(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 684 258 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.07.2006 Bulletin 2006/30

(51) Int Cl.:
G09G 3/28 *(2006.01)*

(21) Application number: **05290170.9**

(22) Date of filing: **25.01.2005**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR LV MK YU

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(54) Method and apparatus for displaying video images on a plasma display panel

(57) The present invention relates to a method and an apparatus for displaying on a plasma display panel. This method is particularly adapted for compensating the phosphor lag. The goal of the invention is to superpose the gravity center of the three color components of the video signal is to apply a delay to the component(s) with the highest time response compared with the other color component(s) in order to compensate the phosphor lag. To this end, different coding schemes are used for the color components. In a first embodiment, specific sub-fields used only by the color component displayed by the phosphor with the highest time response are added at the end of the frame. In a second embodiment, the component associated the phosphor with the highest time response is displayed for a first part in the current frame and in a second part in the next frame.

classical code 12SF

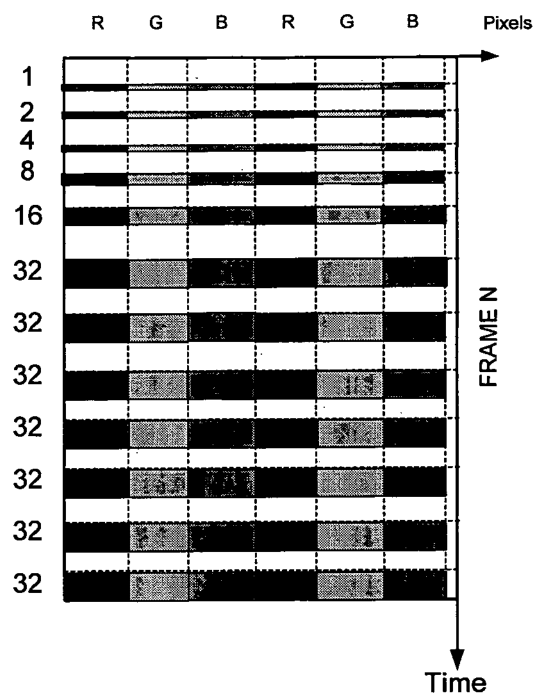

FIG.3A

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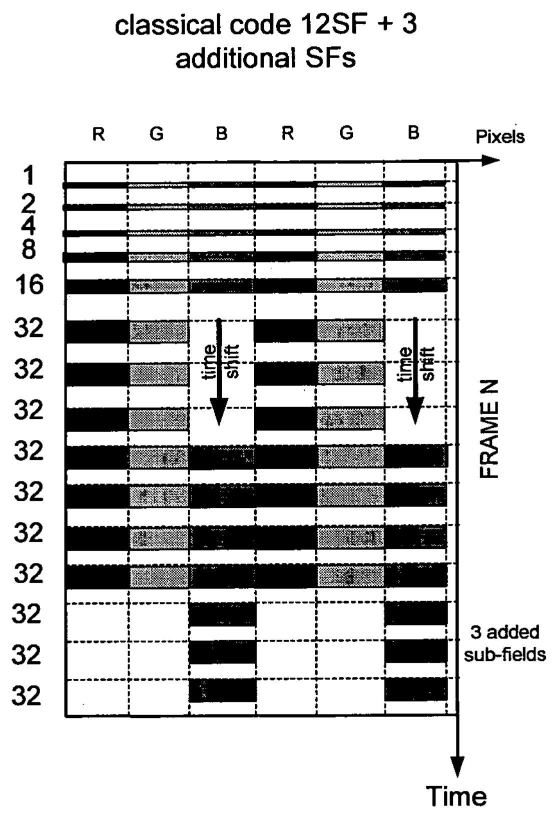
classical code 12SF + 3
additional SFs
R
G
B
R
G
B
Pixels
1
2
4
8
16
32
32
32
32
32
32
32
32
32
32
time shift
time shift
FRAME N
3 added
sub-fields
Time

FIG.3B

Description

[0001] The present invention relates to a method and an apparatus for displaying on a plasma display panel. This method is particularly adapted for compensating the phosphor lag.

Background

[0002] The plasma display technology makes it possible now to achieve flat colour displays of large size with limited depth. This technology gives the possibility of "unlimited" screen size with limited thickness, but generates new kinds of artifacts.
One of these artifacts, called "phosphor lag", is due to the difference of time responses of the different phosphors used in the plasma display panels (PDPs) for producing colored light (Red, Green, Blue). Each of the three colored lights is generated by the same electrical excitation of a gas. This excitation provides some UV rays, which will strike the front plate where a layer of phosphor has been deposited. There are three kinds of phosphors, one for each color. Because it is the same UV excitation for each cell, the response of each phosphor should also be the same. It means that it should have the same amplitude response and the same time response. The difficulty in having both is huge. Generally the trade-off is made to have a correct white level, which means a homogeneous amplitude response for each phosphor. On the other hand, to get the good amplitude response, the homogeneity of the time response is generally sacrificed. Although different powders of phosphor with different time and amplitude responses are used, every panel has some problem of time response especially for the red and green components. This problem is called phosphor lag.

[0003] Figure 1 shows the time response of the three phosphors after switching on and off one pixel. The first diagram of figure 1 represents the drive voltage applied to three cells with different phosphors (blue, red, green) and the second diagram shows the light response of these cells. Compared to the blue cell, the rising and especially falling times of light emission of the red cell and the green cell are much longer, which results in the emission of blue light before red and green lights. Due to the integration ability of the human eye, this effect will be masked if the picture is stationary and the perceived color is only white. In case of a moving object like a white rectangle on a black background, the phosphor lag becomes visible and a blue and a yellow-green edge appears.

