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(54) **LIQUID CRYSTAL DISPLAY DEVICE AND DRIVE CONTROL CIRCUIT**

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Description

Technical Field

[0001] The present invention relates to a drive control circuit for controlling the driving of a liquid-crystal display panel in which each of pixels is divided into two subpixels. Also, the present invention relates to a liquid-crystal display device in which each of pixels of a liquid-crystal display panel is divided into two subpixels.

Background Art

[0002] It is known that, as field of view angle characteristics of a liquid-crystal display device, when the screen is viewed obliquely, a reverse phenomenon occurs such that, as a result of the fact that after the luminance temporarily increases with an increase in the gradation, the luminance is decreased, the luminance increases in an area of a lower gradation than in an area of a higher gradation.

[0003] In order to improve such field of view angle characteristics, hitherto, a technology in which each of pixels of a liquid-crystal display panel is divided into two subpixels has been proposed (see, for example, Japanese Unexamined Patent Application Publication No. 2005-316211 published by Japan Patent Office). In this technology, as shown as an example in Fig. 1, a display electrode for one pixel P (a pixel for each of R, G, and B, which are the three primary colors) of a liquid-crystal display panel 50 is divided into electrodes of two subpixels A and B that are driven by a data driver 60 independently of each other.

[0004] Then, by setting the driving level (gradation at which the subpixels A and B are driven) of the subpixels A and B to mutually different gradations on the basis of the gradation of the input video signal, the luminance characteristics in a case where the whole pixels P are viewed obliquely are made to approach the luminance characteristics in a case where the whole pixels P are from the front.

[0005] In Japanese Unexamined Patent Application Publication No. 2005-316211, which is the above-described document, as such a method of setting drive levels of subpixels, it is described that a gradation conversion table in which the gradation of an input video signal is associated with the output gradation of each subpixel is provided.

[0006] Incidentally, in a liquid-crystal display device in which each pixel of a liquid-crystal display panel is divided into two subpixels in the manner described above, in order that the balance of the luminances of R, G, and B when viewed obliquely is improved, there is a case in which it is desirable that the drive level of the subpixel be changed in accordance with whether the pixel is R, G, or B.

[0007] Fig. 2 shows an example of such a case. In Fig. 2(a), gradation-luminance characteristics in a case

where the drive levels of the subpixels A and B with respect to the input gradation is set as in Fig. 2(b) and the screen is viewed from the front are depicted as GL11. Also, gradation-luminance characteristics in a case where the drive levels of the subpixels A and B are set as in Fig. 2(b) and the screen is viewed obliquely (angle θ) are depicted as GL12.

[0008] Here, for example, the gradation values of R, G, and B are assumed to be 128, 96, and 64, respectively. In Fig. 2(a), also, such gradation values of R, G, and B are depicted. In that case, between the gradation-luminance characteristics GL11 and GL12, the ratio of the luminance of R, G, and B when viewed from the front is about 1:2:5, and the ratio of the luminance of R, G, and B when viewed obliquely is about 5:7:10. As a result, when viewed obliquely, since the ratio of the luminance of R becomes small, the red color becomes dark.

[0009] In Fig. 2(a), the drive levels of the subpixels A and B with respect to the input gradation are set so as to differ from those of Fig. 2(b) (here, so the gradation values become equal as in Fig. 2(c)), so that gradation-luminance characteristics when the screen is viewed from the angle θ described above are also depicted as GL13. In the gradation-luminance characteristics GL13, the luminance when the gradation value is 128 is higher than that of the gradation-luminance characteristics GL12.

[0010] Accordingly, if the drive levels of the subpixels shown in Fig. 2(b) are selected with respect to the pixels of G and B, and the drive level of the subpixel shown in Fig. 2(c) is selected with respect to only the pixel of R, the ratio of the luminance of R when viewed obliquely is increased (the ratio of the luminances of R, G, and B is approached when viewed from the front). As a consequence, it is possible to improve the balance of the luminances of R, G, and B when viewed obliquely.

[0011] Fig. 2 shows two sets of gradation values in Fig. 2(b) and Fig. 2(c). If the drive levels of the subpixels for each of the pixels of R, G, and B are selected correspondingly from among three or more types of drive levels shown as an example in Fig. 3, it is possible to even further improve the balance of the luminances of R, G, and B when viewed obliquely.

[0012] However, as described in Patent Document 1 described above, in the method in which a gradation conversion table in which input gradations are associated with output gradations so as to allow setting of the drive levels of the subpixels, in order to be able to select a driving level from among a plurality of drive levels, it is necessary to provide a separate gradation conversion table for each driving level. As a result, as shown as an example in Fig. 4, as the number of selectable drive levels is increased, the number of gradation conversion tables for the subpixels A and B increases like TA11 and TB11, TA12 and TB12, ... TAm and TBm.

[0013] Then, in recent years, since the resolution of the gradation has been increasingly improved so as to improve display performance, the amount of data of one

individual gradation conversion table is increased. Provision of many such gradation conversion tables with a large amount of data causes the circuit scale of a RAM for storing gradation conversion tables, or the like to increase.

[0014] Further, here, the problem in the case that the driving level is selected from among a plurality of drive levels in accordance with whether the pixel is R, G, or B has been described. Still the same problem also occurs even in a case where, for example, the drive level of a subpixel is selected from among a plurality of drive levels on the basis of the type of the input video signal.

International Application Laid-Open WO 2006/098 247 A1 discloses a display device including a display section providing pixels comprising a plurality of subpixels. An image is displayed based on a luminance gradation of an input display signal. An image frame is output sequentially at double frequency as a former subframe and a latter subframe. This is achieved by generating a former stage display signal by using a former stage Look-Up Table (LUT) and a latter stage display signal by using a latter stage LUT. To achieve gradation expression, one of the subframes is made to maximum luminance ("white") or to minimum luminance ("black") and the respective other subframe is set to achieve a total "integral" luminance to be a luminance of the single frame in a normal hold display.

Patent Application Laid-Open US 2007/0018930 A1 discloses a liquid crystal display comprising a plurality of pixels arranged in a matrix, each pixel including a first subpixel and second subpixel. For color display each pixel uniquely represents one of the primary colors. In order to compensate for the varying transmittance depending on the color of the light emitted, different voltages for the different colors are generated. An image input signal for each pixel is converted into a pair of output image signals for each subpixel, the values of the output image signals generated such, that the synthesis of the gamma curves of the two subpixels approaches a reference gamma curve at the front view angle. The voltages of the two subpixels can be such adjusted, that an image viewed from a lateral side is closer to an image viewed from the front, or, the lateral gamma curve is closer to the front gamma curve.

[0015] In view of the above-described points, it is an object of the present invention to be capable of selecting the drive level of a subpixel with respect to the gradation of an input video signal from among a plurality of drive levels while suppressing an increase in the circuit scale in a liquid-crystal display device in which each pixel of a liquid-crystal display panel is divided into two subpixels.

Disclosure of Invention

[0016] In order to achieve the above-described object, the present invention provides a liquid-crystal display device as defined in the appending claims.

[0017] In the present invention, in such a manner as

to correspond to the gradation of the input video signal, information on the gradation of a first subpixel among the first and second subpixels in which each pixel is divided into is obtained by a first subpixel driving level converter.

5 On the basis of the gradation value of the first subpixel obtained by the first subpixel driving level converter, the first subpixel is driven and controlled.

[0018] Furthermore, the gradation value of the first subpixel obtained by the first subpixel driving level converter is converted into a luminance value of the first subpixel by a first luminance value converter. In addition, the luminance that is the target as the whole pixels corresponding to the gradation of the input video signal is obtained by a second luminance value converter. Then, a subtraction unit subtracts the luminance of the first subpixel from the luminance that is the target as the whole pixels, thereby obtaining the luminance of the second subpixel. On the basis of the gradation value of the second subpixel obtained by a second subpixel driving level converter, the second subpixel is driven and controlled.

[0019] In this case, if the conversion characteristics obtained by the first subpixel driving level converter are changed only, the luminance to be generated by the first luminance value converter will be changed. For this reason, since the difference supplied from the subtraction unit to the second subpixel driving level converter is changed, it is possible to change the drive levels of the two subpixels with respect to the gradation of the input video signal. That is, it is possible to increase the number of selectable drive levels of the subpixels by only increasing variations of the conversion characteristics by the first subpixel driving level converter while the first and second luminance value converters and the second subpixel driving level converter, which perform conversion of characteristics between the gradation and the luminance, are fixed without change.

[0020] Therefore, for this into a liquid-crystal display device in which each pixel of a liquid-crystal display panel is divided into two subpixels, it becomes possible to select the drive level of a subpixel with respect to the gradation of an input video signal from among a plurality of drive levels while an increase in the circuit scale is suppressed.

Brief Description of the Drawings

[0021]

[Fig. 1] Fig. 1 is a panel diagram showing the outline of the configuration of a liquid-crystal display panel in which each of pixels is divided into two subpixels.

[Fig. 2] Fig. 2 includes characteristic views showing examples in which drive levels of subpixels are changed on the basis of the pixels of R, G, and B.

[Fig. 3] Fig. 3 is a characteristic view showing as an example three or more types of drive levels of subpixels.

[Fig. 4] Fig. 4 is a configuration diagram showing an example in which many gradation conversion tables

are provided.

[Fig. 5] Fig. 5 is a block diagram showing the outline of a circuit configuration of a liquid-crystal display device to which an embodiment of the present invention is applied.

[Fig. 6] Fig. 6 is a block diagram showing the configuration of a circuit for generating a gradation signal, within a timing controller of Fig. 5.

[Fig. 7] Fig. 7 is a characteristic view showing gradation-luminance characteristics represented using a look-up table within each RAM of Fig. 6.

[Fig. 8] Fig. 8 is a configuration diagram showing an example of the configuration of a subpixel drive level calculation unit.

[Fig. 9] Fig. 9 is a characteristic view showing an example of the state of changes in the drive level of a subpixel B by a calculation circuit of Fig. 8.

[Fig. 10] Fig. 10 is a configuration diagram showing another configuration example based on a calculation process of the subpixel drive level calculation unit.

