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(54) **Plasma display and driving method**

(57) The present invention relates to a plasma display and a driving method thereof. In the driving method, to prevent a flickering effect in a phase alternating by line (PAL) method, a plurality of subfields divided from one frame are grouped into at least three subfield groups. In

addition, since the number of sustain pulses applied to one frame is large when an automatic power control level is set to be less than a reference value, the plurality of subfields divided from one frame are grouped into two subfield groups to sufficiently obtain a time for applying the sustain pulses.

FIG. 1

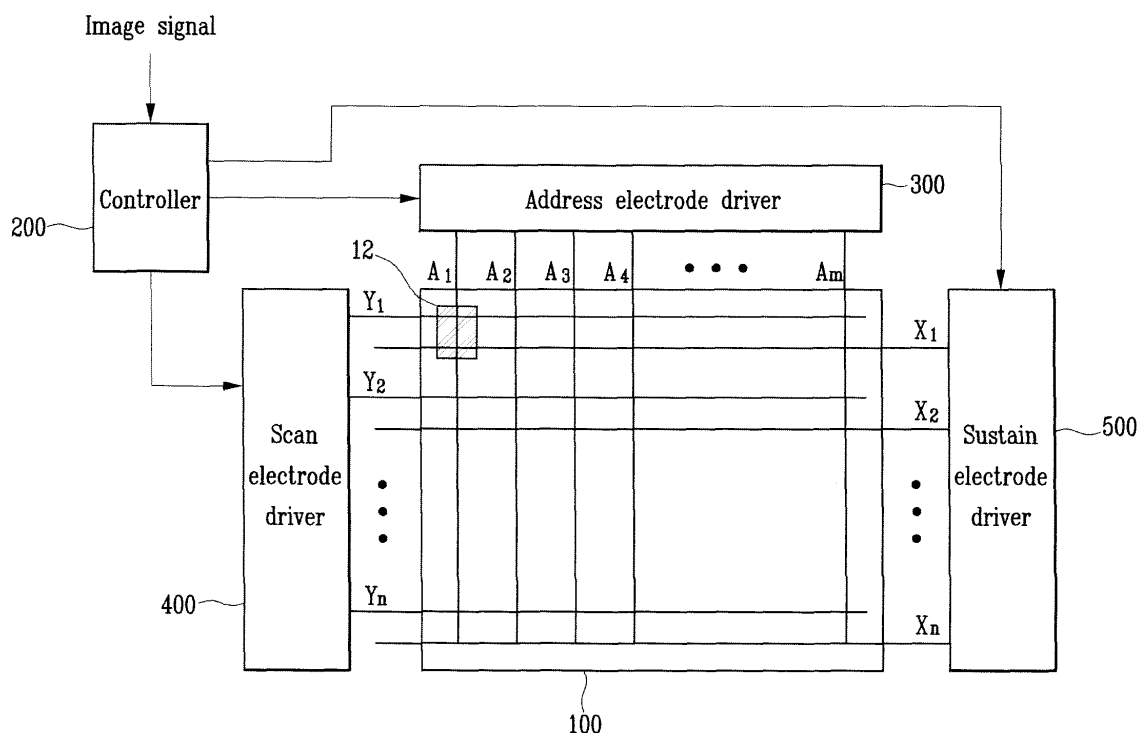


FIG. 2

Subfield group	G1						P1	G2		P2	G3						P3
Subfield	SF1	SF2	SF3	SF4	SF5	SF6		SF7	SF8		SF9	SF10	SF11	SF12	SF13	SF14	
Weight value	4	8	16	24	32	40		1	2		4	8	16	24	32	40	

Description

[0001] The present invention relates to a plasma display and a driving method thereof, and particularly to a plasma display for preventing flicker when an image is realized by receiving a phase alternating by line (PAL) video signal, and improving an image quality, and a driving method thereof.

[0002] A plasma display is a flat panel display that uses plasma generated by gas discharge to display characters or images. It includes, depending on its size, more than several scores to millions of discharge cells (hereinafter, also referred to as "cells") arranged in a matrix pattern.