[0004] In order to minimize this artifact, the gravity center of the red, green and blue curves of the figure 1 can be moved in order to be at the same temporal place. Such an operation is shown at figure 2. The gravity center of a curve means the time where half of the light energy is emitted. In this figure, the blue curve is shifted so that its gravity center matches the gravity centers of the two others. Although the phosphor lag artifact can not be completely avoided, the perceived coloured edges are strongly reduced with this operation.

[0005] To delay the blue light emission, a solution is disclosed in the International patent application WO 02/17288. An intermediate blue image is computed for each couple of consecutive images I and I+1 and this blue image is displayed simultaneously with the red and green components of the image I. This solution provides a great flexibility in terms of shifting delay and works independently of the sub-field coding. But it needs a motion estimator and extra frame memories to interpolate and to hold the intermediate images.

[0006] Another solution is proposed in the international patent application WO 02/093539. The phosphor lag is compensated by shifting differently the sub-fields of the three colour components. In this method, a movement vector corresponding to movement between two successive images is computed. The sub-fields associated with one type of phosphor are displaced, the amplitude of the displacement depending on the amplitude of the movement vector and on the type of phosphor. Due to the compensation at sub-field level, there is no need to interpolate and store intermediate images. Therefore any logic for the interpolation and extra frame memories holding the intermediate images can be saved. Drawbacks of this method are that each sub-field shifting is limited to the pixel resolution and that a motion estimator is needed.

Summary of the invention

[0007] The invention proposes another solution for phosphor lag compensation. The invention concerns a method for displaying a sequence of video images on a plasma display panel comprising a plurality of elementary cells each including one type of phosphor from among at least two types of phosphors (blue, green, red) homogeneously distributed in the display panel, the display of a video image taking place for a display period divided by a plurality of sub-fields during which each elementary cell emits or does not emit coloured light according to the type of phosphor with which it is associated, characterized in that different groups of sub-fields are used for displaying a video image for at least two types of phosphor.

[0008] In a first embodiment, at least one sub-field of the plurality of sub-fields of the display period of a video image is used by only one type of phosphor. Preferably, this (these) sub-field(s) is (are) the one(s) with the highest durations of the display period. If the phosphor using this (these) sub-field(s) is the phosphor having the highest time response, this (these) sub-fields(s) is (are) placed at the end of the display period. For example, if the blue phosphor is the type of phosphor having the highest time response, at least one of the last sub-fields in the display period will be used only by this phosphor.

[0009] In a second embodiment, for at least one type of phosphor, the sub-fields used for displaying a current video image are, for a first part, sub-fields used by the other types of phosphor for displaying the current image and, for a second part, sub-fields used by the other types of phosphor for displaying the image preceding or following the current image. Preferably, the sub-fields of the second part are sub-fields with the highest durations of the display period. If the type of phosphor having said first and second parts of sub-fields is the type of phosphor having the highest time response, the sub-fields of the second part are the sub-fields of the display period of the video image following the current image which are placed at the end of this display period.

[0010] The invention also relates to a plasma display panel for displaying a sequence of video images comprising :

- a plurality of elementary cells each including one type of phosphor from among at least two types of phosphors (blue, green, red) homogeneously distributed in the display panel,
- control means for displaying each video image during a display period divided by a plurality of sub-fields during which each elementary cell emits or does not emit coloured light according to the type of phosphor with which it is associated,

characterized in that it further comprises image processing means for encoding the image using different groups of sub-fields for at least two types of phosphor.

[0011] In a first embodiment, the image processing means comprise sub-field encoding means for encoding a current video image into sub-field code and time shifting means for shifting a part of the sub-field code of at least one color component of the image associated to one type of phosphor and activating dedicated sub-fields of the plurality of sub-fields of the display period, said dedicated sub-field being used only by said color component.

[0012] In a second embodiment, the image processing means comprise sub-field encoding means for encoding a current video image into sub-field code, a sub-field memory for storing a part of the sub-field code of at least one color component of the current image associated to one type of phosphor and time shifting means for reintroducing it in the sub-field code of the next picture.

[0013] The invention concerns also a device implementing the above-mentioned method.

Brief description of the drawings

[0014] Exemplary embodiments of the invention are illustrated in the drawings and are explained in more detail in the following description. The drawings showing in:

- Figure 1 the time responses of examples of blue, red and green phosphors;
- Figure 2 the time responses of the phosphors of Figure 1 where the response of the blue phosphor is shifted;
- Figure 3A a classical 12-subfields coding scheme ;
- Figure 3B a 15-subfields coding scheme according to a first embodiment of the invention;
- Figure 4 a block diagram for coding input video data according the subfield coding scheme of figure 3B;
- Figure 5A a classical 12-subfields coding scheme of figure 3A shown on two consecutive frames displaying a 255 to 61 transition;
- Figure 5B a 12-subfields coding scheme according to a second embodiment of the invention for a 255 to 61 transition;

Figure 6 a 12-subfields coding scheme according to the second embodiment of the invention for a 255 to 0 transition; and

Figure 7 a block diagram for coding input video data according the subfield coding scheme of figure 5B or 5C;

Description of preferred embodiments

[0015] The best way to superpose the gravity center of the three color components of the video signal is to apply a delay to the component(s) with the highest time response compared with the other color component(s). The invention will be described for a panel where green and red phosphors have similar temporal characteristics and where blue has a higher time response compared with the red and green color components.