[Fig. 11] Fig. 11 is a configuration diagram showing still another configuration example based on the calculation process of the subpixel drive level calculation unit.

[Fig. 12] Fig. 12 is a configuration diagram showing a configuration example of a generalized subpixel drive level calculation unit.

[Fig. 13] Fig. 13 is a characteristic view showing an example of changes of the drive level of the subpixel B on the basis of the configuration of Fig. 12.

[Fig. 14] Fig. 14 is a block diagram showing a configuration example in which an LUT of the subpixel drive level calculation unit is used.

[Fig. 15] Fig. 15 is a characteristic view showing as an example a state of changes of drive levels of subpixels on the basis of the circuit of Fig. 6.

Best Mode for Carrying Out the Invention

[0022] An exemplary embodiment of the present invention will be described below specifically with reference to the attached drawings. Fig. 5 is a block diagram showing the outline of a circuit configuration of a liquid-crystal display device to which an exemplary embodiment is applied. The liquid-crystal display device is provided with a video signal processing circuit 20, a timing controller 30, a CPU 40 for controlling the video signal processing circuit 20 and the timing controller 30, a liquid-crystal display panel 50, a data driver (data-line driving circuit) 60 for driving the liquid-crystal display panel 50, and a gate driver (scanning-line driving circuit) 70.

[0023] A video signal input to the liquid-crystal display device from the outside is sent to the video signal processing circuit 20. In the video signal processing circuit 20, processing, such as extraction of a synchronization signal, IP conversion (conversion from a signal of an interlace method into a signal of a progressive method),

scaling (image size conversion in accordance with the resolution of a liquid-crystal panel), or the like, is performed on the input video signal. Then, the video signal that has undergone the processing of the video signal processing circuit 20 and the synchronization signal extracted by the video signal processing circuit 20 are sent to the timing controller 30.

[0024] The timing controller 30, as is well known, supplies a video signal (gradation signal), a polarity inversion control signal, and a timing control signal to the data driver 60, and also supplies a timing control signal to the gate driver 70, thereby controlling the driving of the liquid-crystal display panel 50.

[0025] The liquid-crystal display panel 50 is such that, like the liquid-crystal panel shown as an example using the same reference numeral in Fig. 1, a display electrode for one pixel P (pixel) for each of R, G, and B, which are the three primary colors, is divided into electrodes of two subpixels A and B. The data driver 60 drives the two subpixels A and B independently of each other like the data driver indicated using the same reference numeral in Fig. 1.

[0026] The timing controller 30 has a function of generating a gradation signal to be supplied to the data driver 60. Fig. 6 is a block diagram showing the configuration of a circuit for generating this gradation signal, within the internal configuration of the timing controller 30. A RAM 1, a RAM 2, a RAM 3, a subpixel drive level calculation unit 4, and a subtraction circuit 5 are provided.

[0027] The RAM 1 functions as a converter for converting the gradation values of the whole pixels into luminance values. The RAM 1 is stored with a look-up table (LUT) in which the gradation values and the luminance values are associated with each other so that the gradation-luminance characteristics GL shown in Fig. 7 are represented as target gradation-luminance characteristics (also referred to as "target characteristics") when the whole pixels P (Fig. 1) are viewed from the front of the screen.

[0028] The RAM 2 functions as a converter for converting the luminance value of one of the subpixels A into a gradation value. The RAM 2 is stored with a look-up table in which the gradation values and the luminance values are associated with each other so that the gradation-luminance characteristics GLA shown in Fig. 7 are shown as the gradation-luminance characteristics of the subpixel A for realizing the target characteristics GL shown in Fig. 7.

[0029] The RAM 3 functions as a converter for converting the gradation value of the other subpixel B into a luminance value. The RAM 3 is stored with a look-up table in which the gradation values and the luminance values are associated with each other so that the gradation-luminance characteristics GLB shown in Fig. 7 are shown as the gradation-luminance characteristics of the subpixel B for realizing the target characteristics GL shown in Fig. 7.

[0030] Regarding the gradation-luminance character-

istics GLA and the gradation-luminance characteristics GLB, the ratio of the luminance value corresponding to the same gradation value (for example, the ratio of the luminance value $f(x)A$ to the $f(x)B$ corresponding to the gradation value x in the figure) is equal to the ratio of the area of the subpixel A to that of the subpixel B. Furthermore, regarding the gradation-luminance characteristics GLA and the gradation-luminance characteristics GLB, the value (for example, $f(x)A + f(x)B$ in the figure) such that the luminance values corresponding to the same gradation value are added is equal to the luminance value ($f(x)$ in the figure) of the target characteristics GL corresponding to the gradation value.

[0031] The subpixel drive level calculation unit 4, under the control of the CPU 40 (Fig. 5), calculates the gradation value of the subpixel B (Fig. 1) corresponding to the gradation value of the video signal to be input to the timing controller 30. For the configuration of the subpixel drive level calculation unit 4, any one of the configuration examples described below may be adopted.

<Configuration Example based on Calculation of Subpixel Drive Level Calculation Unit 4>

[0032] First, a description will be given of an example in which the subpixel drive level calculation unit 4 is formed by a calculation circuit for multiplication or the like. For example, as shown in Fig. 8, the subpixel drive level calculation unit 4 is formed by a calculation circuit 10 that sets the gradation value of the video signal to be input to the timing controller 30 to x_0 and performs power calculation of

$$x_1 = x_0^{1/n},$$

and a calculation result x_1 thereof is used as the gradation value of the subpixel B. In the case of this configuration example, the CPU 40 supplies a control signal that specifies the value of this n (may not be an integer) to the calculation circuit 10.

[0033] Fig. 9 shows as an example the drive levels of the subpixel B with respect to the gradation of an input video signal in a case where the value of this n is changed in two or more ways. By changing the value of n in two or more ways, it is possible to change the drive level of the subpixel B in two or more ways similarly to that shown as an example in Fig. 3.

[0034] Fig. 10 shows a specific configuration example of the subpixel drive level calculation unit 4 using calculation circuits.

In this example, when the gradation value of the video signal to be input to the timing controller 30 is set as x_0 and a calculation result X_1 thereof is set as the gradation value of the subpixel B, the calculation of

$$x_1 = x_0^{4.25}$$

is performed to obtain the drive level of the subpixel B with respect to the gradation of the input video signal.

[0035] The configuration of Fig. 10 will be described. The gradation value x_0 of the input video signal is supplied to a 1/2 square circuit 111, which is a circuit for calculating a square root, whereby $x_0^{0.5}$ is obtained. In addition, the output $x_0^{0.5}$ of the 1/2 square circuit 111 is supplied to another 1/2 square circuit 112, whereby an output $x_0^{0.25}$ is obtained. The output $x_0^{0.25}$ of the 1/2 square circuit 112 is supplied to a multiplication circuit 113.

Furthermore, the gradation value x_0 of the input video signal is supplied to a multiplication circuit 114 so as to obtain a squared output x_0^2 . In addition, the squared output x_0^2 of the multiplication circuit 114 is supplied to another multiplication circuit 115, whereby a squared output x_0^4 is obtained, and the output x_0^4 is supplied to a multiplication circuit 113.

In the multiplication circuit 113, the supplied signal $x_0^{0.25}$ and signal x_0^4 are multiplied to obtain a multiplication output $x_0^{4.25}$.

[0036] Fig. 11 shows still another configuration example of the subpixel drive level calculation unit 4 using calculation circuits.

In this example, when the gradation value of the video signal to be input to the timing controller 30 is set as x_0 and a calculation result x_1 thereof is set as the gradation value of the subpixel B, the calculation of

$$x_1 = x_0^{5.625}$$

is performed to obtain the drive level of the subpixel B with respect to the gradation of the input video signal.

[0037] The configuration of Fig. 11 will be described. The gradation value x_0 of the input video signal is supplied in sequence to 1/2 square circuits 121, 122, and 123, which are circuits for calculating a square root, whereby an output $x_0^{0.125}$ is obtained. Then, the output $x_0^{0.5}$ of the 1/2 square circuit 121 and the output $x_0^{0.125}$ of the 1/2 square circuit 123 are supplied to a multiplication circuit 124, whereby a multiplication output $x_0^{0.625}$ is obtained. The multiplication output $x_0^{0.625}$ of the multiplication circuit 124 is supplied to a multiplication circuit 125.

Furthermore, by using three multiplication circuits 126, 127, and 128, a multiplication output x_0^5 is obtained from the gradation value x_0 of the input video signal. This multiplication output x_0^5 is supplied to the multiplication circuit 125.

In the multiplication circuit 125, the supplied signal $x_0^{0.625}$ and signal x_0^5 are multiplied together, thereby obtaining a multiplication output $x_0^{5.625}$.

[0038] Fig. 12 shows a generalized circuit for obtaining an arbitrary multiplier number using such multiplication circuits and square root circuits. This example shows a configuration in which the gradation value of an input video signal to be input to the timing controller 30 is set as x_0 and a calculation result $g(x_0)$ is set as the gradation value of the subpixel B, so that the calculation result $g(x_0)$ can be set to an arbitrary multiplier number.

In the configuration of Fig. 12, 1/2 square circuits 131 to 133, which are circuits for calculating a square root, multiplication circuits 134 to 140, and selectors 141 to 146 are provided. The selectors 141 to 146 are selection means for selecting one of each signal of the multiplier numbers supplied correspondingly from circuits of previous stages and a signal "1". By externally controlling the selected states of the selectors 141 to 146, the multiplier number of the output signal $g(x_0)$ is determined.

[0039] The configuration of Fig. 12 will be described. The gradation value x_0 of an input video signal is supplied in sequence to the 1/2 square circuits 131, 132, and 133, which are circuits for calculating a square root, and in the respective 1/2 square circuits 131, 132, and 133, multiplication outputs $x_0^{0.5}$, $x_0^{0.25}$, and $x_0^{0.125}$ are obtained.

[0040] The output $x_0^{0.125}$ of the 1/2 square circuit 133 is supplied to the multiplication circuit 134 via the selector 141. The output $x_0^{0.25}$ of the 1/2 square circuit 132 is supplied to the multiplication circuit 134 via the selector 142. In the multiplication circuit 134, the outputs of the selectors 141 and 142 are multiplied, and the multiplication output is supplied to a multiplication circuit 135.