[0003] As methods for expressing grayscales of the plasma display, a grayscale expression method for dividing one frame into a plurality of subfields and time-divisionally controlling the subfields is generally used.

[0004] In addition, image displaying methods in the plasma display device are classified as a National Television System Committee (NTSC) method and a phase alternate line (PAL) method according to a vertical synchronization frequency. A time corresponding to one frame is 16.67ms (=1/60 second) since the NTSC method uses a 60Hz vertical synchronization frequency, and a time corresponding to one frame is 20ms (=1/50 second) since the PAL method uses a 50Hz vertical synchronization frequency.

[0005] That is, the time corresponding to one frame in the PAL method is longer than that of the NTSC method. In this case, since a user may perceive intervals between frames when subfields of one frame are arranged by minimum increment arrangement or minimum decrement arrangement that is generally used in the NTSC method, a screen may seem to flicker. That is, a subfield perceived as the brightest one has the highest weight value, which is conventionally provided as a first subfield or a last subfield of the frame when the subfields are arranged. Accordingly, the user perceives that the screen seems to vary every 20ms, and the interval in this case may be sufficiently perceived by the user, so that a flicker effect for flickering the screen may be generated.

[0006] The above information disclosed in this section is only for enhancement of understanding of the background of the invention and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

[0007] The present invention has been made in an effort to provide a plasma display for reducing a flickering effect in a phase alternating by line (PAL) method, and a driving method thereof. In an exemplary driving method of a plasma display for dividing one frame into a plurality of subfields respectively having weight values and grouping the plurality of subfields into at least two subfield groups, an automatic power control level for one frame is determined according to an externally input image signal, the plurality of subfields are grouped into time-sequential first, second, and third subfield groups when the automatic power control level for one frame is higher than a reference value, and the plurality of subfields are grouped into the first subfield group and a fourth subfield group when the automatic power control level for one frame is lower than the reference value.

[0008] Here, the number of subfields included in the fourth subfield group is the same as that of the third subfield group, and a sum of weight values of the plurality of subfields in the fourth subfield group is the same as that of the third subfield group.

[0009] In this case, the weight value of a first subfield having the highest weight value among the plurality of subfields in the fourth subfield group corresponds to a sum of the weight values of a second subfield having the highest weight value among the plurality of subfields in the third subfield group and the weight values of the plurality of subfields in the second subfield group. In addition, a sum of the weight values of a first subfield having the highest weight value among the plurality of subfields in the fourth subfield group and a second subfield having the second highest weight value among the plurality of subfields in the fourth subfield group is greater than a sum of the weight values of a third subfield having the highest weight value among the plurality of subfields in the third subfield group and a fourth subfield having the second highest weight value next to the third subfield among the plurality of subfields in the third subfield group, by a sum of the weight values of the plurality of subfields in the second subfield group.

[0010] Further, the second subfield group includes a fifth subfield having the least weight value among the plurality of subfields divided from one frame. In this case, the second subfield group includes a sixth subfield having the second least weight value next to the fifth subfield among the first subfield and the plurality of subfields divided from one frame.

[0011] In addition, the subfields are arranged from the subfield having the least weight value to the subfield having the highest weight value in the respective first to fourth subfield groups, and a sum of the weight values of the plurality of subfields in the first subfield group is the same as that of the plurality of subfields in the third subfield group.

[0012] Further, a time corresponding to one frame is determined by a vertical synchronization frequency of a phase alternate line (PAL) method. An exemplary plasma display includes a plasma display panel (PDP) and a controller. The controller drives the PDP while dividing one frame into a plurality of subfields, generates a control signal for grouping the plurality of subfields into at least two subfield groups, and determines an automatic power control level through an input image signal. The controller groups the plurality of subfields into a first subfield group having a first number of subfields, a second subfield group having a second number of subfields that is smaller than the first number, and a third subfield group having a third number of subfields that is greater than the second number when the automatic power

control level corresponding to one frame is higher than a reference value, and groups the plurality of subfields into the first subfield group and a fourth subfield group having the third number of subfields when the automatic power control level corresponding to one frame is lower than the reference value.