[0016] The principle of the invention is to use different sub-field coding schemes for the color components.

[0017] The invention takes into account the fact that the phosphor lag is due for a big part to the position of the high level sub-fields (high duration sub-fields). These sub-fields are the ones, which are "shifted" according to the invention.

[0018] In a first embodiment, some specific sub-fields are added in the video frame (display period) and are dedicated to phosphor lag compensation. A new coding scheme using these specific sub-fields is defined. The number of the added sub-fields depends on the delay to be applied. In reference to Figure 3B to be compared to Figure 3A, 3 specific sub-fields are added. This number of sub-fields seems to be the minimum for the actual panels.

[0019] In Figure 3A, the 3 color components are coded with a classical 12 sub-fields code. The sub-fields have the following weights:

1 2 4 8 16 32 32 32 32 32 32 32

In Figure 3B, the red and green components are also coded with this classical 12 sub-fields code and the blue component is coded on 15 sub-fields : the 12 sub-fields of the classical code and 3 specific 32 weighted sub-fields dedicated to phosphor lag compensation and placed at the end of the frame.

[0020] In this example, the three first 32 weighted sub-fields are always off for the blue component and the three final 32 weighted sub-fields are always off for the two other colour components. The idea is here to apply a shift to the rising and falling edges of the blue light emission. That is done by applying a time delay on the highly weighted sub-fields. If we consider that the front edge starts with the first 32 weighted sub-field for the red and green components, there is three addressing times plus three sustain periods delay for the blue component, that means (3*0.7*20)/15+(0.3*20*96)/351=4.44 ms if the addressing time represents 70% of the frame period (or display period) and the duration of the frame period is 20 ms. This time corresponds approximately to the shift to be applied to the blue component to superpose its gravity centre with the gravity centres of the red and green components.

[0021] Simulations show that there is no additional false contour due to the "holes" created in the blue coding scheme by the 3 first weighted sub-fields OFF. Another advantage of this method is that it is possible to shift one or more colour components of the video signal and, if several components are shifted, to shift them differently.

[0022] Figure 4 shows the block diagram of a plasma display panel implementing the method illustrated by Figure 3B. A 8-bit video signal (one for each colour) is inputted to image processing means 10. It includes a sub-field encoding block 11 for coding the 8-bit video signal into a 12-bit video signal (one bit for each sub-field) and a time shifting block 12 for converting the 12-bit signal into 15-bit video signal so as to shift the blue component (more particularly the highly weighted sub-fields of the blue component) as shown by figure 3B. This signal is then transmitted to the drivers13 of the display panel. Then the drivers 13 generate control signals for driving the state of the cells of the cells 14 of the PDP.

[0023] This method does not need motion estimator or additional memory. Furthermore, it can be possible to use the specific sub-fields for increasing the luminance of the display panel for the static images.

[0024] In a second embodiment, a classical coding scheme is used for all color components but the video information of the blue component is spread on two successive frames. This embodiment is illustrated by Figures 5A and 5B. Figure 5A shows a transition for all color components between a video level 255 and a video level 61 on two successive frames N and N+1. These two levels are coded with a classical 12-sub-fields code. The sub-fields used have the same weights as those given in figure 3A. In figure 5B, these levels are coded with this classical 12-sub-fields code using a split coding.

[0025] In this embodiment, for the blue component, the sub-fields used for displaying a current video image are, for a first part, sub-fields used by the red and green components for displaying the current image and, for a second part, sub-fields used by the red and green components for displaying the next image in the image sequence to be displayed. In figure 5B, some sub-fields used for displaying red and green video information of frame N+1 are used for displaying blue video information of the frame N.

[0026] In the example of figure 5B, for the red and green components of the video signal, the sub-fields of the frame N are used for displaying the level 255 and the sub-fields of the frame N+1 are used for displaying the level 61. For the blue component, some sub-fields (32-weighted sub-fields) of frame N+1 are used for displaying the level 255. Consequently, the level 255 is displayed for a part (sub-fields with weights 1, 2, 4, 8, 16 and four 32-weighted sub-fields) during the frame N and for a second part (three 32-weighted sub-fields) during the frame N+1. The three first 32-weighted sub-fields of the frame N are used for displaying a part of the blue video information of the frame N-1. Thus, the displaying of the blue video information associated to the 32-weighted sub-fields is shifted three 32-weighted sub-fields forward. In the same manner, the first 32-weighted sub-field for displaying the level 61 is shifted three 32-weighted sub-fields forward.

[0027] This split coding scheme is applied on the high level sub-fields. That means that a sub-field bit plan memory should be provided in the display panel for storing the second part of the sub-field codes of the current video image. In the example of figure 5B, for the blue component, the code of the three last 32 weighted sub-fields are stored to be used as the three first 32-weighted sub-fields of the frame N+1. The depth of this extra memory depends on the delay to apply to the blue component (3 sub-fields seems to be the minimum). In the example of figure 5B, 3-bit data should be stored for each pixel of the picture to be displayed.

[0028] In this embodiment, it is possible to position precisely the rising edge of the blue component compared with the two other components (like the first embodiment). For the falling edge, it is not so good as in the first embodiment because the low weighted sub-fields of the frame N+1 are placed before the shifted 32 weighted sub-fields of the frame N. But, simulations do not show critical cases.

[0029] One critical case, illustrated by figure 6, could be the case of a 255 to 0 transition where there is no activated 32 weighted sub-fields for the green and red components in the next frame and no activated low weighted sub-fields for the blue component. There is a "hole" in the blue light emission between the last 32-weighted subfield of frame N and the first 32-weighted subfield of frame N+1 but it creates few false contours. But, in most cases, this high transition is quite unusual in video domain and at least one low weighted sub-field in the frame N+1 is activated.

