

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
3 January 2008 (03.01.2008)

PCT

(10) International Publication Number
WO 2008/000751 A1(51) International Patent Classification:
G09G 3/32 (2006.01)(74) Agents: LE DANTEC, Claude et al.; Thomson, 46, Quai
Alphonse Le Gallo, F-92100 Boulogne Billancourt (FR).(21) International Application Number:
PCT/EP2007/056386(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH,
CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG,
ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL,
IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK,
LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW,
MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL,
PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY,
TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA,
ZM, ZW.

(22) International Filing Date: 26 June 2007 (26.06.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
06300743.9 30 June 2006 (30.06.2006) EP
06301063.1 19 October 2006 (19.10.2006) EP(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL,
PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM,
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).(71) Applicant (for all designated States except US): THOM-
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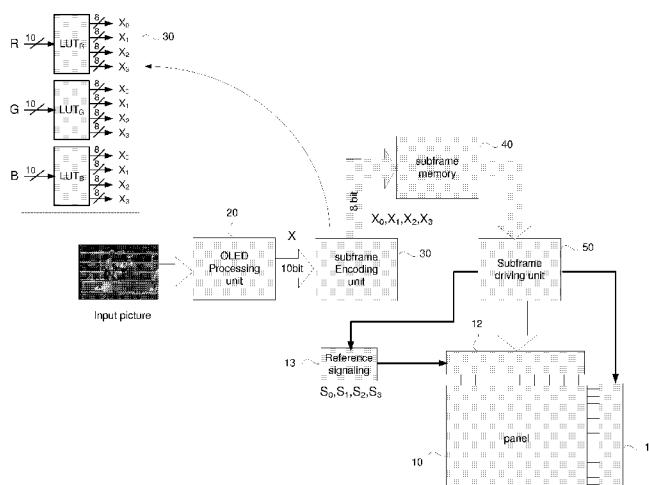
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Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: METHOD FOR GRayscale RENDITION IN AN AM-OLED



WO 2008/000751 A1

(57) Abstract: The present invention relates to an apparatus for displaying an input picture of a sequence of input pictures during a video frame made up of N consecutive sub-frames, with $N \geq 2$, comprising - an active matrix (10) comprising a plurality of light emitting cells, - encoding means (30,40) for encoding the video data of each pixel of the input picture to be displayed and delivering N sub-frame data, each sub-frame data being displayed during a sub-frame, - a driving unit (50,11,12,13) for selecting row by row the cells of said active matrix (10) and converting, sub-frame by sub-frame, the sub-frame data delivered by said encoding means into signals to be applied to the selected cells of the matrix, According to the invention, at least one of the N sub-frame data generated for a pixel is different from the video data of said pixel.

METHOD FOR GRayscale RENDITION IN AN AM-OLED

Field of the invention

The present invention relates to a grayscale rendition method in an active matrix OLED (Organic Light Emitting Display) where each cell of the display is controlled via an association of several Thin-Film Transistors (TFTs). This method has been more particularly but not exclusively developed for video application.

10 Background of the invention

The structure of an active matrix OLED or AM-OLED is well known. It comprises :

- an active matrix containing, for each cell, an association of several TFTs with a capacitor connected to an OLED material; the capacitor acts as a memory component that stores a value during a part of the video frame, this value being representative of a video information to be displayed by the cell during the next video frame or the next part of the video frame; the TFTs act as switches enabling the selection of the cell, the storage of a data in the capacitor and the displaying by the cell of a video information corresponding to the stored data;

- a row or gate driver that selects row by row the cells of the matrix in order to refresh their content;

- a data or source driver that delivers the data to be stored in each cell of the current selected row; this component receives the video information for each cell; and

- a digital processing unit that applies required video and signal processing steps and that delivers the required control signals to the row and data drivers.