[0013] In addition, the controller establishes the second subfield group to include a first subfield having the least weight value among the plurality of subfields divided from one frame and a second subfield having the second least weight value next to the first subfield, and the controller establishes a sum of the weight values of the plurality of subfields in the fourth subfield group to be a sum of the weight values of the plurality of subfields in the second subfield and the weight values of the plurality of subfields in the third subfield group.

[0014] Further, the controller establishes the weight value of a first subfield having the highest weight value among the plurality of subfields in the fourth subfield group to be greater than the weight value of a second subfield having the highest weight value among the plurality of subfields in the first subfield group, and the controller establishes the weight value of a third subfield having the second highest weight value among the plurality of subfields in the fourth subfield group to be greater than the weight value of a fourth subfield having the second highest weight value among the plurality of subfields in the first subfield group. In this case, the controller determines a time corresponding to one frame according to a vertical synchronization frequency of a phase alternate line (PAL) method.

[0015] In an exemplary driving method of a plasma display for dividing one frame into a plurality of subfields respectively having weight values, an automatic power control level for one frame is determined according to an externally input image signal, the plurality of subfields are grouped into time-sequential N groups when the automatic power control level for one frame is greater than a reference value, and the plurality of subfields are grouped into time-sequential M groups when the automatic power control level for one frame is less than the reference value. Here, M is less than N.

[0016] Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a schematic diagram of a plasma display according to an exemplary embodiment of the present invention.

FIG. 2 is a diagram representing subfield arrangement in a phase alternating by line (PAL) method according to the first exemplary embodiment of the present invention.

FIG. 3 is a flowchart representing an operation of a controller according to a second exemplary embodiment of the present invention.

FIG. 4A and FIG. 4B are diagrams representing subfield arrangement in the PAL method according to the second exemplary embodiment of the present invention.

[0017] FIG. 1 is a schematic diagram of a plasma display according to an exemplary embodiment of the present invention.

[0018] As shown in FIG. 1, the plasma display according to the exemplary embodiment of the present invention includes a plasma display panel (PDP) 100, a controller 200, an address electrode driver 300, a scan electrode driver 400, and a sustain electrode driver 500. The PDP 100 includes a plurality of address electrodes A1 to Am extending in a column direction, and a plurality of sustain electrodes X1 to Xn and a plurality of scan electrodes Y1 to Yn extending in a row direction. The plurality of Y electrodes Y1 to Yn and X electrodes X1 to Xn are arranged in pairs. Discharge cells 12 are formed at intersections of adjacent Y electrodes Y1 to Yn and X electrodes X1 to Xn, and the A electrodes A1 to Am.

[0019] The controller 200 divides one frame into a plurality of subfields respectively having weight values, and forms each subfield to have an address period and a sustain period. In addition, the controller 200 generates subfield data that indicate a non-light emitting state for the plurality of discharge cells 12 in the plurality of subfields, measures a screen load ratio from image data input for one frame, and determines a total number of sustain pulses applied to one frame according to the screen load ratio. In this case, the controller 200 applies the reduced number of sustain pulses when the screen load ratio is high to prevent power consumption from being increased. Further, the controller 200 determines the number of sustain pulses applied to each subfield according to a corresponding weight value.

[0020] Also, the controller 200 outputs an address electrode driving control signal, a sustain electrode driving control signal, and a scan electrode driving control signal according to the subfield data and the number of sustain pulses.

[0021] The address electrode driver 300 receives the address electrode driving control signal from the controller 200 to apply a signal for selecting a displayed discharge cell to each of the A electrodes A1 to Am. The scan electrode driver 400 receives the scan electrode driving control signal from the controller 200 to apply a driving voltage to the Y electrodes Y1 to Yn, and the sustain electrode driver 500 receives the sustain electrode driving control signal from the controller 200 to apply the driving voltage to the X electrodes X1 to Xn.