[0030] Figure 7 shows a block diagram of a plasma display panel implementing the method illustrated by Figure 5B. A 8-bit video signal (one for each colour) is inputted to image processing means 20. It includes a sub-field encoding block 21 for coding it into a 12-bit video signal (one bit for each sub-field), a . sub-field memory 23 and a time shifting block 22. The bit associated to the three last 32-weighted sub-field in the 12-bit video signal of the current image are stored in the sub-field memory 23 and introduced in the next image as shown in figure 5B by the time shifting block 22. The video signal thus processed is then transmitted to the drivers 24 of the display panel for controlling the cells 25 of the panel.

[0031] This second embodiment does not need motion estimator or specific sub-fields for compensating the phosphor lag.

[0032] It has to be noted that the disclosed embodiments are examples and that the number of shifted sub-fields and their position as well as the number of shifted colour components can be subject of modification of other embodiments of the invention that are considered to fall within the scope of the claims.

Claims

1. Method for displaying a sequence of video images on a plasma display panel comprising a plurality of elementary cells each including one type of phosphor from among at least two types of phosphors (blue, green, red) homogeneously distributed in the display panel, the display of a video image taking place for a display period divided by a plurality of sub-fields during which each elementary cell emits or does not emit coloured light according to the type of phosphor with which it is associated, **characterized in that** different groups of sub-fields are used for displaying a video image for at least two types of phosphor.

2. Method according to Claim 1, **characterized in that** at least one sub-field of the plurality of sub-fields of the display period of a video image is used by only one type of phosphor.

3. Method according to claim 2, **characterized in that** said at least one sub-field is one of the sub-fields with the highest durations of the display period.

4. Method according to claim 2 or 3 **characterized in that** said at least one sub-field is used by the type of phosphor having the highest time response and **in that** said sub-field is placed at the end of the display period.

5. Method according to Claim 1, **characterized in that**, for at least one type of phosphor, the sub-fields used for displaying a current video image are, for a first part, sub-fields used by the other types of phosphor for displaying said current image and, for a second part, sub-fields used by the other types of phosphor for displaying the image preceding or following the current image.

6. Method according to claim 5, **characterized in that** the sub-fields of said second part are sub-fields with the highest durations of the display period.

7. Method according to claim 5 or 6 **characterized in that** the type of phosphor having said first and second parts of sub-fields is the type of phosphor having the highest time response and **in that** the sub-fields of the second part are placed at the end of the display period of the video image following the current image.

8. Plasma display panel for displaying a sequence of video images comprising :

   - a plurality of elementary cells (14;25) each including one type of phosphor from among at least two types of phosphors (blue, green, red) homogeneously distributed in the display panel,
   - control means (13;24) for displaying each video image during a display period divided by a plurality of sub-fields during which each elementary cell emits or does not emit coloured light according to the type of phosphor with which it is associated,

   characterized in that it further comprises image processing means (10;20) for encoding the image using different groups of sub-fields for at least two types of phosphor.

9. Plasma display panel according to Claim 8, **characterized in that** the image processing means (10) comprise sub-field encoding means (11) for encoding a current video image into sub-field code and time shifting means (12) for shifting a part of the sub-field code of at least one color component of the image associated to one type of phosphor and activating dedicated sub-fields of the plurality of sub-fields of the display period, said dedicated sub-field being used only by said color component.

10. Plasma display panel according to Claim 8, **characterized in that** the image processing means (20) comprise sub-field encoding means (21) for encoding a current video image into sub-field code, a sub-field memory (23) for storing a part of the sub-field code of at least one color component of the current image associated to one type of phosphor and time shifting means (22) for reintroducing it in the sub-field code of the next picture.

11. Device **characterized in that** it used for implementing the method according to one of the claims 1 to 6.

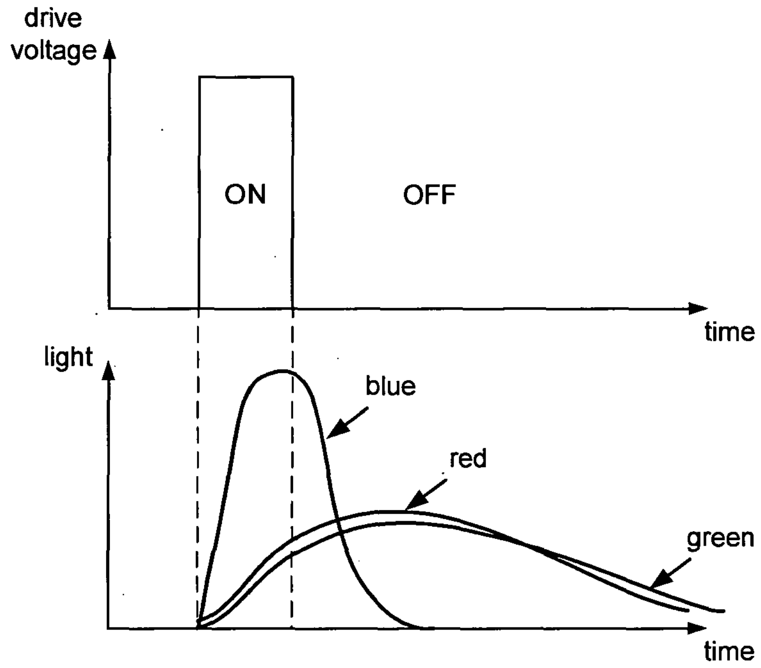
drive
voltage
ON
OFF
time
light
blue
red
green
time