Actually, there are two ways for driving the OLED cells. In a first way, digital video information sent by the digital processing unit is converted by the data drivers into a current whose amplitude is proportional to the video information. This current is provided to the appropriate cell of the matrix. In a second way, digital video information sent by the digital processing unit is converted by the data drivers into a voltage whose amplitude is proportional to the video information. This current or voltage is provided to the appropriate cell of the matrix.

From the above, it can be deduced that the row driver has a quite simple function since it only has to apply a selection row by row. It is more or less a shift register. The data driver represents the real active part and can be 5 considered as a high level digital to analog converter. The displaying of video information with such a structure of AM-OLED is the following. The input signal is forwarded to the digital processing unit that delivers, after internal processing, a timing signal for row selection to the row driver synchronized with the data sent to the data drivers. The data transmitted to 10 the data driver are either parallel or serial. Additionally, the data driver disposes of a reference signaling delivered by a separate reference signaling device. This component delivers a set of reference voltages in case of voltage driven circuitry or a set of reference currents in case of current driven circuitry. Usually the highest reference is used for the white 15 and the lowest for the smallest gray level. Then, the data driver applies to the matrix cells the voltage or current amplitude corresponding to the data to be displayed by the cells.

Independently of the driving concept (current driving or voltage driving) 20 chosen for the cells, the grayscale level is defined by storing during a frame an analog value in the capacitor of the cell. The cell keeps this value up to the next refresh coming with the next frame. In that case, the video information is rendered in a fully analog manner and stays stable during the 25 whole frame. This grayscale rendition is different from the one in a CRT display that works with a pulse. Figure 1 illustrates the grayscale rendition in the case of a CRT and an AM-OLED.

Figure 1 shows that in the case of CRT display (left part of figure 1), the 30 selected pixel receives a pulse coming from the beam and generating on the phosphor of the screen a lighting peak that decreases rapidly depending on the phosphor persistence. A new peak is produced one frame later (e.g. 20ms later for 50hz, 16,67ms later for 60Hz). In this example, a level L1 is displayed during the frame N and a lower level L2 is displayed during a frame N+1. In case of an AMOLED (right part of figure 1), the luminance of 35 the current pixel is constant during the whole frame period. The value of the pixel is updated at the beginning of each frame. The video levels L1 and L2 are also displayed during the frames N and N+1. The illumination surfaces

for levels L1 and L2, shown by hatched areas in the figure, are equal between the CRT device and the AM-OLED device if the same power management system is used. All the amplitudes are controlled in an analog way.

5

The grayscale rendition in the AM-OLED introduces some artifacts. One of them is the rendition of low grayscale level rendition. Figure 2 shows the displaying of the two extreme gray levels on a 8-bit AM-OLED. This figure shows the difference between the lowest gray level produced by using a 10 data signal C_1 and the highest gray level (for displaying white) produced by using a data signal C_{255} . It is obvious that the data signal C_1 must be much lower than C_{255} . C_1 should normally be 255 times as low as C_{255} . So, C_1 is very low. However, the storage of such a small value can be difficult due to the inertia of the system. Moreover, an error in the setting of this value 15 (drift...) will have much more impact on the final level for the lowest level than for the highest level.

Another problem of the AM-OLED appears when displaying moving pictures. This problem is due to the reflex mechanism, called optokinetic nystagmus, 20 of the human eyes. This mechanism drives the eyes to pursue a moving object in a scene to keep a stationary picture on the retina. A motion-picture film is a strip of discrete still pictures that produces a visual impression of continuous movement. The apparent movement, called visual phi phenomenon, depends on persistence of the stimulus (here the picture). 25 Figure 3 illustrates the eye movement in the case of the displaying of a white disk moving on a black background. The disk moves towards left from the frame N to the Frame N+1. The brain identifies the movement of the disk as a continuous movement towards left and creates a visual perception of a continuous movement. The motion rendition in an AM-OLED conflicts with 30 this phenomenon, unlike the CRT display. The perceived movement with a CRT and an AM-OLED when displaying the frame N and N+1 of Figure 3 is illustrated in Figure 4. In the case of a CRT display, the pulse displaying suits very well to the visual phi phenomenon. Indeed, the brain has no problem to identify the CRT information as a continuous movement. 35 However, in the case of the AM-OLED picture rendition, the object seems to stay stationary during a whole frame before jumping to a new position in the

next frame. Such a movement is quite difficult to be interpreted by the brain that results in either blurred pictures or vibrating pictures (judder).