The output $x_0^{0.5}$ of the 1/2 square circuit 131 is supplied to the multiplication circuit 135 via the selector 143. In the multiplication circuit 135, the output of the multiplication circuit 134 is multiplied by the output of the selector 143, and a multiplication output thereof is supplied to a multiplication circuit 136.

[0041] Furthermore, the gradation value x_0 of the input video signal is supplied to a multiplication circuit 137, whereby a squared output x_0^2 is obtained. The output x_0^2 is supplied to a multiplication circuit 138, whereby a further squared output x_0^4 is obtained. The output x_0^4 of the multiplication circuit 138 is supplied to a multiplication circuit 139 via the selector 144, and the output x_0^2 of the multiplication circuit 137 is supplied to the multiplication circuit 139 via the selector 145. In the multiplication circuit 139, the outputs of the selectors 144 and 145 are multiplied, and a multiplication output thereof is supplied to a multiplication circuit 140.

[0042] Furthermore, the gradation value x_0 of the input video signal is supplied to a multiplication circuit 140 via the selector 146, and in the multiplication circuit 140, the output of the multiplication circuit 139 is multiplied by the output of the selector 146. In addition, the output of the multiplication circuit 140 is supplied to the multiplication circuit 136, and in the multiplication circuit 136, the output of the multiplication circuit 135 is multiplied by the output of the multiplication circuit 140.

As a result of being configured as described above, for

the multiplication output $g(x_0)$ of the multiplication circuit 136, any desired power multiplier number can be selected on the basis of the selected state in the selectors 141 to 146. For example, the configuration can be arranged as the subpixel drive level calculation unit shown in Fig. 10, and can also be configured as the subpixel drive level calculation unit shown in Fig. 11. It is possible to freely determine the configuration so that a necessary drive level of a subpixel is obtained.

[0043] Fig. 13 shows a characteristic example of an input gradation x_0 and a gradation at which the subpixel B is driven, which is an output gradation, in a case where a power multiplier number is changed in the configuration of Fig. 12. An example is shown in which the characteristics are a straight line when the power multiplier number is set at x_0^1 and in the state, the power multiplier number is changed to $x_0^{1.5}$, x_0^2 , $x_0^{2.5}$, x_0^3 , x_0^4 , x_0^5 , x_0^6 , and $x_0^{7.875}$.

As can be seen from Fig. 13, it is possible to freely change the characteristics by changing the processing state in one subpixel drive level calculation unit.

<Configuration Example of Subpixel Drive Level Calculation Unit 4 using LUT>

[0044] As shown in Fig. 14, an address generation circuit 11, a plurality of sets, each set being formed of two RAMs, of RAMs 12 (RAMs 12 (1) and 12 (1'), 12 (2) and 12 (2'), 12 (m) and 12 (m')), a data selection circuit 13, and a linear interpolation circuit 14 constitute the subpixel drive level calculation unit 4.

[0045] The RAMs 12 of each set are each stored with a look-up table in which discrete gradation values of an input video signal (gradation values more coarse than the resolution of the actual gradation in the liquid-crystal display device) are associated with the gradation values of the subpixel B, and the driving level with respect to the input video signal is made different for each set (the drive levels are made equal in the two RAMs of the same set).

[0046] Although these look-up tables are the same as the gradation conversion table described with reference to Fig. 4 in that input gradations and output gradations are associated with each other, since only discrete gradation values are stored, it is possible to suppress an increase in the circuit scale even if a plurality of look-up tables are provided.

[0047] The address generation circuit 11 is a circuit for generating, as reference addresses, two gradation values x_0-a and x_0+b , with the gradation value x_0 of the input video signal being held therebetween in the look-up table in the RAM 12.

[0048] The reference address x_0-a generated by the address generation circuit 11 is supplied to the one side (the RAMs 12 (1), 12 (2), ... 12 (m)) of the RAMs 12 of each set. The reference address x_0+b generated by the address generation circuit 11 is supplied to the other side (the RAMs 12 (1'), 12 (2'), ... 12 (m')) of the RAMs 12 of each set.

[0049] The gradation values read from the look-up tables in the RAMs 12 of each set on the basis of the reference addresses $x0-a$ and $x0+b$ are sent to the data selection circuit 13.

[0050] The data selection circuit 13 is a circuit for selecting gradation values from one set of RAMs from among a plurality of sets of RAMs (two gradation values corresponding to the reference addresses $x0-a$ and $x0+b$, respectively). In the case of this configuration example, the CPU 40 (Fig. 5) supplies, to the data selection circuit 13, a control signal that specifies the set of the RAMs 12 to be selected.

[0051] The linear interpolation circuit 14 is a calculation circuit for performing linear interpolation on two gradation values selected by the data selection circuit 13 on the basis of the ratio of the value a to the value b , which are used for the address generation circuit 11 to generate the reference addresses, and the interpolation result of the linear interpolation circuit 14 is set as the gradation value $x1$ of the subpixel B.

[0052] Also, in this configuration example, by switching the selections in the data selection circuit 13, it is possible to change the drive level of the subpixel B with respect to the gradation value $x0$ of the input video signal in two or more ways similarly to that shown as an example in Fig. 9.

[0053] As shown in Fig. 6, the gradation value $x0$ of the video signal that is input to the timing controller 30 from the video signal processing circuit 20 (Fig. 5) is supplied as a reference address to the RAM 1. The luminance value $f(x0)$ (the luminance value corresponding to the gradation value $x0$ in the target characteristics GL of Fig. 7) read from the look-up table in the RAM 1 on the basis of the reference address $x0$ is sent to the subtraction circuit 5.

[0054] Furthermore, this gradation value $x0$ of the input video signal is also supplied to the subpixel drive level calculation unit 4. The gradation value $x1$ of the subpixel B, which is calculated by the subpixel drive level calculation unit 4 in such a manner as to correspond to the gradation value $x0$, is output from the timing controller 30 and is sent to the data driver 60 (Fig. 5), and is also supplied as a reference address to the RAM 3.

[0055] The luminance value $f(x1)$ (the luminance value corresponding to the gradation value $x1$ in the gradation-luminance characteristics GLB of Fig. 7) read on the basis of the reference address $x1$ from the look-up table inside the RAM 3 is sent to the subtraction circuit 5.

[0056] The subtraction circuit 5 subtracts the luminance value $f(x1)$ from the luminance value $f(x0)$, and supplies a subtraction result $f(x2) = f(x0) - f(x1)$ as a reference address to the RAM 2. The gradation value $x2$ (the gradation value corresponding to the luminance value $f(x2)$ in the gradation-luminance characteristics GLA of Fig. 7) read from the look-up table inside the RAM 2 on the basis of the reference address $f(x2)$ is output from the timing controller 30 and is sent to the data driver 60.

[0057] On the basis of the gradation values $x1$ and $x2$

sent from the timing controller 30, the data driver 60 (Fig. 5) drives the subpixels B and A (Fig. 1) among the pixels P of the liquid-crystal panel 50, respectively.

[0058] In the liquid-crystal display device, if the calculation result of the gradation value $x1$ of the subpixel B by the subpixel drive level calculation unit 4 in the timing controller 30 is changed only under the control of the CPU 40, since the luminance value $f(x1)$ sent from the RAM 3 to the subtraction circuit 5 is changed, the reference address $f(x2)$ supplied from the subtraction circuit 5 to the RAM 2 is changed. Therefore, it is possible to change the drive levels of the subpixels A and B with respect to the gradation of the video signal to be input to the timing controller 30.

[0059] Fig. 15 shows a state of changes in the drive levels of the subpixels A and B using the circuit of Fig. 6 by using, as an example, a case in which the drive level of the subpixel B is changed as shown in Fig. 9 by the subpixel drive level calculation unit 4.

[0060] As described above, in the liquid-crystal display device, it is possible to increase the number of selectable drive levels of the subpixels A and B by only increasing variations of the calculation result by the subpixel driving the level calculation unit 4 while the number of RAMs in which gradation-luminance characteristics of the whole pixels P, the subpixel A, and the subpixel B are stored as look-up tables, is fixed to three, that is, the RAMs 1 to 3.

[0061] As a result, in the liquid-crystal display device, it is possible to select (for example, the driving level is selected from among a plurality of drive levels in accordance with whether the pixel is R, G, or B as shown in Fig. 2, or the drive level of the subpixel is selected from among a plurality of drive levels in accordance with the type of the input video signal) the drive level of a subpixel with respect to the gradation of the input video signal from among a plurality of drive levels while an increase in the circuit scale is suppressed.

[0062] Furthermore, in a method of providing only a gradation conversion table in which the gradation of an input video signal and output gradations for each subpixel are associated with each other as described in the document (Japanese Unexamined Patent Application Publication No. 2005-316211) given in the Background Art, there are cases in which target gradation-luminance characteristics cannot be realized with high accuracy. However, in the liquid-crystal display device, it is possible to realize target gradation-luminance characteristics with high accuracy by increasing variations of the calculation result by the subpixel drive level calculation unit 4 inside the timing controller.