FIG.1

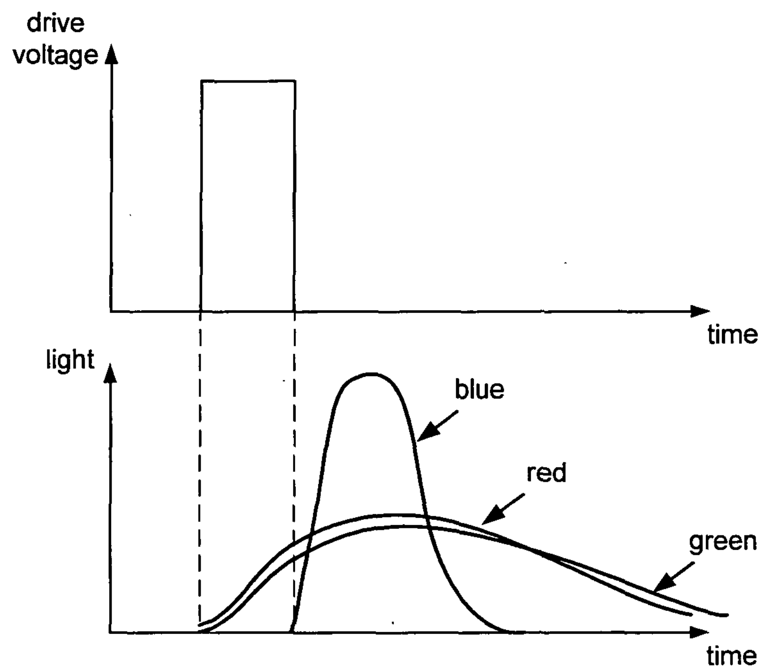
drive
voltage
time
light
blue
red
green
time

FIG.2

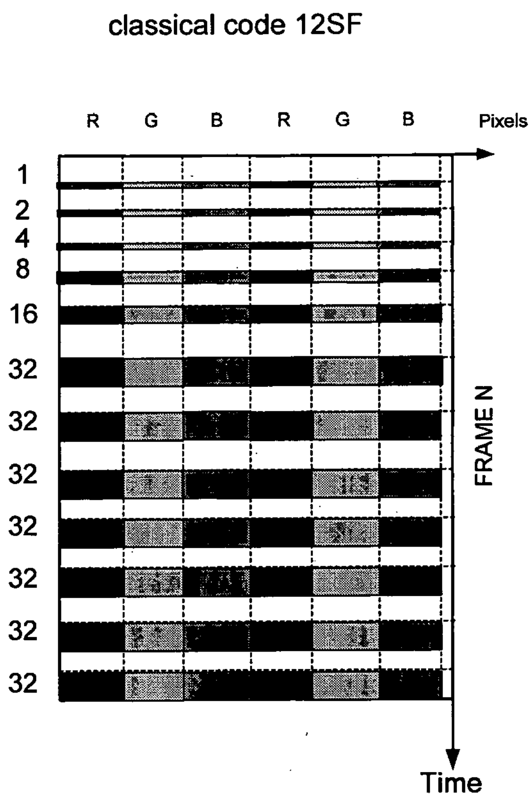
classical code 12SF
R G B R G B Pixels
1
2
4
8
16
32
32
32
32
32
32
32
FRAME N
Time

FIG.3A

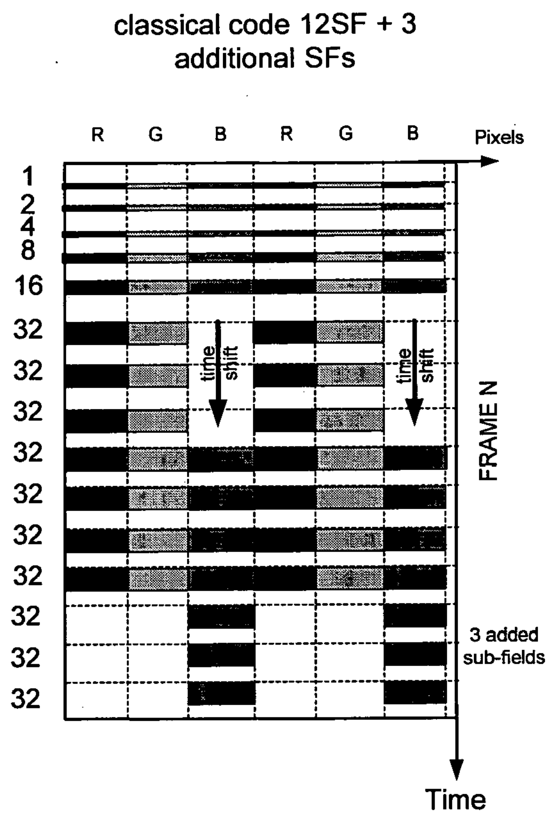
classical code 12SF + 3 additional SFs
R G B R G B Pixels
1
2
4
8
16
32
32
32
32
32
32
32
32
32
32
time shift
time shift
FRAME N
3 added sub-fields
Time