5 The international patent application WO 05/104074 in the name of Deutsche Thomson-Brandt Gmbh discloses a method for improving the grayscale rendition in an AM-OLED when displaying low grayscale levels and/or when displaying moving pictures. The idea is to split each frame into a plurality of subframes wherein the amplitude of the signal can be adapted to conform to the visual response of a CRT display.

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In this patent application, the amplitude of the data signal applied to the cell is variable during the video frame. For example, this amplitude is decreasing. To this end, the video frame is divided in a plurality of sub-frames SF_i and the data signal which is classically applied to a cell is converted into a plurality of independent elementary data signals, each of these elementary data signals being applied to the cell during a sub-frame. The duration D_i of the different sub-frames can also be variable. The number of sub-frames is higher than two and depends on the refreshing rate that can be used in the AMOLED. The difference with the sub-fields in plasma display 20 panels is that the sub-frames are analog (variable amplitudes) in this case.

Figure 5 shows the division of an original video frame into 6 sub-frames SF_0 to SF_5 with respective durations D_0 to D_5 . Six independent elementary data signals $C(SF_0)$, $C(SF_1)$, $C(SF_2)$, $C(SF_3)$, $C(SF_4)$ and $C(SF_5)$, are used for displaying a video level respectively during the sub-frames SF_0 , SF_1 , SF_2 , SF_3 , SF_4 and SF_5 . The amplitude of each elementary data signal $C(SF_i)$ is either C_{black} or higher than C_{min} . C_{black} designates the amplitude of the elementary data signal to be applied to a cell for disabling light emission and C_{min} is a threshold that represents the signal amplitude value above which the working of the cell is considered as good (fast write, good stability...). C_{black} is lower than C_{min} . In this figure, the amplitude of the elementary data signals decreases from the first sub-frame to the sixth sub-frame. As the elementary data signals are based on reference voltages or reference currents, this decrease can be carried out by decreasing the reference 30 voltages or currents used for these elementary signals.

The object of the invention is to propose a display device having an increased bit depth. The video data of the input picture are converted into N sub-frame data by a sub-frame encoding unit and then each sub-frame data is converted into an elementary data signal. According to the invention, at 5 least one sub-frame data of a pixel is different from the video data of said pixel.

The invention relates to an apparatus for displaying an input picture of a sequence of input pictures during a video frame made up of N consecutive 10 sub-frames, with $N \geq 2$, comprising

- an active matrix comprising a plurality of light emitting cells,
- encoding means for encoding the video data of each pixel of the input picture to be displayed and delivering N sub-frame data, each sub-frame data being displayed during a sub-frame, and

15 - a driving unit for selecting row by row the cells of said active matrix, converting, sub-frame by sub-frame, the sub-frame data delivered by said encoding means into signals to be applied to the selected cells of the matrix. According to the invention, at least one of the N sub-frame data generated for a pixel is different from the video data of said pixel.

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Other features are defined in the appended dependent claims.

Brief description of the drawings

25 Exemplary embodiments of the invention are illustrated in the drawings and in more detail in the following description.

In the figures :

Fig.1 shows the illumination during frames in the case of a CRT and an AM-OLED;

30 Fig.2 shows the data signal applied to a cell of the AM-OLED for displaying two extreme grayscale levels in a classical way;

Fig.3 illustrates the eye movement in the case of a moving object in a sequence of pictures;

35 Fig.4 illustrates the perceived movement of the moving object of Fig.3 in the case of a CRT and an AM-OLED;

Fig.5 shows a video frame comprising 6 sub-frames;

Fig.6 shows a simplified video frame comprising 4 sub-frames,

Fig.7 shows a first display device comprising a sub-frame encoding unit delivering sub-frame data,

Fig.8 shows a second display device wherein the sub-frame data are motion compensated;

5 Fig.9 illustrates the generation of interpolated pictures for different sub-frames of the video frame in the display device of figure 8,

Fig.10 to 13 illustrate different ways to associate input picture and interpolated pictures to sub-frames of a video frame, and

Fig.14 illustrates the interpolation and sub-frame encoding operations in the
10 display device of figure 8.

