gray-scale expresser for expressing a middle gray-scale of the input video signal by a field train formed by a plurality of fields with display rates higher than the video signal, wherein

the gray-scale converter converts a gray-scale so as to include, among the plurality of pixels expressing a middle gray-scale, at least one pixel converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one pixel converted to a second characteristic value obtained by adding a negative correction value,

the gray-scale expresser expresses a gray-scale so as to include at least one field converted to a third characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one field converted to a second characteristic value obtained by adding a negative correction value, and

the gray-scale converter and the gray-scale expresser are controlled to display an gray-scale based on an input video signal.

11. An image display device as set forth in claim **10**, controlling the gray-scale converter to convert a gray-scale when the input video signal includes a moving picture and controlling the gray-scale expresser to express a middle gray-scale by a field train when the input video signal is formed by a still image.

12. An image display device as set forth in claim **10**, wherein

the device further comprises a reference voltage generator generating reference voltages corresponding to the third characteristic value and the fourth characteristic value in the gray-scale expresser and

the display is driven by reference voltages of the fields generated by the reference voltage generator corresponding to the first and second characteristic values converted in gray-scale by the gray-scale converter.

13. An image display method enabling an expression of a middle gray-scale of an input video signal by effective voltages of a field train formed by a plurality of fields with a display rate higher than the video signal and a gray-scale display in accordance with the input video signal, comprising:

a step of generating drive voltages corresponding to a first voltage corresponding to a level brighter than the input video signal and a second voltage corresponding to a level darker than the input video signal and

a step of applying the generated drive voltages to liquid crystal cells, wherein

the second voltage is set at a voltage lower than a threshold voltage of a liquid crystal cell.

14. An image display method enabling an expression of a middle gray-scale of an input video signal by effective voltages of a field train formed by a plurality of fields with a display rate higher than the video signal and a gray-scale display in accordance with the input video signal, comprising:

a step of generating drive voltages corresponding to a first voltage corresponding to a level brighter than the input video signal and a second voltage corresponding to a level darker than the input video signal and

a step of applying the generated drive voltages to liquid crystal cells, wherein

the first voltage is set at a voltage higher than a voltage at which a characteristic value of a liquid crystal cell starts to becomes substantially maximum.

15. An image display method enabling an expression of a middle gray-scale of an input video signal by effective voltages of a field train formed by a plurality of fields with a display rate higher than the video signal and a gray-scale display in accordance with the input video signal, comprising the steps of:

driving a display including liquid crystal cells displaying an image by a gray-scale in accordance with drive voltages while changing a time ratio displayed by a bright level brighter than the input video signal and a dark level darker than the input video signal.

16. An image display method enabling a gray-scale display in accordance with an input video signal, comprising:

a gray-scale conversion step of converting a gray-scale of an input video signal to characteristic values of pixels two-dimensionally arranged with respect to the image to be displayed and

a gray-scale expression step of expressing a middle gray-scale of the input video signal by a field train formed by a plurality of fields with display rates higher than the video signal, wherein

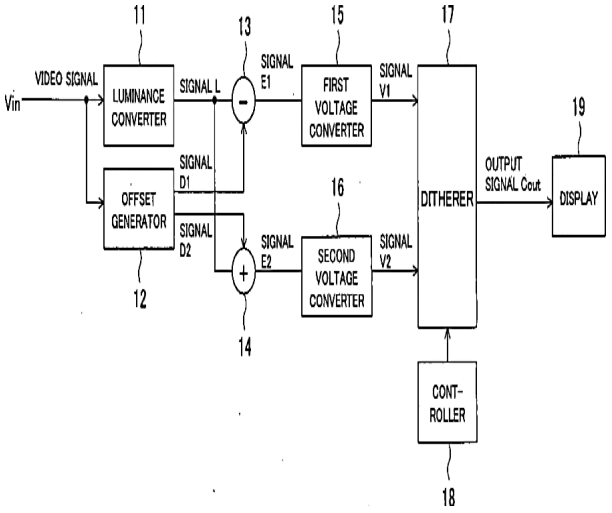
the gray-scale conversion step converts a gray-scale so as to include, among the plurality of pixels expressing a middle gray-scale, at least one pixel converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one pixel converted to a second characteristic value obtained by adding a negative correction value,

the gray-scale expressing step expresses a gray-scale so as to include at least one field converted to a first characteristic value obtained by adding a positive correction value to the gray-scale of the input video signal and at least one field converted to a second characteristic value obtained by adding a negative correction value, and

the gray-scale converter and the tone expresser are controlled to display the gray-scale based on an input video signal.

* * * * *

专利名称(译)	图像显示装置和图像显示方法		
公开(公告)号	US20080272998A1	公开(公告)日	2008-11-06
申请号	US10/571911	申请日	2005-07-15
[标]申请(专利权)人(译)	矢野智也 SHIROCHI YOSHIKI ISOBE利信 IIDA梅基厄		
申请(专利权)人(译)	矢野智也 SHIROCHI YOSHIKI ISOBE利信 IIDA梅基厄		
当前申请(专利权)人(译)	索尼公司		
[标]发明人	YANO TOMOYA SHIROCHI YOSHIKI ISOBE TOSHINOBU IIDA MAKIO		
发明人	YANO, TOMOYA SHIROCHI, YOSHIKI ISOBE, TOSHINOBU IIDA, MAKIO		
IPC分类号	G09G3/36		
CPC分类号	G09G3/2018 G09G3/2051 G09G3/2055 G09G3/3607 G09G3/3611 G09G3/3696 G09G2320/0242 G09G2320/0247 G09G2320/0276 G09G2320/028 G09G2320/0613 G09G2320/0673		
优先权	2005166014 2005-06-06 JP 2004210347 2004-07-16 JP		
外部链接	Espacenet USPTO		

摘要(译)

提供了一种图像显示装置和图像显示方法，其能够通过使用多个像素或场来显示中间灰度级，并且同时改善视角特性。当通过直视型液晶显示屏显示图像时，输入视频信号的灰度级被转换为相对于显示图像二维排列的像素的特征值（透射率），并且灰度级是转换为在表示中间灰度级的多个像素或场中包括至少一个像素或场，其被转换为通过将正校正值加到输入视频信号的灰度级而获得的第一特征值，至少一个像素或场被转换成通过将负校正值加到输入视频信号的灰度级而获得的第二特征值。