FIG.3B

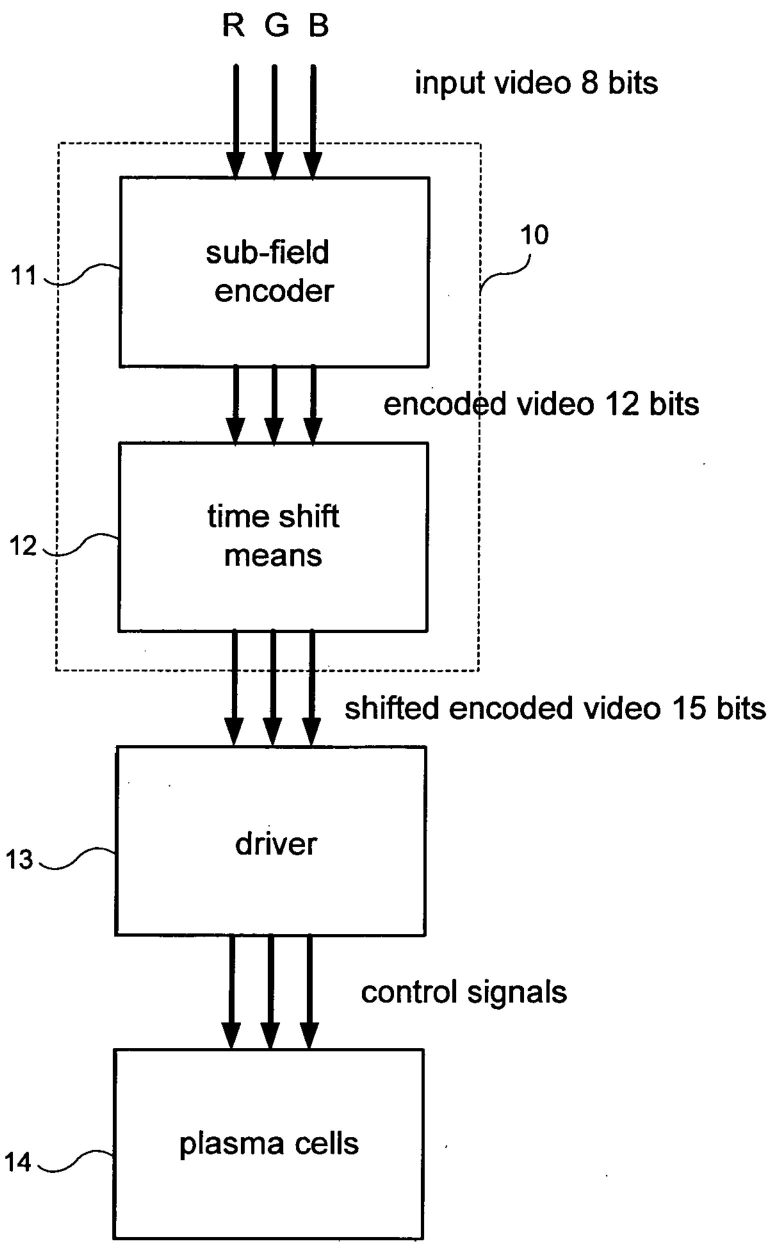
R G B
input video 8 bits
10
11
sub-field
encoder
encoded video 12 bits
12
time shift
means
shifted encoded video 15 bits
13
driver
control signals
14
plasma cells

FIG.4

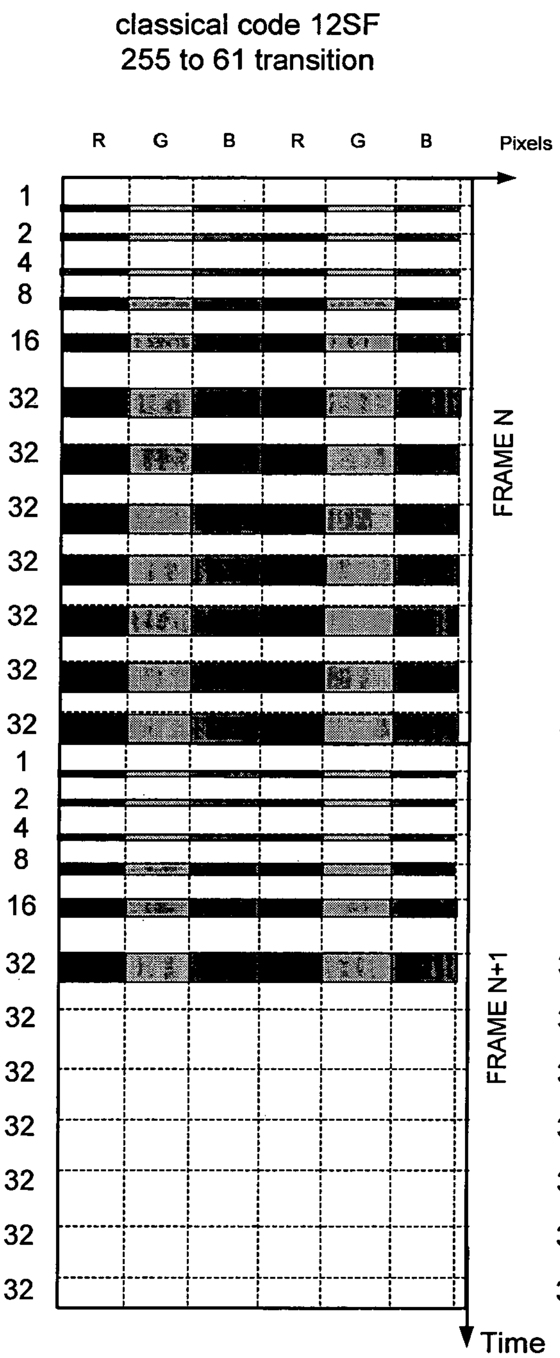
classical code 12SF
255 to 61 transition
R G B R G B Pixels
1
2
4
8
16
32
32
32
32
32
32
32
1
2
4
8
16
32
32
32
32
32
32
32
FRAME N
FRAME N+1
Time