Description of preferred embodiments

In order to simplify the specification, we will take the example of a video
15 frame built of 4 analog sub-frames SF_0 to SF_3 having the same duration $D_0=D_1=D_2=D_3=T/4$ using a voltage driven system. The reference voltages of each sub-frame are selected in order to have luminance differences of 30% between two consecutive sub-frames. This means that, at each sub-frame (every 5ms) the reference voltages are updated according with the refresh of
20 the cell for the given sub-frame. All values and numbers given here are only examples. These hypotheses are illustrated by Figure 6. In practice, the number of sub-frames, their size and the amplitude differences are fully flexible and can be adjusted case by case depending on the application.

25 The invention will be explained in the case of a voltage driven system. In this case, the relation between the input video (input) and the luminance generated by the cell for said input video is a power of n, where n is close to 2. In case of current driven system, the relation between the input video (input) and the luminance generated by the cell for said input video is linear.
30 It is equivalent to have n=1.

Therefore, in case of a voltage driven system, the luminance (Out) generated by a cell is for this example:

$$\text{Out} = \frac{1}{4} \times (X_0)^2 + \frac{1}{4} \times (0.7 \times X_1)^2 + \frac{1}{4} \times (0.49 \times X_2)^2 + \frac{1}{4} \times (0.343 \times X_3)^2$$

35 where X_0 , X_1 , X_2 and X_3 are sub-frame data (8-bit information linked to the video values) used for the four sub-frames SF_0 , SF_1 , SF_2 and SF_3 .

In case of a current driven system, the luminance is

$$\text{Out} = \frac{1}{4} \times (X_0) + \frac{1}{4} \times (0.7 \times X_1) + \frac{1}{4} \times (0.49 \times X_2) + \frac{1}{4} \times (0.343 \times X_3)$$

This system enables to dispose of more bits as illustrated by the following

5 example:

- The maximum luminance is obtained for $X_0=255$, $X_1=255$, $X_2=255$ and $X_3=255$ which leads to an output luminance value of

$$\begin{aligned} \text{Out} &= \frac{1}{4} \times (255)^2 + \frac{1}{4} \times (0.7 \times 255)^2 + \frac{1}{4} \times (0.49 \times 255)^2 + \frac{1}{4} \times (0.343 \times 255)^2 \\ &= 30037.47 \text{ units} \end{aligned}$$

- The minimum luminance (without using the limit C_{\min}) is obtained for $X_0=0$,

10 $X_1=0$, $X_2=0$ and $X_3=1$ which leads to an output luminance value of

$$\begin{aligned} \text{Out} &= \frac{1}{4} \times (0)^2 + \frac{1}{4} \times (0.7 \times 0)^2 + \frac{1}{4} \times (0.49 \times 0)^2 + \frac{1}{4} \times (0.343 \times 1)^2 \\ &= 0.03 \text{ units} \end{aligned}$$

With a standard display without analog sub-frames (or sub-fields) having the same maximum luminance, the minimum luminance would be equal to

15 $\left(\frac{1}{N}\right)^2 \times 30037.47$ where N represents the bit depth. So

- for a 8-bit mode, the minimum luminance value is $\left(\frac{1}{255}\right)^2 \times 30037.47 = 0.46$ units,

- for a 9-bit mode, the minimum luminance value is $\left(\frac{1}{512}\right)^2 \times 30037.47 = 0.11$ units, and

20 - for a 10-bit mode, the minimum luminance value is $\left(\frac{1}{1024}\right)^2 \times 30037.47 = 0.03$ units.