[0063] Further, in the above examples, as shown in Fig. 6, the RAM 1, the RAM 2, and the RAM 3 are provided, and these RAMs are each stored with a look-up table in which gradation values and luminance values are associated with each other so that the target characteristics GL, the gradation-luminance characteristics GLA, and the gradation-luminance characteristics GLB shown in Fig. 7 are shown. However, not being limited

to such RAMs, appropriate means for generating information on the correspondence between gradations and luminances for realizing target characteristics GL, gradation-luminance characteristics GLA, and gradation-luminance characteristics GLB may be provided. Explanation of Reference Numerals

[0064]

1: RAM, 2: RAM, 3: RAM, 4: subpixel drive level calculation unit, 5: subtraction circuit, 10: calculation circuit, 11: address generation circuit, 12 (1) and 12 (1'), 12 (2) and 12 (2'), 12 (m) and 12 (m'): RAM, 13: data selection circuit, 14: linear interpolation circuit, 20: video signal processing circuit, 30: timing controller, 40: CPU, 50: liquid-crystal display panel, 60: data driver, 70: gate driver, 111, 112, 121, 122, 123, 131, 132, 133: 1/2 square circuit, 113, 114, 115, 124, 125, 126, 127, 128, 134, 135, 136, 137, 138, 139, 140: multiplication circuit, 141, 142, 143, 144, 145, 146: selector

Claims

1. A liquid-crystal display device comprising:

a liquid-crystal display panel (50) comprising a plurality of pixels, each pixel for one of a primary color, and in which each of the pixels (P) is divided into a first subpixel (B) and a second subpixel (A) ;
a driving circuit (60, 70) configured to drive the liquid-crystal panel (50); and
a drive control circuit (30) configured to control the driving of the liquid-crystal display panel (50) by using the driving circuit (60, 70), wherein the drive control circuit (30) includes a first subpixel driving level converter (4) configured to obtain a first gradation value (x1) for driving the first subpixel (B) of a pixel (P) of the liquid-crystal display panel (50) on the basis of the gradation value of the pixel (P) from an input video signal, (x0) , and

characterized in

that the drive control circuit (30) further comprises:

a first luminance value converter (3) configured to convert the gradation value (x1) for driving the first subpixel (B) into a luminance value (f(x1)) ,
a second luminance value converter (1) for converting the gradation value of each pixel (P) of the input video signal (x0) into a luminance value (f(x0)), wherein each of the first luminance value converter (3) and the second luminance value converter (1) includes a storage unit having stored therein a look-up table in which gradation

values and luminance values are associated with each other,

a subtraction unit (5) configured to calculate a difference between the luminance value (f(x0)) converted by the second luminance value converter (1) and the luminance value (f(x1)) converted by the first luminance value converter (3), and

a second subpixel driving level converter (2) including a storage unit having stored therein a look-up table in which gradation values and luminance values are associated with each other configured to convert the difference (f(x2)) of the luminance values calculated by the subtraction unit (5) into a gradation value (X2) for driving the second subpixel (A) of the liquid-crystal display panel (50) using said storage unit of the second subpixel driving level converter.

2. The liquid-crystal display device according to Claim 1, wherein the first subpixel driving level converter (4) includes a calculation circuit (114, 126) for multiplying the gradation value of the input video signal and a calculation circuit for obtaining a square root (111, 121).

3. The liquid-crystal display device according to Claim 1, wherein the first subpixel driving level converter (4) includes
a storage unit (12) configured to store therein a plurality of sets of look-up tables, each set of look-up tables comprising two look-up tables, wherein in each look-up table discrete gradation values of the input video signal and the gradation values of the first subpixel (B) are associated with each other, and for each set of look-up tables the driving levels of the input video signal are different;
an address generator (11) configured to generate two gradation values (x0-a, x0+b) as reference addresses in the look-up table with a gradation value (x0) of the input video signal being held therebetween;
a selector (13) configured to select gradation values from one of the plurality of sets of look-up tables corresponding to the reference addresses; and
an interpolation unit (14) configured to perform interpolation on the gradation values selected by the selector (13), and to set the result of the interpolation as a gradation value of the first subpixel (B).

Patentansprüche

1. Flüssigkristallanzeigevorrichtung, die Folgendes umfasst:

ein Flüssigkristallanzeigefeld (50), das mehrere Pixel umfasst, jedes Pixel für eine der Primär-

farben, wobei jedes der Pixel (P) in ein erstes Subpixel (B) und ein zweites Subpixel (A) unterteilt ist;

eine Ansteuerschaltung (60, 70), die konfiguriert ist, das Flüssigkristallanzeigefeld (50) anzusteuern; und

eine Ansteuersteuerschaltung (30), die konfiguriert ist, das Ansteuern des Flüssigkristallanzeigefeldes (50) durch Verwenden der Ansteuer-schaltung (60, 70) zu steuern, wobei die Ansteuersteuerschaltung (30) folgendes enthält:

einen ersten Subpixelansteuerstufenum-setzer (4), der konfiguriert ist, einen ersten Gradationswert (x1) zum Ansteuern des ersten Subpixels (B) eines Pixels (P) des Flüssigkristallanzeigefeldes (50) auf der Basis des Gradationswerts des Pixels (P) von einem Eingangsvideosignal (x0) zu erhalten, und

dadurch gekennzeichnet ist,

dass die Ansteuersteuerschaltung (30) ferner folgendes umfasst:

einen ersten Luminanzwertumsetzer (3), der konfiguriert ist, den Gradationswert (x1) zum Ansteuern des ersten Subpixels (B) in einen Luminanzwert (f(x1)) umzusetzen, einen zweiten Luminanzwertumsetzer (1), zum Umsetzen des Gradationswerts jedes Pixels (P) des Eingangsvideosignals (x0) in einen Luminanzwert (f(x0)) ,

wobei der erste Luminanzwertumsetzer (3) und der zweite Luminanzwertumsetzer (1) eine Speichereinheit enthalten, in der eine Nachschlagetabelle gespeichert ist, in der Gradationswerte und Luminanzwerte einander zugeordnet sind,

eine Subtraktionseinheit (5), die konfiguriert ist, eine Differenz zwischen dem Luminanzwert (f(x0)), der durch den zweiten Luminanzwertumsetzer (1) umgesetzt wird, und den Luminanzwert (f(x1)), der durch den ersten Luminanzwertumsetzer (3) umgesetzt wird, zu berechnen, und

einen zweiten Subpixelansteuerstufenum-setzer (2), der eine Speichereinheit enthält, in der eine Nachschlagetabelle gespeichert ist, in der Gradationswerte und Luminanzwerte einander zugeordnet sind, und der konfiguriert ist, die Differenz (f(x2)) der Luminanzwerte, die durch die Subtraktions-einheit (5) berechnet wurden, in einen Gradationswert (x2) zum Ansteuern des zweiten Subpixels (A) des Flüssigkristallanzeigefeldes (50) unter Verwendung der Spei-

chereinheit des zweiten Subpixelansteuer-stufenumsetzers umzusetzen.

2. Flüssigkristallanzeigevorrichtung nach Anspruch 1, wobei der erste Subpixelansteuerstufenumsetzer (4) eine Berechnungsschaltung (114, 126) zum Multiplizieren des Gradationswerts des Eingangsvideosignals und eine Berechnungsschaltung zum Erhalten einer Quadratwurzel (111, 121) enthält.

3. Flüssigkristallanzeigevorrichtung nach Anspruch 1, wobei der erste Subpixelansteuerstufenumsetzer (4) folgendes enthält:

eine Speichereinheit (12), die konfiguriert ist, darin mehrere Gruppen von Nachschlagetabellen zu speichern, wobei jede Gruppe von Nachschlagetabellen zwei Nachschlagetabellen umfasst, wobei in jeder Nachschlagetabelle diskrete Gradationswerte des Eingangsvideosignals und die Gradationswerte des ersten Subpixels (B) einander zugeordnet sind, und für jede Gruppe von Nachschlagetabellen die Ansteuerstufen des Eingangsvideosignals unterschiedlich sind; einen Adressgenerator (11), der konfiguriert ist, zwei Gradationswerte (x0-a, x0+b) als Referenzadressen in der Nachschlagetabelle zu erzeugen, wobei dazwischen ein Gradationswert (x0) des Eingangsvideosignals gehalten wird; eine Auswahlrichtung (13), die konfiguriert ist, Gradationswerte aus einer der mehreren Gruppen von Nachschlagetabellen entsprechend den Referenzadressen auszuwählen; und

eine Interpolationseinheit (14), die konfiguriert ist, eine Interpolation an den Gradationswerten, die von der Auswahlrichtung (13) ausgewählt werden, auszuführen und das Ergebnis der Interpolation als einen Gradationswert des ersten Subpixels (B) einzusetzen.

Revendications

1. Dispositif d'affichage à cristaux liquides comprenant :

- un panneau d'affichage à cristaux liquides (50) comprenant plusieurs pixels, chaque pixel étant pour une couleur primaire, et dans lequel chacun des pixels (P) est divisé en un premier sous-pixel (B) et en un second sous-pixel (A) ;
- un circuit d'actionnement (60, 70) conçu pour actionner le panneau à cristaux liquides (50) ; et
- un circuit de commande d'actionnement (30) conçu pour commander l'actionnement du panneau d'affichage à cristaux liquides (50) en utilisant le circuit d'actionnement (60, 70),

dans lequel le circuit de commande d'actionnement (30) comprend :

- un premier convertisseur de niveau d'actionnement de sous-pixel (4) conçu obtenir une première valeur de gradation (x_1) pour actionner le premier sous-pixel (B) d'un pixel (P) du panneau d'affichage à cristaux liquides (50) en fonction de la valeur de gradation du pixel (P) depuis un signal vidéo d'entrée (x_0), et **caractérisé en ce que** le circuit de commande d'actionnement (30) comprend en outre :
 - un premier convertisseur de valeur de luminance (3) conçu pour convertir la valeur de gradation (x_1) pour actionner le premier sous-pixel (B) en une valeur de luminance ($f(x_1)$) ;
 - un second convertisseur de valeur de luminance (1) pour convertir la valeur de gradation de chaque pixel (P) du signal vidéo d'entrée (x_0) en une valeur de luminance ($f(x_0)$) ,

dans lequel chacun du premier convertisseur de valeur de luminance (3) et du second convertisseur de valeur de luminance (1) comprend une unité de stockage dans laquelle est stockée une table à consulter dans laquelle des valeurs de gradation et des valeurs de luminance sont associées les unes aux autres ;

- une unité de soustraction (5) conçue pour calculer une différence entre la valeur de luminance ($f(x_0)$) convertie par le second convertisseur de valeur de luminance (1) et la valeur de luminance ($f(x_1)$) convertie par le premier convertisseur de valeur de luminance (3) ; et
- un second convertisseur de niveau d'actionnement de sous-pixel (2) comprenant une unité de stockage dans laquelle est stockée une table à consulter dans laquelle des valeurs de gradation et des valeurs de luminance sont associées les unes aux autres, et conçu pour convertir la différence ($f(x_2)$) des valeurs de luminance calculée par l'unité de soustraction (5) en une valeur de gradation (x_2) pour actionner le second sous-pixel (A) du panneau d'affichage à cristaux liquides (50) en utilisant ladite unité de stockage du second convertisseur de niveau d'actionnement de sous-pixel.

2. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel le premier convertisseur de niveau d'actionnement de sous-pixel (4) comprend un circuit de calcul (114, 126) afin de multiplier la valeur de gradation du signal vidéo d'entrée et un circuit de calcul pour obtenir une racine carrée (11, 121).
3. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel le premier convertisseur

de niveau d'actionnement de sous-pixel (4) comprend :

- une unité de stockage (12) conçue pour stocker plusieurs ensembles de tables à consulter, chaque ensemble de tables à consulter comprenant deux tables à consulter, et dans laquelle, dans chaque table à consulter, des valeurs de gradation discrètes du signal vidéo d'entrée et les valeurs de gradation du premier sous-pixel (B) sont associées les unes aux autres et, pour chaque ensemble de tables à consulter, les niveaux d'actionnement du signal vidéo d'entrée sont différents ;
- un générateur d'adresses (11) conçu pour générer deux valeurs de gradation (x_0-a , x_0+b) en qualité d'adresses de référence dans la table à consulter avec une valeur de gradation (x_0) du signal vidéo d'entrée maintenue entre elles ;
- un sélecteur (13) conçu pour sélectionner des valeurs de gradation à partir d'un desdits plusieurs ensembles de tables à consulter correspondant aux adresses de référence ; et
- une unité d'interpolation (14) conçue pour effectuer une interpolation des valeurs de gradation sélectionnées par le sélecteur (13), et pour définir le résultat de l'interpolation comme étant la valeur de gradation du premier sous-pixel (B).