[0022] The plasma display for reducing the flickering effect in a phase alternating by line (PAL) method according to a first exemplary embodiment of the present invention, and a driving method thereof, will now be described.

[0023] FIG. 2 is a diagram representing subfield arrangement in the PAL method according to the first exemplary embodiment of the present invention.

[0024] As shown in FIG. 2, one frame is divided into the plurality of subfields SF1 to SF14, the plurality of subfields are grouped into three subfield groups G1 to G3, and idle periods P1 to P3 are respectively formed after the respective subfield groups are finished.

[0025] Among the plurality of subfields divided from one frame, the subfields having relative higher weight values are dispersedly provided to the first subfield group G1 and the third subfield group G3. That is, as shown in FIG. 2, the first subfield group G1 includes the first subfield SF1, the second subfield SF2, the third subfield SF3, the fourth subfield SF4, the fifth subfield SF5, and the sixth subfield SF6 respectively having weight values of 4, 8, 16, 24, 32, and 40. In a like manner of the first subfield group G1, the third subfield group G3 includes the ninth subfield SF9, the tenth subfield SF10, the eleventh subfield SF11, the twelfth subfield SF12, the thirteenth subfield SF13, and the fourteenth subfield SF14 respectively having the weight values of 4, 8, 16, 24, 32, and 40. As described, since the sixth subfield SF6 and the fourteenth subfield SF14 having the higher weight values are dispersedly provided to the first subfield group G1 and the third subfield group G3, an interval between light emitting axes by a starting point of the subfield group is within a vertical synchronization frequency range of 50Hz to 100Hz. Human eyes may not perceive the flickering effect with respect to a vertical frequency that is greater than 60Hz, and therefore the flickering effect may be reduced.

[0026] In addition, the second subfield group G2 includes subfields having relatively lower weight values among the plurality of subfields divided from one frame. That is, as shown in FIG. 2, the second subfield group G2 includes the seventh subfield SF7 and the eighth subfield SF8 respectively having the weight values of 1 and 2. Accordingly, when expressing the low grayscale, a time difference between subfields that emit light in the cell may be reduced, and therefore a false contour at a boundary between the grayscales may be reduced when a low grayscale motion picture is expressed.

[0027] In FIG. 2, while it is illustrated that one frame includes 14 subfields respectively having weight values, it is not limited thereto, and another subfield arrangement may be applied in the first exemplary embodiment of the present invention. Further, in FIG. 2, it is illustrated that each subfield group has a subfield configuration of a minimum increment arrangement, but it is not limited thereto, and another subfield configuration such as a minimum decrement arrangement may be applied in the first exemplary embodiment of the present invention.

[0028] As described, according to the first exemplary embodiment of the present invention, in the PAL method in which a time applied to one frame is approximately 3.33ms longer than in the NTSC method, since the subfields having higher weight values are dispersedly disposed in different subfield groups, the flickering effect may be reduced. In addition, when the low grayscale image is realized, the false contour may be reduced.

[0029] When driving the plasma display, the controller calculates an automatic power control (APC) level during one frame from an external image, and determines the total number of sustain pulses applied to one frame according to the calculated APC level.

[0030] In this case, the APC level according to the exemplary embodiment of the present invention indicates power consumed while driving one frame, and the number of sustain pulses is adjusted according to the APC level to control power consumption. In general, when the APC level is low, the number of sustain pulses applied to one frame is increased since the load is reduced. However, when the APC level is high, the number of sustain pulses applied to one frame is reduced since the load is increased.

[0031] Accordingly, as the number of cells having higher grayscales in one frame increases, the number of sustain pulses applied to one frame is reduced since the APC level increases. However, as the number of cells having lower grayscales increases, the number of sustain pulses applied to one frame increases since the APC level decreases.