This shows that the use of the analog sub-frames while simply based on 8-bit data drivers enables to generate increased bit-depth when sub-frame data related to a same video data can be different from said video data.

25 However, the conversion of a video data into sub-frame data must be done carefully.

Indeed, in a standard system (no analog sub-frame or sub-field), half the input amplitude corresponds to fourth of the output amplitude since the relation input/output is following a quadratic curve in voltage driven mode. This has to be followed also while using an analog sub-field concept. In 5 other words, if the input video value is half of the maximum available, the output value must be fourth of that obtained with $X_0=255$, $X_1=255$, $X_2=255$ and $X_3=255$. This can not be achieved simply with $X_0=128$, $X_1=128$, $X_2=128$ and $X_3=128$. Indeed,

$$\text{Out} = \frac{1}{4} \times (128)^2 + \frac{1}{4} \times (0.7 \times 128)^2 + \frac{1}{4} \times (0.49 \times 128)^2 + \frac{1}{4} \times (0.343 \times 128)^2 = 7568.38$$

10 which is not $30037.47 / 4 = 7509.37$. This is due to the fact that $(a+b+c+d)^2 \neq a^2 + b^2 + c^2 + d^2$.

Consequently, a specific sub-frame encoding is used in order that the 15 relation input/output follows a power of n, the value n depending on the display behaviour.

In the example of an input value of 128, the sub-frame data should be $X_0=141$, $X_1=114$, $X_2=107$ and $X_3=94$.

Indeed,

$$20 \quad \text{Out} = \frac{1}{4} \times (141)^2 + \frac{1}{4} \times (0.7 \times 114)^2 + \frac{1}{4} \times (0.49 \times 107)^2 + \frac{1}{4} \times (0.343 \times 94)^2 = 7509.37$$

which is exactly equal to $30037.47/4$. Such an optimization is done for each possible input video level. This specific encoding is implemented by a Look-Up table (LUT) inside the display device. The number of inputs of this LUT depends on the bit depth to be rendered. In case of 8-bit, the LUT has 255 25 input levels and, for each input level, four 8-bit output levels (one per sub-frame) are stored in the LUT. In case of 10-bit, the LUT has 1024 input levels and, for each input level, four 8-bit outputs (one per sub-frame).

Now let us assume that we would like to have a display capable of rendering 30 10-bit material. In that case the output level should correspond to $\left(\frac{X}{1024}\right)^2 \times 30037.47$ where X is a 10-bit level growing from 1 to 1024 by a step of 1. Below, you can find an example of encoding table that could be accepted to render 10-bit in our example. This is only an example and further optimization can be done depending on the display behavior:

10-bit analog display		Analog sub-frame encoding				
Input video data X	Awaited Energy	Sub-frame data X_0	Sub-frame data X_1	Sub-frame data X_2	Sub-frame data X_3	Energy
1	0.03	0	0	0	1	0.03
2	0.11	0	1	0	0	0.12
3	0.26	1	0	0	0	0.25
4	0.46	1	1	1	1	0.46
5	0.72	1	1	2	2	0.73
6	1.03	2	0	0	1	1.03
7	1.40	2	1	2	1	1.39
8	1.83	2	2	2	2	1.85
9	2.32	3	0	1	0	2.31
10	2.86	3	2	1	1	2.83
11	3.47	3	3	1	1	3.44
12	4.13	4	1	0	0	4.12
13	4.84	4	2	2	2	4.85
14	5.61	4	3	2	3	5.61
15	6.45	5	1	1	1	6.46
16	7.33	5	3	0	0	7.35
17	8.28	5	4	1	1	8.30
18	9.28	6	1	1	2	9.30
19	10.34	6	3	2	0	10.34
20	11.46	6	4	3	0	11.50
21	12.63	7	1	2	1	12.64
22	13.86	7	3	2	3	13.86
23	15.15	7	4	4	0	15.17
24	16.50	7	5	4	3	16.54
...
512	7509.37	141	114	107	94	7509.37
...
1024	30037.47	255	255	255	255	30037.47