FIG.5A

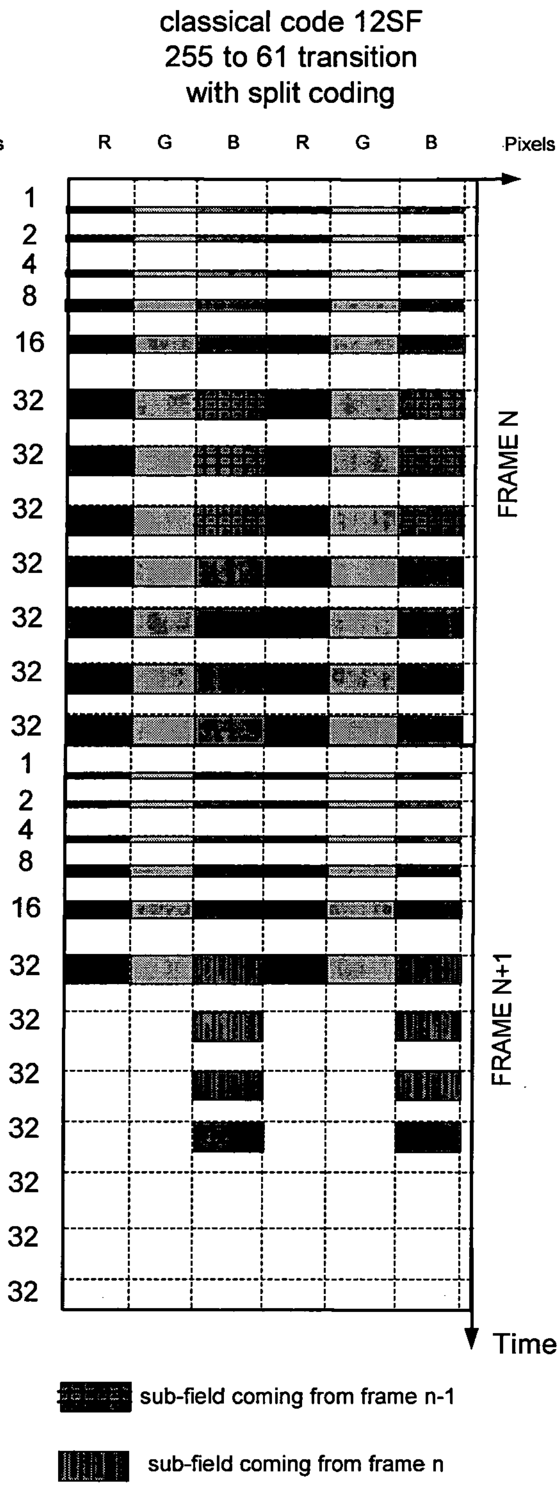
classical code 12SF
255 to 61 transition
with split coding
R G B R G B Pixels
1
2
4
8
16
32
32
32
32
32
32
32
1
2
4
8
16
32
32
32
32
32
32
32
FRAME N
FRAME N+1
Time
sub-field coming from frame n-1
sub-field coming from frame n