[0032] According to the first exemplary embodiment of the present invention, since the plurality of subfields divided from one frame are grouped into three subfield groups G1 to G3, a time corresponding to one subfield is reduced. Accordingly, since a time for applying the appropriate number of sustain pulses is lacking in the frame in which the low grayscale cells are largely included to have the low APC level, luminance may be deteriorated.

[0033] A driving method of the plasma display for preventing the luminance deterioration in the PAL method when the APC level is low according to a second exemplary embodiment of the present invention will now be described.

[0034] FIG. 3 is a flowchart representing an operation of the controller 200 according to a second exemplary embodiment of the present invention, and FIG. 4A and FIG. 4B are diagrams representing subfield arrangement in the PAL method according to the second exemplary embodiment of the present invention.

[0035] As shown in FIG. 3, according to the second exemplary embodiment of the present invention, the controller 200 detects an average signal level (ASL) from R, G, and B data according to an externally input image signal. The ASL may be given as Equation 1.

[Equation 1]

$$ASL = \sum_{x=1}^N \sum_{y=1}^M \frac{R_{x,y} + G_{x,y} + B_{x,y}}{3 \times N \times M}$$

Here, $R_{x,y}$, $G_{x,y}$, and $B_{x,y}$ respectively denote R, G, and B grayscale values at a discharge cell of a position (x, y), and N and M respectively denote horizontal and vertical sizes of each frame. The controller 200 calculating the ASL as above determines the APC level from the ASL in step S310.

In addition, the controller 200 compares the APC level corresponding to one frame and a reference value in step S320.

When the determined APC level is greater than the reference value, since the number of sustain pulses applied to one frame is relatively reduced by the APC level, the plurality of subfields are grouped into three subfield groups G1 to G3 as shown in the subfield arrangement in FIG. 2.

However, since the number of sustain pulses applied to one frame is increased by the APC level when the determined APC level is lower than the reference value, if the plurality of subfields are grouped into three subfield groups G1 to G3 as shown in FIG. 2, a time for applying the appropriate number of sustain pulses may not be sufficient to realize luminance.

Accordingly, when the APC level is lower than the reference value, the controller 200 groups the plurality of subfields into two subfield groups G1 and G3' in step S340.

That is, the seventh subfield and the eighth subfield (not shown in FIG. 4A and FIG. 4B) in the second subfield group G2 (not shown in FIG. 4A and FIG. 4B) are eliminated when the APC level is lower than the reference value, and the weight values of the seventh and eighth subfields are additionally provided to subfields having relatively higher weight values among the third subfield group G3'. In this case, as shown in FIG. 4A, the weight values of the subfields SF7 and SF8 in the second subfield group G2 (not shown in FIG. 4A) are dispersedly provided to the fourteenth subfield SF14 and the thirteenth subfield SF13 having the highest weight values in the third subfield group G3', or as shown in FIG. 4B, they may be provided to the fourteenth subfield SF14.

Therefore, according to the second exemplary embodiment of the present invention, a sufficient time for applying the large number of sustain pulses is obtained since the subfield having the low weight value is eliminated when the APC level is low, and the luminance may be improved since the weight values of the eliminated subfields are dispersedly provided to both of the subfield having the highest weight value and the subfield having the second highest subfield or only to the subfield having the highest weight value.

In FIG. 3, the reference value is an APC level value from which a time for applying the sustain pulse to the plurality of discharge cells starts to be insufficient during a time corresponding to one subfield since the number of sustain pulses applied to one subfield is large, which is well known to a person of an ordinary skill in the art and therefore detailed description thereof will be omitted.

The subfield arrangement shown in FIG. 4A and FIG. 4B is only an example to describe the second exemplary embodiment of the present invention, and another subfield arrangement having another weight value configuration may be applied in the second exemplary embodiment of the present invention. In addition, while the minimum increment arrangement is illustrated in FIG. 4A and FIG. 4B as the subfield arrangement, it is not limited thereto, and the minimum decrement arrangement may be applied according to the second exemplary embodiment of the present invention.