Table 1

The table 1 shows an example of a 10-bit encoding based on the preceding hypotheses. Several options can be used for the generation of the encoding table but it is preferable to follow at least one of these rules:

5 - Minimize the error between the awaited energy and the displayed energy

- The digital value X_i of the most significant sub-frame (with the highest value $C_{\max}(SF_i)$) is growing with the input value.
- Try to keep as much as possible the energy of $X_n \times C_{\max}(SF_n) > X_{n+1} \times C_{\max}(SF_{n+1})$.

5 - Try to avoid to have $X_i=0$ if X_{i-1} and X_{i+1} are different from 0.

- Try to reduce as much as possible the energy changes of each sub-frame when the video value are changing

Figure 7 illustrates a display device wherein video data are encoded into sub-frame data. The input video data of the pictures to be displayed that are for example 3x8 bit data (8 bit for red, 8 bit for green, 8 bit for green) are first processed by a standard OLED processing unit 20 used for example for applying a de-gamma function to the video data. Other processing operations can be made in this unit. For the sake of clarity, we will consider the data of only one color component. The data outputted by the processing unit are for example 10 bit data. These data are converted into sub-frame data by a sub-frame encoding unit 30. The unit 30 is for example a look-up table (LUT) or 3 LUTs (one for each color component) including the data of table 1. It delivers N sub-frame data for each input data, N being the number of sub-frames in a video frame. If the video frame comprises 4 sub-frames as illustrated by figure 6, each 10-bit video data is converted into four 8-bit sub-frame data as defined in table 1. Each 8-bit sub-frame data is associated to a sub-frame. The n sub-frame data of each pixel are then stored in a sub-frame memory 40, a specific area in the memory being allocated to each sub-frame. Preferably, the sub-frame memory is able to store the sub-frame data for 2 pictures. The data of one picture can be written in the memory while the data of the other picture are read. The sub-frame data are then read sub-frame by sub-frame and transmitted to a sub-frame driving unit 50. This unit controls the row driver 11 and the data driver 12 of the active matrix 10 and transmits the sub-frame data to the data driver 12. The data driver 12 converts the sub-frame data into sub-frame signals based on reference voltages or currents. An example of conversion of sub-frame data X_i into a sub-frame signal based on reference signals is given in the table 2:

Sub-frame data X_i	Sub-frame signal based on reference voltages
0	$V7$
1	$V7 + (V6 - V7) \times 9/1175$
2	$V7 + (V6 - V7) \times 32/1175$
3	$V7 + (V6 - V7) \times 76/1175$
4	$V7 + (V6 - V7) \times 141/1175$
5	$V7 + (V6 - V7) \times 224/1175$
6	$V7 + (V6 - V7) \times 321/1175$
7	$V7 + (V6 - V7) \times 425/1175$
8	$V7 + (V6 - V7) \times 529/1175$
9	$V7 + (V6 - V7) \times 630/1175$
10	$V7 + (V6 - V7) \times 727/1175$
11	$V7 + (V6 - V7) \times 820/1175$
12	$V7 + (V6 - V7) \times 910/1175$
13	$V7 + (V6 - V7) \times 998/1175$
14	$V7 + (V6 - V7) \times 1086/1175$
15	$V6$
16	$V6 + (V5 - V6) \times 89/1097$
17	$V6 + (V5 - V6) \times 173/1097$
18	$V6 + (V5 - V6) \times 250/1097$
19	$V6 + (V5 - V6) \times 320/1097$
20	$V6 + (V5 - V6) \times 386/1097$
21	$V6 + (V5 - V6) \times 451/1097$
22	$V6 + (V5 - V6) \times 517/1097$
...	...
250	$V1 + (V0 - V1) \times 2278/3029$
251	$V1 + (V0 - V1) \times 2411/3029$
252	$V1 + (V0 - V1) \times 2549/3029$
253	$V1 + (V0 - V1) \times 2694/3029$
254	$V1 + (V0 - V1) \times 2851/3029$
255	$V0$