FIG. 1

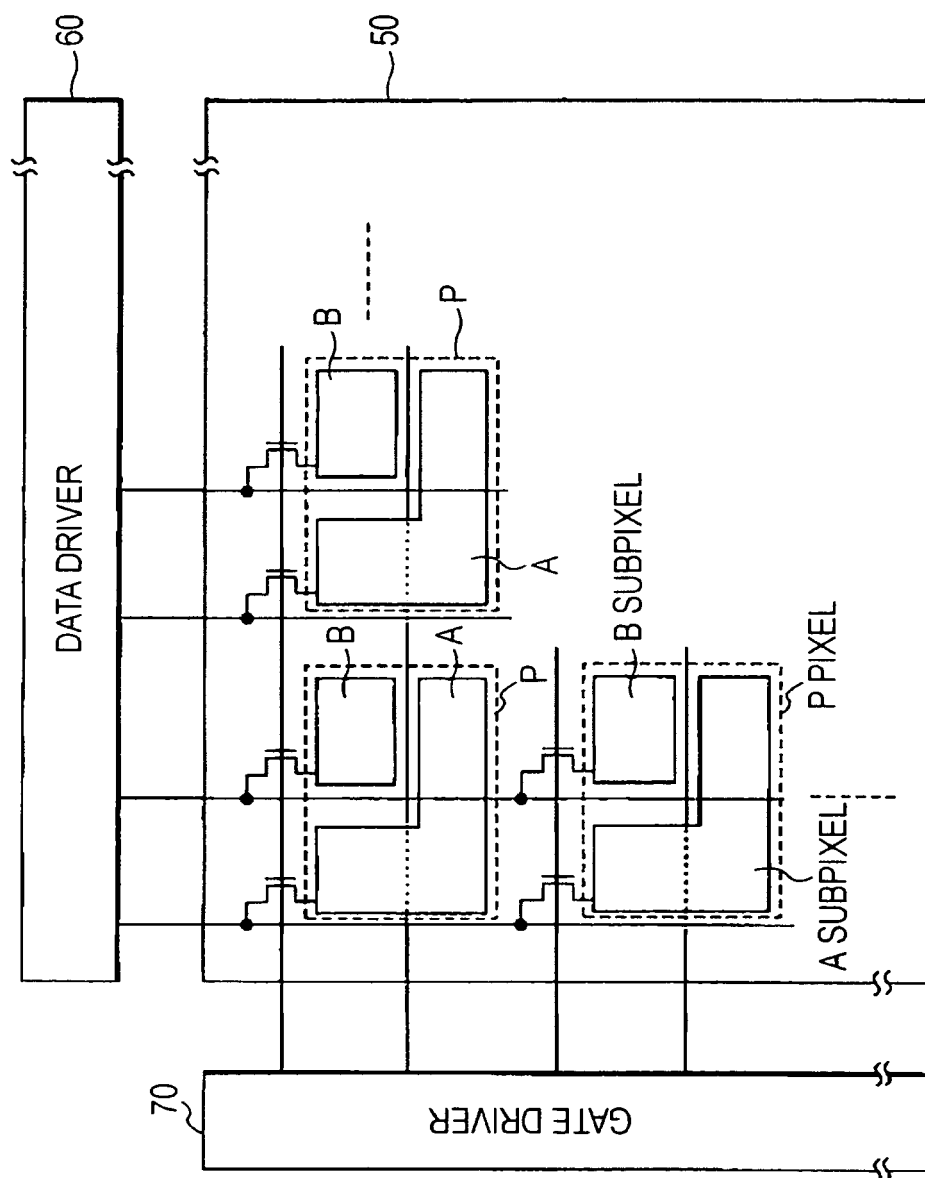


FIG. 2A

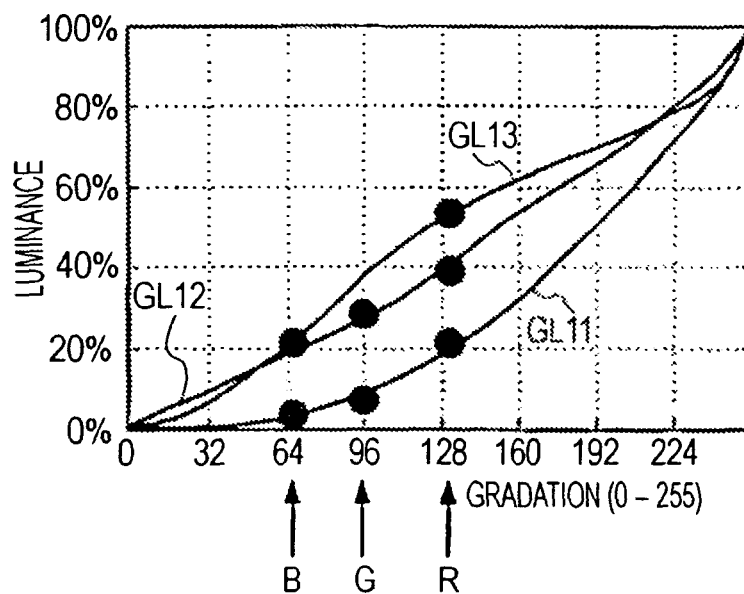


FIG. 2B

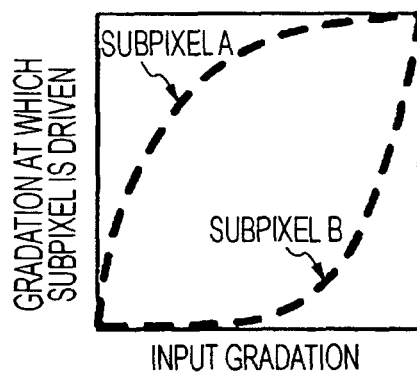


FIG. 2C

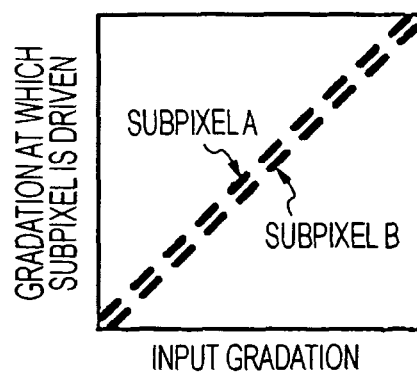


FIG. 3

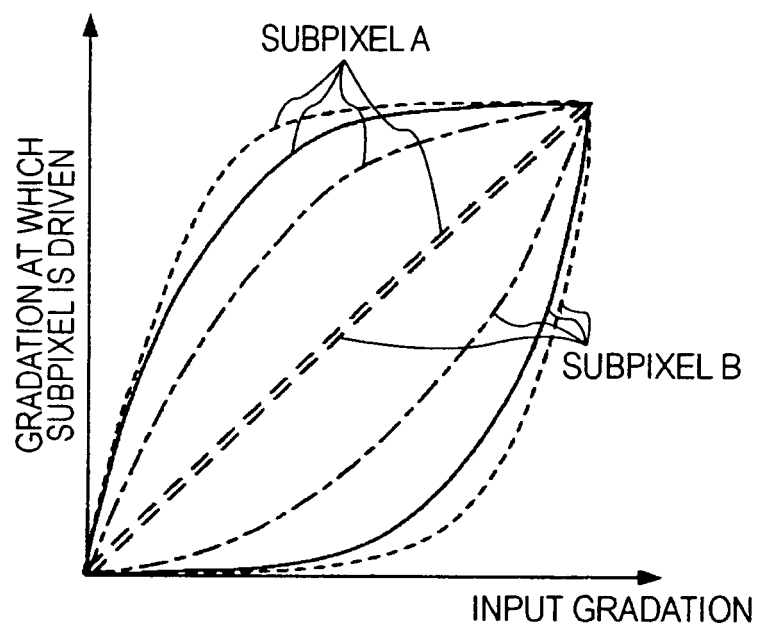


FIG. 4

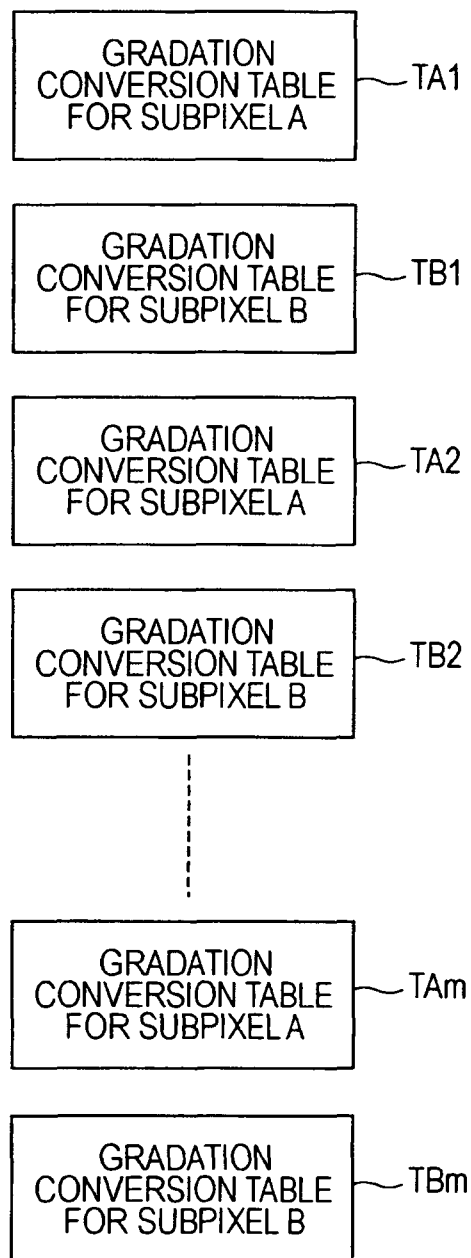


FIG. 5

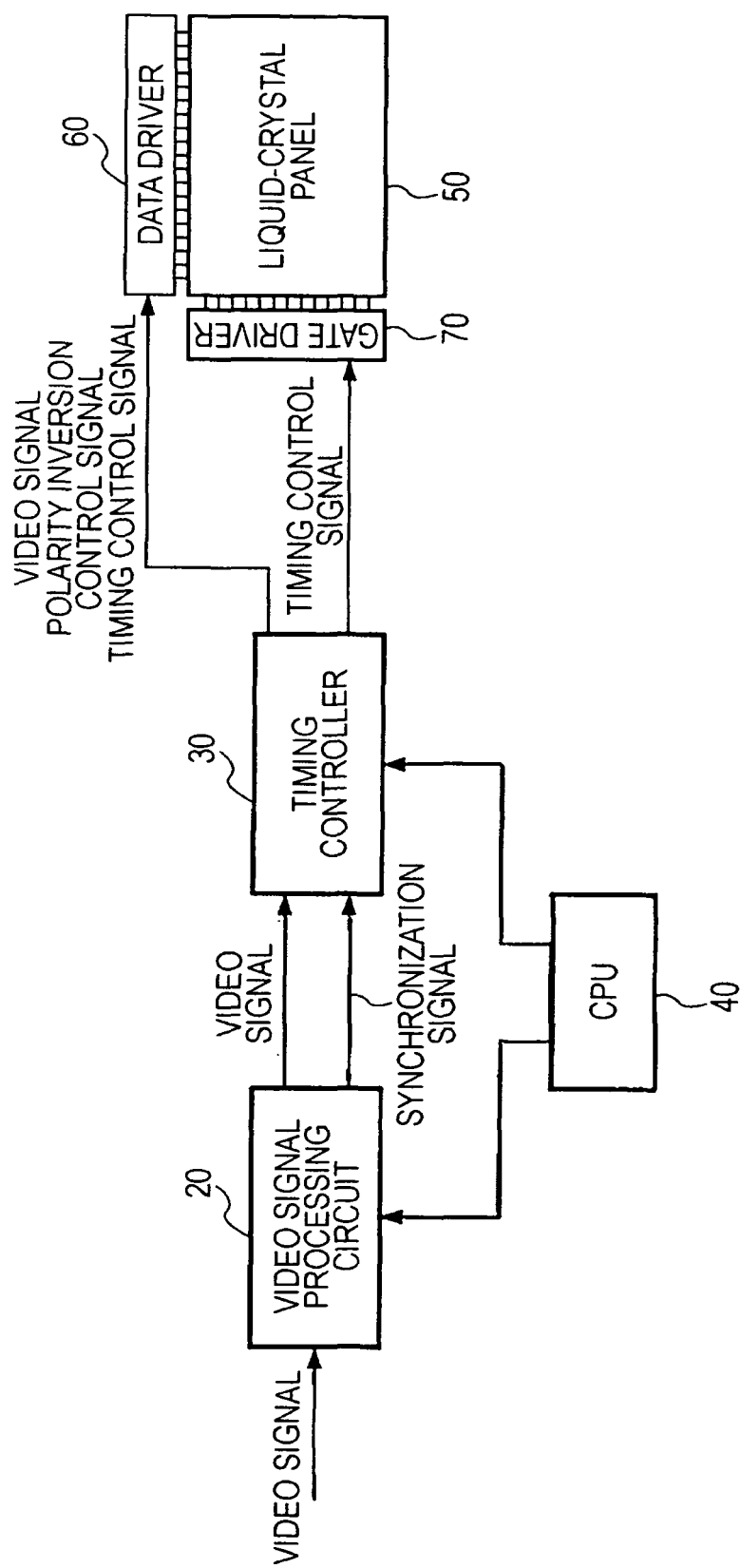


FIG. 6

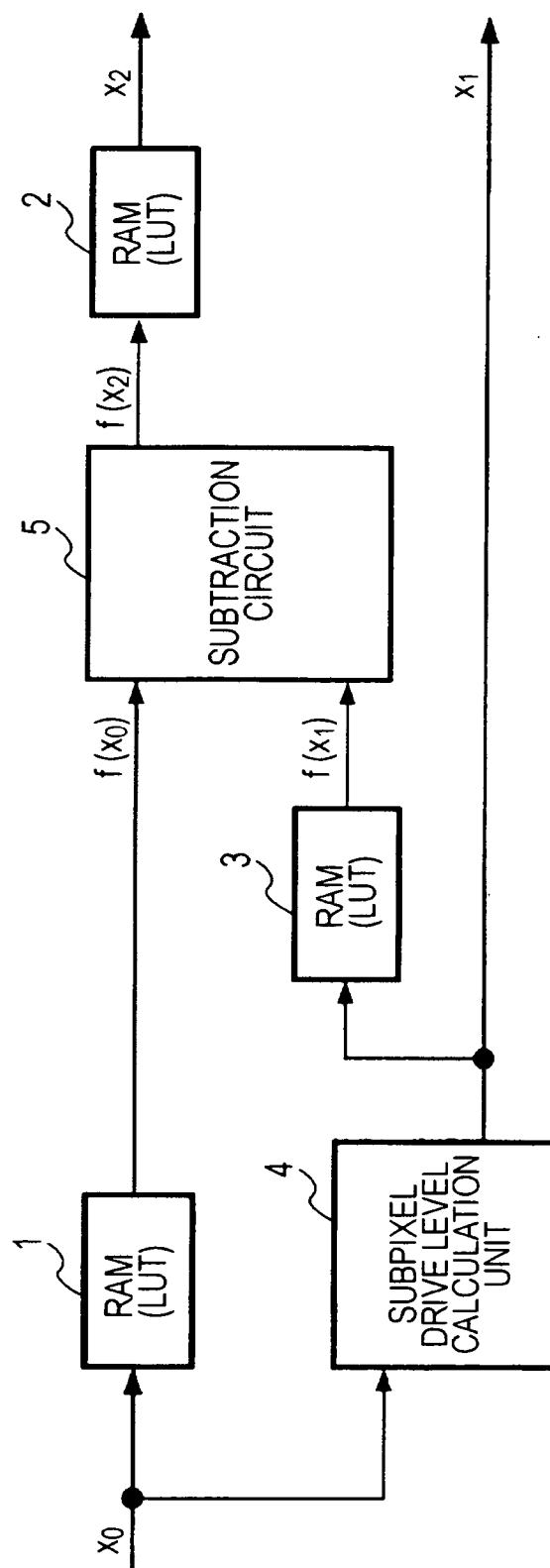


FIG. 7

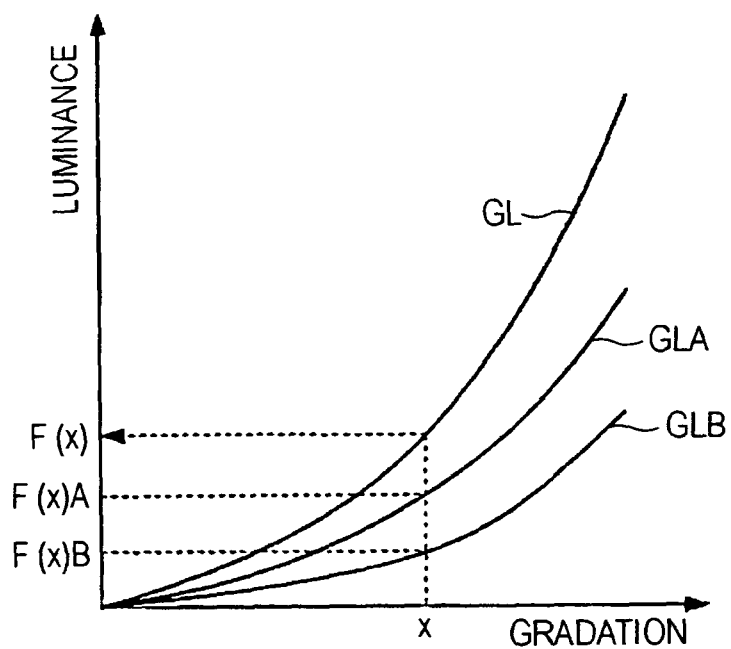


FIG. 8

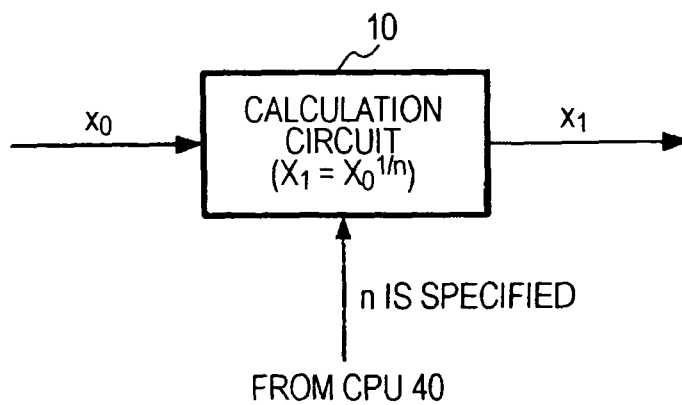