While this invention has been described in connection with what is presently considered to be practical exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

As described above, according to the exemplary embodiment of the present invention, in the PAL method, since the subfield arrangement of the frame varies according to the automatic power control level, the flickering effect may be reduced, and the luminance deterioration may be prevented.

Claims

1. A driving method for a plasma display for dividing a frame into a plurality of subfields respectively having weight values, the driving method comprising:

determining an automatic power control level for a frame according to an externally input image signal;

grouping the plurality of subfields into N subfield groups when the automatic power control level for the frame is greater than a reference value; and
grouping the plurality of subfields into M subfield groups when the automatic power control level for the frame is less than the reference value,

wherein M is less than N.

2. The driving method of claim 1, wherein M is 2 and N is 3.

3. The driving method of claim 1 or 2, comprising:

grouping the plurality of subfields into time-sequential first, second, and third subfield groups (G1, G2, G3) when the automatic power control level for the frame is higher than a reference value; and
grouping the plurality of subfields into the first subfield group (G1) and a fourth subfield group (G3') when the automatic power control level for the frame is lower than the reference value.

4. The driving method of claim 3, wherein the number of subfields included in the fourth subfield group is the same as that of the third subfield group, and a sum of weight values of the plurality of subfields in the fourth subfield group is the same as that of the third subfield group.

5. The driving method of claim 4, wherein the weight value of a first subfield having the highest weight value among the plurality of subfields in the fourth subfield group corresponds to a sum of the weight values of a second subfield having the highest weight value among the plurality of subfields in the third subfield group and the weight values of the plurality of subfields in the second subfield group.

6. The driving method of claim 4, wherein a sum of the weight values of a first subfield having the highest weight value among the plurality of subfields in the fourth subfield group and a second subfield having the second highest weight value among the plurality of subfields in the fourth subfield group is greater than a sum of the weight values of a third subfield having the highest weight value among the plurality of subfields in the third subfield group and a fourth subfield having the second highest weight value next to the third subfield among the plurality of subfields in the third subfield group, by a sum of the weight values of the plurality of subfields in the second subfield group.

7. The driving method of any one of claims 3 to 6, wherein the second subfield group comprises a fifth subfield having the least weight value among the plurality of subfields divided from one frame.

8. The driving method of claim 7, wherein the second subfield group comprises a sixth subfield having the second least weight value next to the fifth subfield among the first subfield and the plurality of subfields divided from one frame.

9. The driving method of any one of claims 3 to 8, wherein the subfields are arranged from the subfield having the least weight value to the subfield having the highest weight value in the respective first to fourth subfield groups.

10. The driving method of claim 9, wherein a sum of the weight values of the plurality of subfields in the first subfield group is the same as that of the plurality of subfields in the third subfield group.

11. The driving method of any one of the preceding claims, wherein a time corresponding to one frame is determined by a vertical synchronization frequency of a phase alternate line (PAL) system.

12. A plasma display comprising:

a plasma display panel (PDP); and
a controller for driving the PDP, the controller being arranged to divide a frame into a plurality of subfields and to determine an automatic power control level for the frame through an input image signal,

wherein the controller is further arranged to:

group the plurality of subfields into N subfield groups when the automatic power control level for the frame is greater than a reference value; and
group the plurality of subfields into M subfield groups when the automatic power control level for the frame is

less than the reference value,

wherein M is less than N.