Table 2

These sub-frame signals are then converted by data driver 12 into voltage or current signals to be applied to cells of the active matrix 10 selected by the row driver 11. The reference voltages or currents to be used by the data driver 12 are defined in a reference signaling unit 13. In case of a voltage driven device, the unit 13 delivers reference voltages and in case of a current driven device, it delivers reference currents. An example of reference voltages is given by the table 3:

Reference voltages	Voltage (Volts)
V0	3
V1	2.6
V2	2.2
V3	1.4
V4	0.6
V5	0.3
V6	0.16
V7	0

Table 3

The decrease of the maximal amplitude of the sub-frame data from the first sub-frame SF_0 to the fourth sub-frame SF_3 illustrated by figure 6 is obtained 5 by decreasing the amplitude of the reference voltages used for a sub-frame SF_i compared to those used for the sub-frame SF_{i-1} . For example, 4 sets of reference voltages $S1, S2, S3$ and $S4$ are defined in the reference signaling unit 13 and the set of reference voltages used by the data driver 12 is changed at each sub-frame of the video frame. The change of set of 10 reference voltages is controlled by the sub-frame driving unit 50.

Preferably, the sub-frame data stored in the sub-frame memory are motion compensated to reduce artifacts (motion blur, false contours, etc.). So a 15 second display device illustrated by Figure 8 wherein the sub-frame data are motion compensated. In addition to the elements of figure 7, it comprises a motion estimator 60 placed before the OLED processing unit 20, a picture memory 70 connected to the motion estimator for storing at least one picture and a picture interpolation unit 80 placed between the OLED processing unit 20 and the sub-frame encoding unit 30.

20 The principle is that each input picture is converted into a sequence of picture, each one corresponding to the time period of a given sub-frame of the video frame. In the present case (4 sub-frames), each input picture is converted by the picture interpolation unit 80 into 4 pictures, the first one 25 being for example the original one and the three others being interpolated from the input picture and motion vectors by means well known from the man skilled in the art.

Figure 9 shows one basic principle of motion compensated sub-frame data in 50Hz. In this example, a motion vector is computed for a given pixel between a first input picture (frame T) and a second input picture (frame T+1) by the motion estimator 60. On this vector, three new pixels are 5 interpolated representing intermediate video levels of the given pixel at intermediate time periods. Three interpolated pictures can be generated in this way. The input picture and the interpolated picture are then used for determining the sub-frame data. The input picture is used for generating the 10 sub-frame data X_0 , the first interpolated picture is used for generating the sub-frame data X_1 , the second interpolated picture is used for generating the sub-frame data X_2 and the third interpolated picture is used for generating the sub-frame data X_3 . The input picture can be displayed during a sub-frame different from the sub-frame SF_0 . Advantageously, the input picture corresponds to the most luminous sub-frame (i.e the sub-frame having the 15 highest duration and/or the highest maximal amplitude). Indeed, usually interpolated pictures are suffering from artifacts linked to the up-conversion algorithm selected. It is quite impossible to have artifact free up-conversion. Therefore, it is then important to reduce such artifacts by using the interpolated pictures for less luminous sub-frames.

20

Figures 10 to 13 illustrate different possibilities of associating the input picture and the interpolated pictures to the sub-frames of a video frame. The input is always associated to the most luminous sub-frame.