FIG. 9

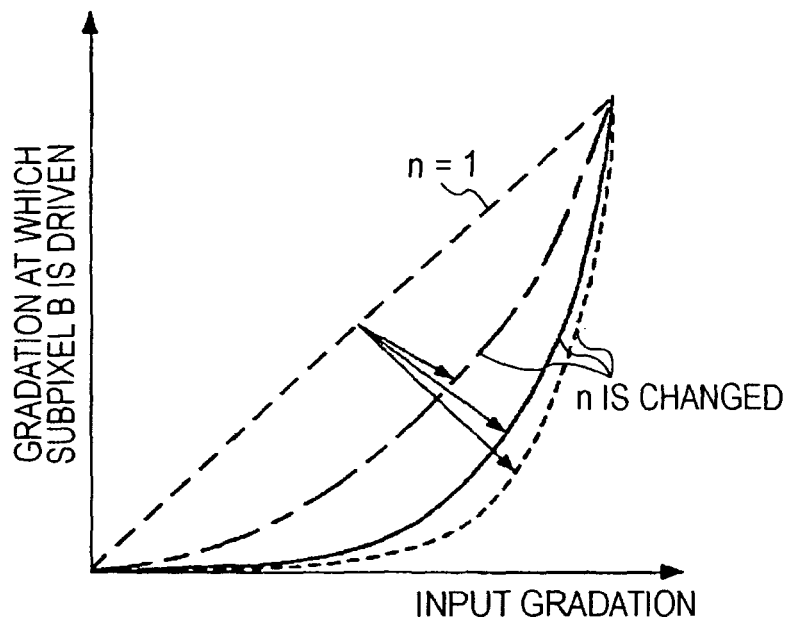


FIG. 10

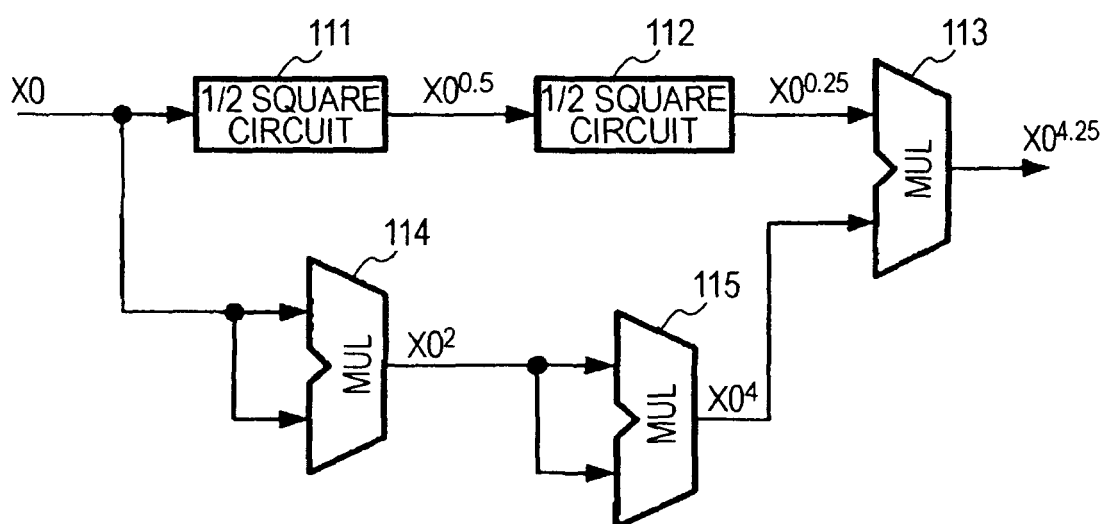


FIG. 11

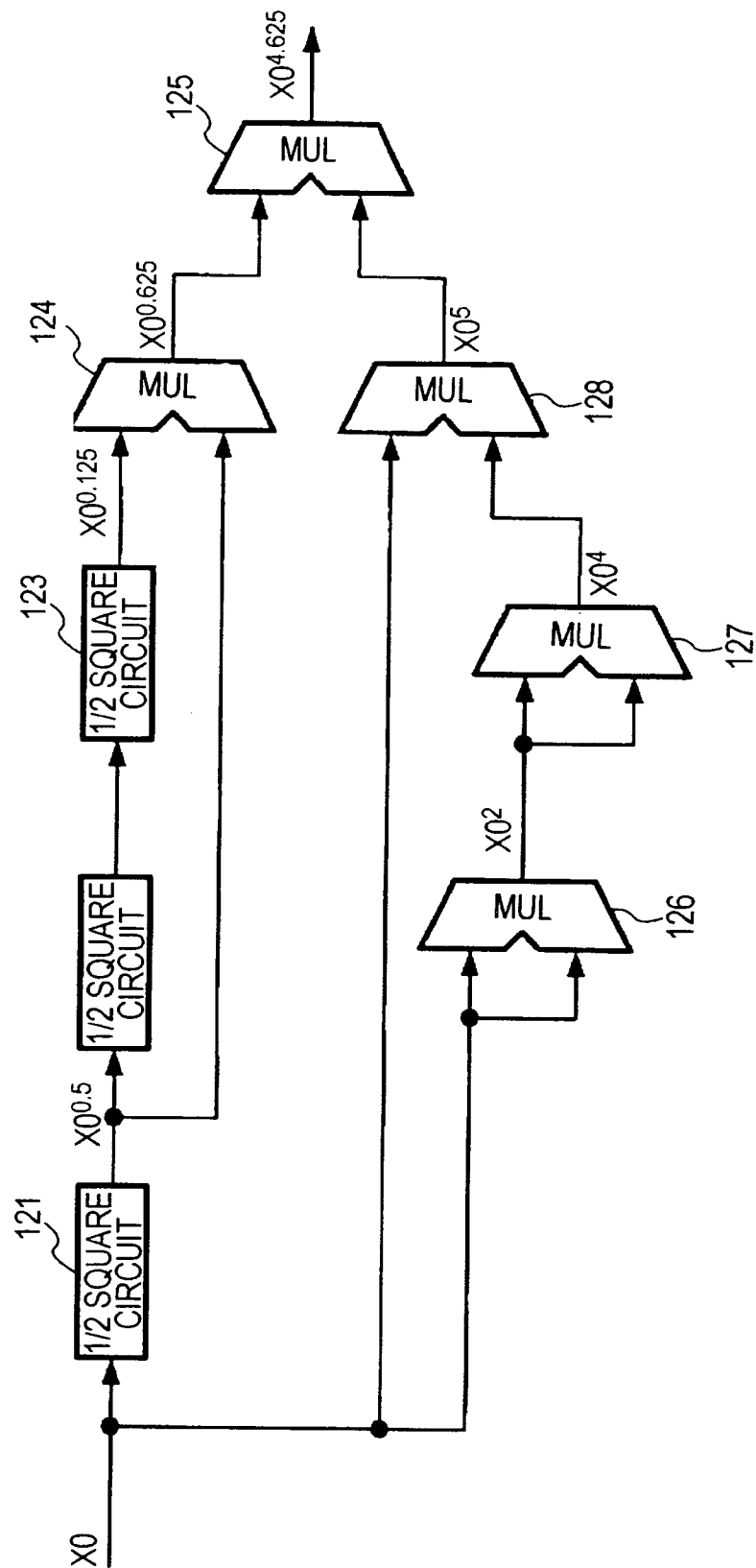


FIG. 12

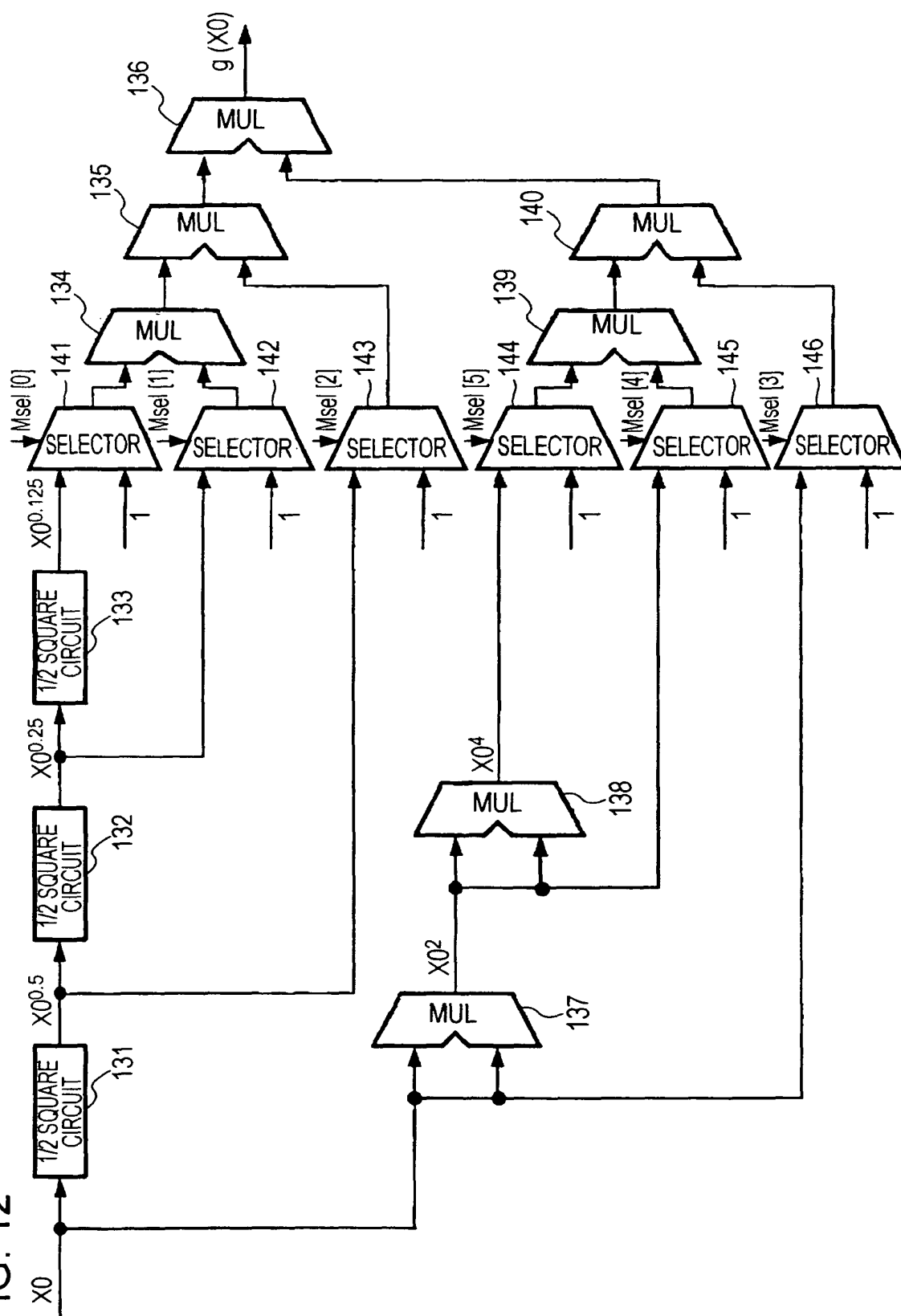


FIG. 13

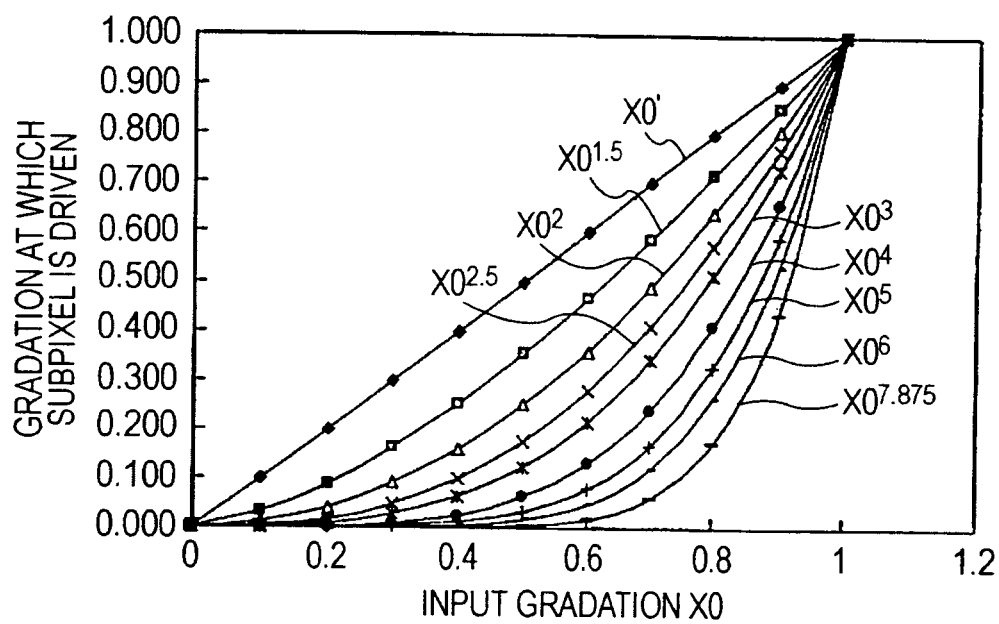


FIG. 14

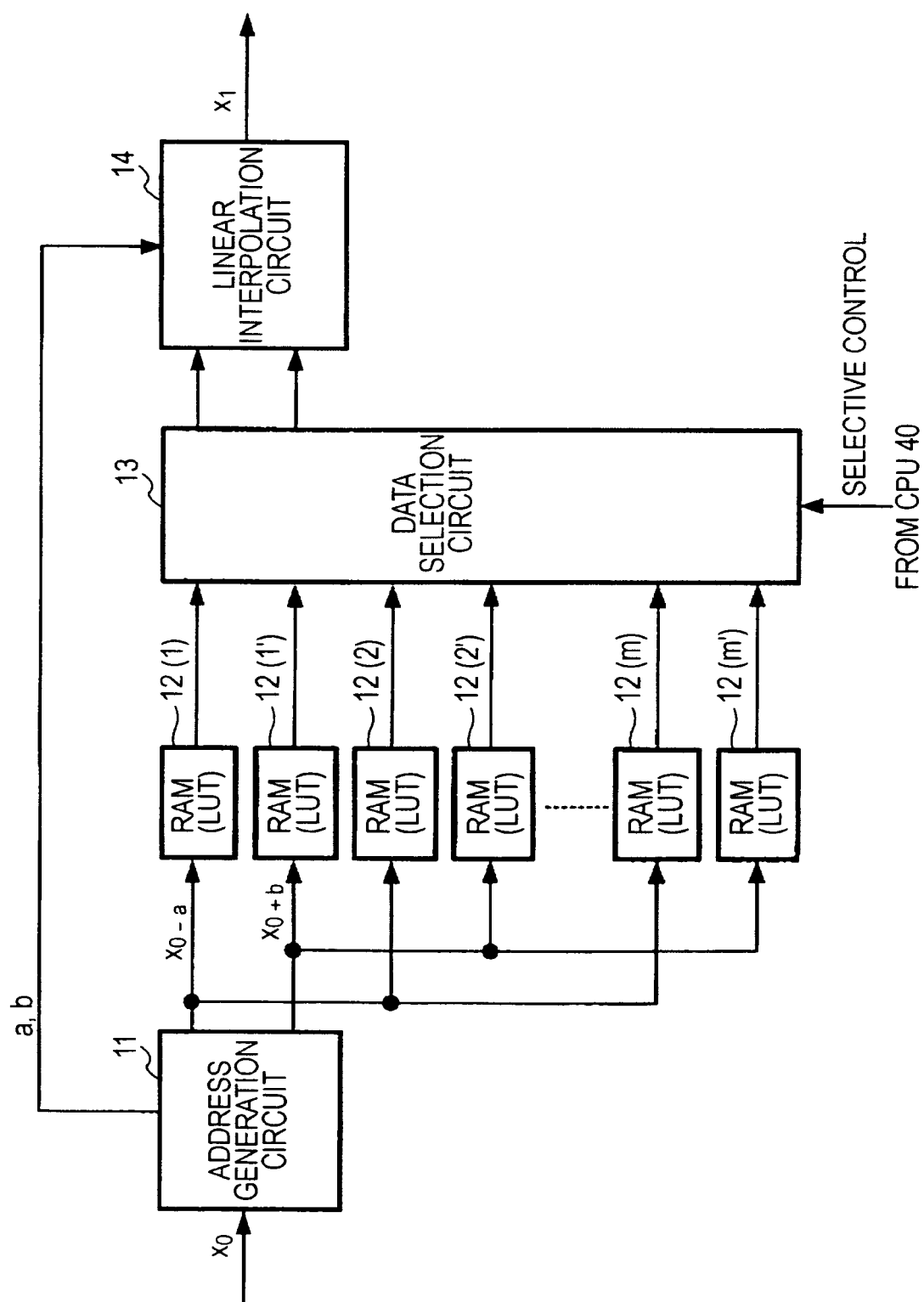
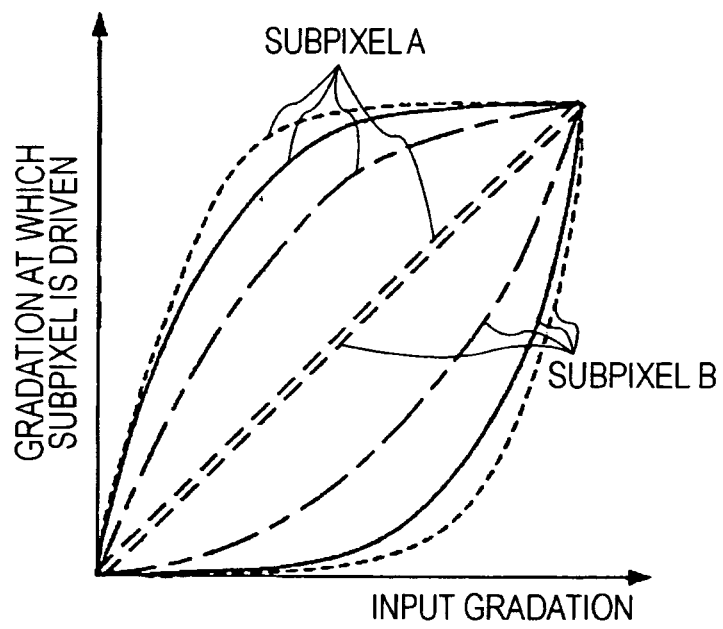


FIG. 15



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005316211 A [0003] [0005] [0062]
- WO 2006098247 A1 [0014]
- US 20070018930 A1 [0014]

专利名称(译)	液晶显示装置和驱动控制电路		
公开(公告)号	EP2133862B1	公开(公告)日	2013-02-27
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[标]申请(专利权)人(译)	索尼公司		
申请(专利权)人(译)	索尼公司		
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摘要(译)

在液晶显示面板的每个像素被划分为两个子像素的情况下，可以从多个驱动电平中选择相对于输入视频信号的灰度的子像素的驱动电平，电路规模被抑制。因此，在本发明中，提供了第一子像素驱动电平转换器，用于基于输入视频信号的每个像素的灰度值获得用于驱动第一子像素的第一灰度值，并且驱动第一子像素并基于第一灰度值进行控制。然后，将由第一子像素驱动电平转换器获得的第一灰度值转换为亮度值，并且获得与亮度值的差，使得转换整个像素的灰度值。将所获得的差转换为灰度值，并且获得用于驱动第二子像素的第二灰度值。基于第二灰度值驱动和控制第二子像素。

$$x_1 = x_0^{1/n},$$