- 5 **13.** The plasma display of claim 12, wherein the controller is arranged to group the plurality of subfields into a first subfield group having a first number of subfields, a second subfield group having a second number of subfields that is smaller than the first number, and a third subfield group having a third number of subfields that is greater than the second number when the automatic power control level corresponding to the frame is higher than a reference value, and to group the plurality of subfields into the first subfield group and a fourth subfield group having the third number of subfields when the automatic power control level corresponding to the frame is lower than the reference value.
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- 14.** The plasma display of claim 13, wherein the controller is arranged to establish the second subfield group to include a first subfield having the least weight value among the plurality of subfields divided from one frame and a second subfield having the second least weight value next to the first subfield.
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- 15.** The plasma display of claim 13, wherein the controller is arranged to establish a sum of the weight values of the plurality of subfields in the fourth subfield group to be a sum of the weight values of the plurality of subfields in the second subfield and the weight values of the plurality of subfields in the third subfield group.
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- 16.** The plasma display of claim 15, wherein the controller is arranged to establish the weight value of a first subfield having the highest weight value among the plurality of subfields in the fourth subfield group to be greater than the weight value of a second subfield having the highest weight value among the plurality of subfields in the first subfield group.
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- 17.** The plasma display of claim 16, wherein the controller is arranged to establish the weight value of a third subfield having the second highest weight value among the plurality of subfields in the fourth subfield group to be greater than the weight value of a fourth subfield having the second highest weight value among the plurality of subfields in the first subfield group.
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- 18.** The plasma display of any one of claims 12 to 17, wherein the controller is arranged to determine a time corresponding to one frame according to a vertical synchronization frequency of a phase alternate line (PAL) system.
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FIG. 1