FIG.5B

classical code 12SF
255 to 0 transition
with split coding

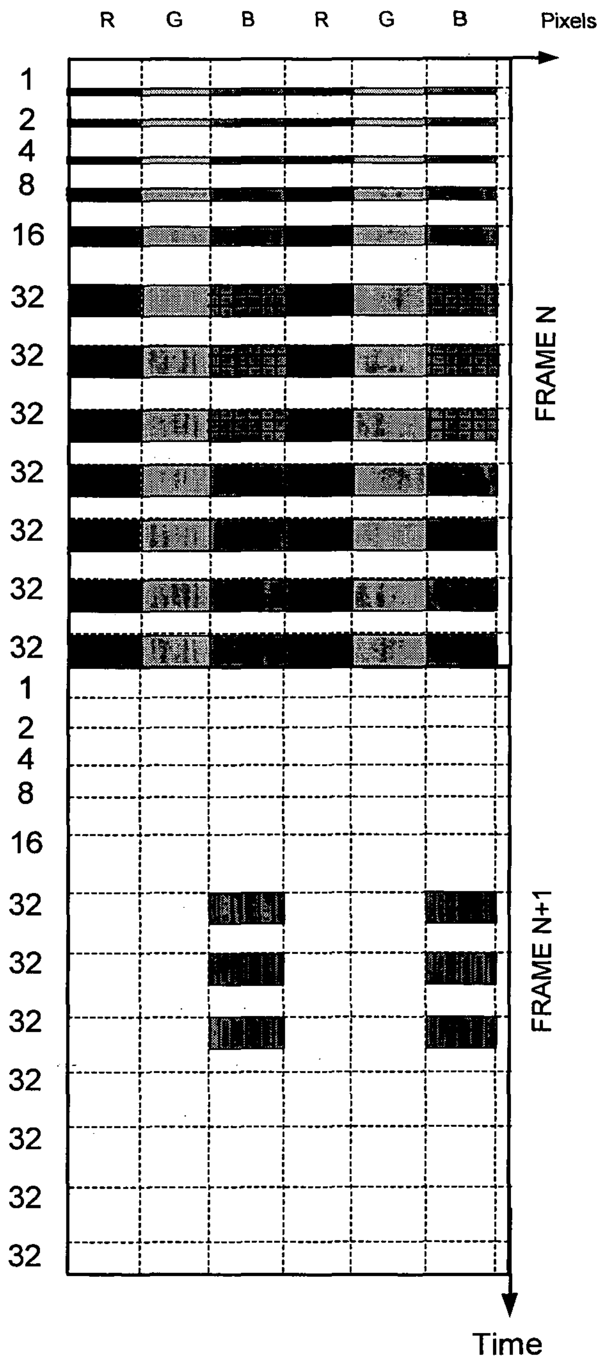

FIG.6

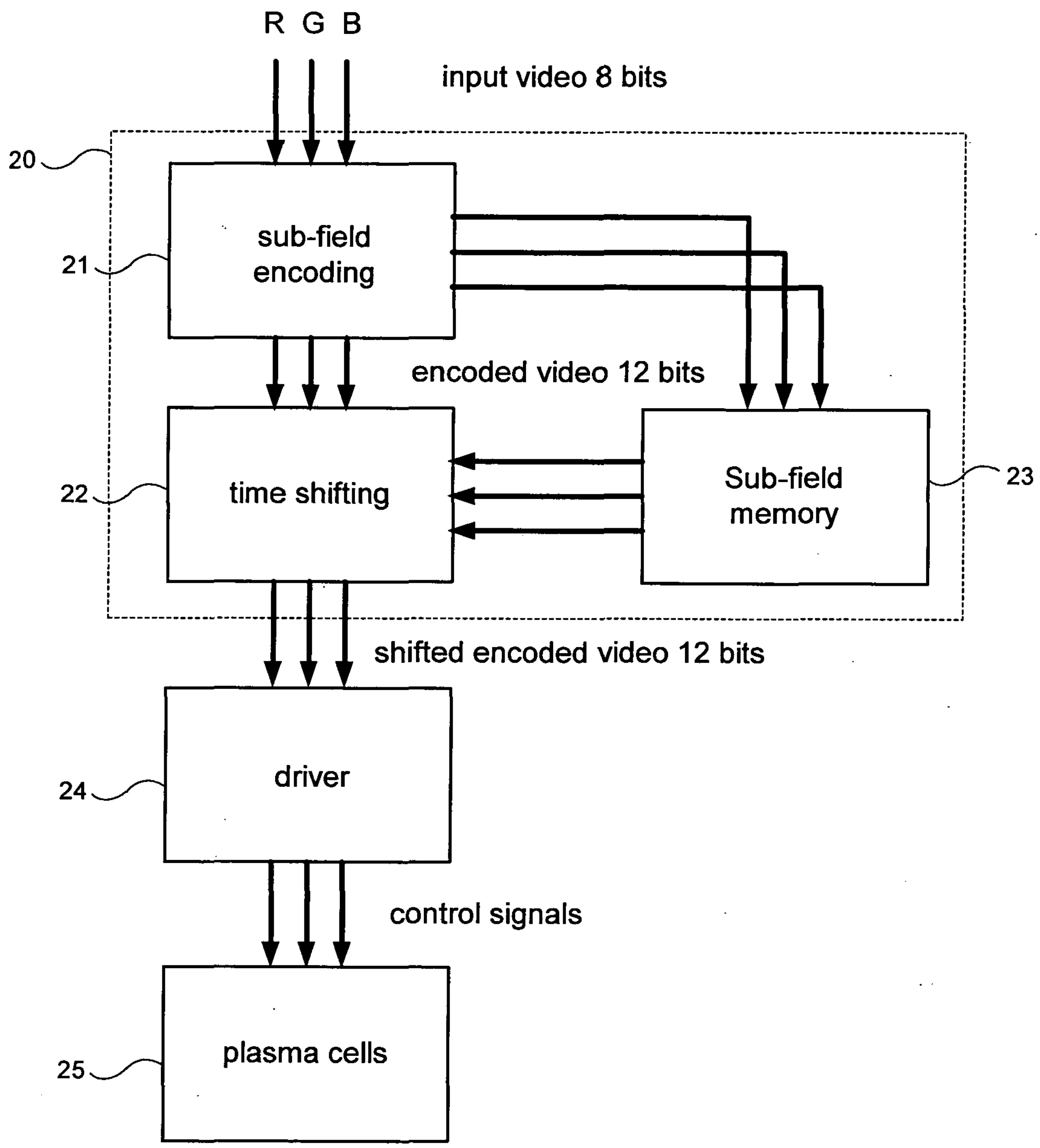
R G B
input video 8 bits
20
21
sub-field encoding
encoded video 12 bits
22
time shifting
Sub-field memory
23
shifted encoded video 12 bits
24
driver
control signals
25
plasma cells

FIG.7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 29 0170

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 1 288 899 A (THOMSON LICENSING S.A) 5 March 2003 (2003-03-05) * the whole document * -----	1-4,8,9, 11	G09G3/28
X	EP 1 291 835 A (DEUTSCHE THOMSON-BRANDT GMBH) 12 March 2003 (2003-03-12) * the whole document * -----	1-4,8,9, 11	
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X	PATENT ABSTRACTS OF JAPAN vol. 2002, no. 05, 3 May 2002 (2002-05-03) -& JP 2002 014647 A (FUJITSU HITACHI PLASMA DISPLAY LTD), 18 January 2002 (2002-01-18) * the whole document * -----	1,5-8, 10,11	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 April 2005	Harke, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 29 0170

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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18-04-2005

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			JP	2003177698	A	27-06-2003
			TW	220841	B	01-09-2004
			US	2003057894	A1	27-03-2003
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			CN	1407523	A	02-04-2003
			EP	1288899	A1	05-03-2003
			JP	2003177698	A	27-06-2003
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