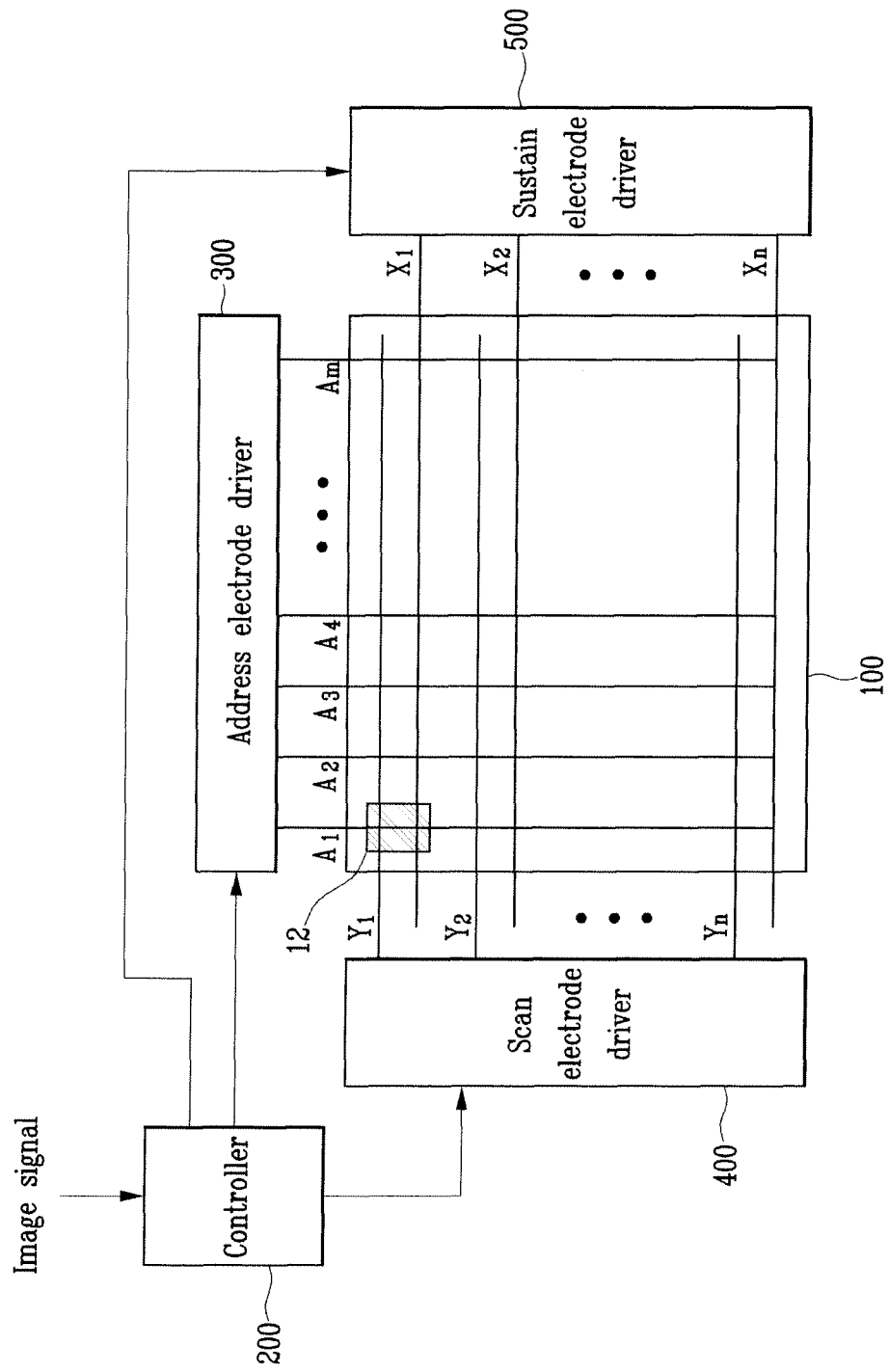


FIG.2

Subfield group	G1						P1	G2		P2	G3						P3
Subfield	SF1	SF2	SF3	SF4	SF5	SF6		SF7	SF8		SF9	SF10	SF11	SF12	SF13	SF14	
Weight value	4	8	16	24	32	40		1	2		4	8	16	24	32	40	

FIG. 3

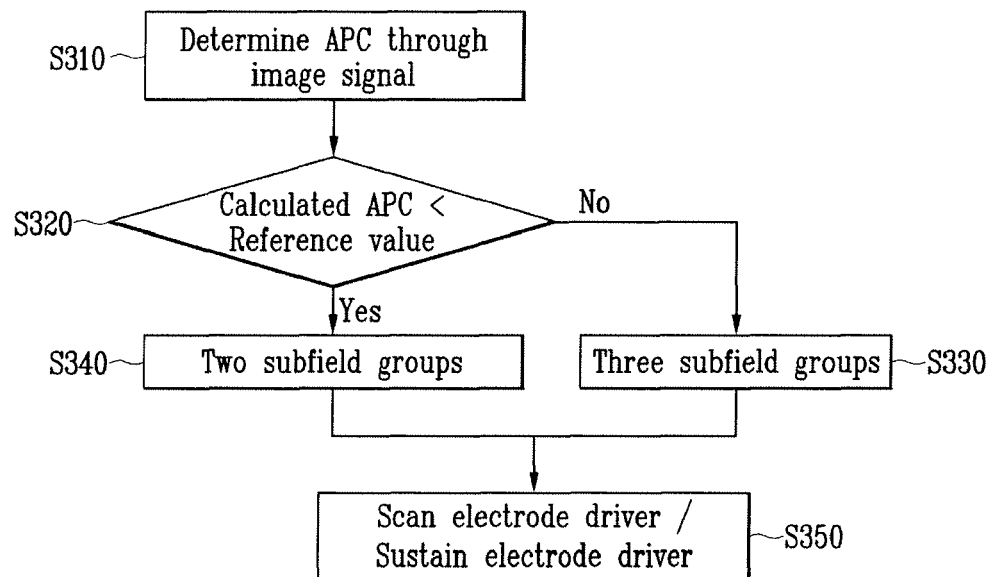


FIG. 4A

Subfield group	G1							P1	G3'							P3'
Subfield	SF1	SF2	SF3	SF4	SF5	SF6			SF9	SF10	SF11	SF12	SF13	SF14		
Weight value	4	8	16	24	32	40			4	8	16	24	33	42		

FIG. 4B

Subfield group	G1								P1	G3'								P3'
Subfield	SF1	SF2	SF3	SF4	SF5	SF6				SF9	SF10	SF11	SF12	SF13	SF14			
Weight value	4	8	16	24	32	40				4	8	16	24	32	43			