25

Figure 14 illustrates the interpolation and the sub-frame encoding operations. The input picture is a 10-bit picture outputted by the OLED processing unit 20. This 10-bit input picture is converted into n 10-bit interpolated pictures (or sub-pictures), where n represents the amount of sub-frames. In the present case, the input picture is converted into 4 sub-30 pictures, the first one being the input picture and the three being interpolated pictures. Each sub-picture is forwarded to a separated encoding look-up table LUT_i delivering, for each sub-picture, the appropriate sub-frame data X_i . Each encoding LUT_i corresponds to a column X_i of the table 1. In the present case, the LUT_0 is used for the first sub-picture (input picture) and 35 delivers subframe data X_0 (associated to sub-frame SF_0), the LUT_1 is used for the second sub-picture (first interpolated picture) and delivers subframe data X_1 (associated to sub-frame SF_1), the LUT_2 is used for the third sub-

picture (second interpolated picture) and delivers subframe data X_2 (associated to sub-frame SF_2), and the LUT_3 is used for the fourth sub-picture (third interpolated picture) and delivers subframe data X_3 (associated to sub-frame SF_3). The sub-frame data delivered by the LUTs are coded in 8
5 bit and each LUT delivers data for the three color components.

WHAT IS CLAIMED IS :

- 1) Apparatus for displaying an input picture of a sequence of input pictures
5 during a video frame made up of N consecutive sub-frames, with $N \geq 2$, comprising
 - an active matrix (10) comprising a plurality of light emitting cells,
 - encoding means (30,40) for encoding the video data of each pixel of the input picture to be displayed and delivering N sub-frame data, each sub-
10 frame data being displayed during a sub-frame, and
 - a driving unit (50,11,12,13) for selecting row by row the cells of said active matrix (10) and converting, sub-frame by sub-frame, the sub-frame data delivered by said encoding means into signals to be applied to the selected cells of the matrix,
- 15 characterized in that at least one of the N sub-frame data generated for a pixel is different from the video data of said pixel.
- 20 2) Apparatus according to claim 1, wherein the sub-frame data generated for a n-bit video data are k-bit data with $k < n$.
- 25 3) Apparatus according to one of the preceding claims, wherein the encoding means (30) comprises at least one look-up table for encoding the video data of each pixel into N sub-frame data and a sub-frame memory (40) for storing said sub-frame data.
- 30 4) Apparatus according to claim 3, wherein the driving unit comprises
 - a row driver (11) for selecting row by row the cells of the active matrix (10)
 - a sub-frame driving unit (50) for reading, sub-frame by sub-frame, the sub-frame data stored in the sub-frame memory and controlling the row driver (11), and
 - a data driver (12) for converting the sub-frame data read by the sub-frame driving unit (50) into sub-frame signals and applying said sub-frame signals to the cells of the matrix selected by the row driver (11).
- 35 5) Apparatus according to claim 4, wherein the driving unit further comprises a reference signaling unit (13) that delivers to the data driver (12) reference signals on which the sub-frame signals to be applied to the cells are based.

- 6) Apparatus according to claim 5, wherein the reference signals change at each sub-frame within a video frame.
- 5 7) Apparatus according to claim 6, wherein the reference signals are decreasing from the first sub-frame to the last sub-frame within a video frame.
- 10 8) Apparatus according to claim 6, wherein the reference signals are increasing from the first sub-frame to the last sub-frame within a video frame.
- 15 9) Apparatus according to claim 6, wherein, within a video frame, the reference signals are increasing from the first sub-frame to an intermediate sub-frame and decreasing from said intermediate sub-frame to the last sub-frame, said intermediate sub-frame being different from the first and the last sub-frames.
- 20 10) Apparatus according to claim 6, wherein, within a video frame, the reference signals are decreasing from the first sub-frame to an intermediate sub-frame and increasing from said intermediate sub-frame to the last sub-frame, said intermediate sub-frame being different from the first and the last sub-frames.
- 25 11) Apparatus according to any one of claims 1 to 10, wherein it further comprises
 - a motion estimator (60) for computing a motion vector for each pixel of an input picture to be displayed during a current video frame, said motion vector being representative of the motion of said pixel between the current video frame and a next video frame,
 - 30 - an interpolation unit (80) for computing, for each input picture, N-1 interpolated pictures based on the motion vectors computed for said input picture,
and wherein the video data of each pixel of said input picture and interpolated pictures are encoded by the encoding means (40) into N sub-frame data, each sub-frame data being derived from one of said input picture and interpolated pictures.
- 35

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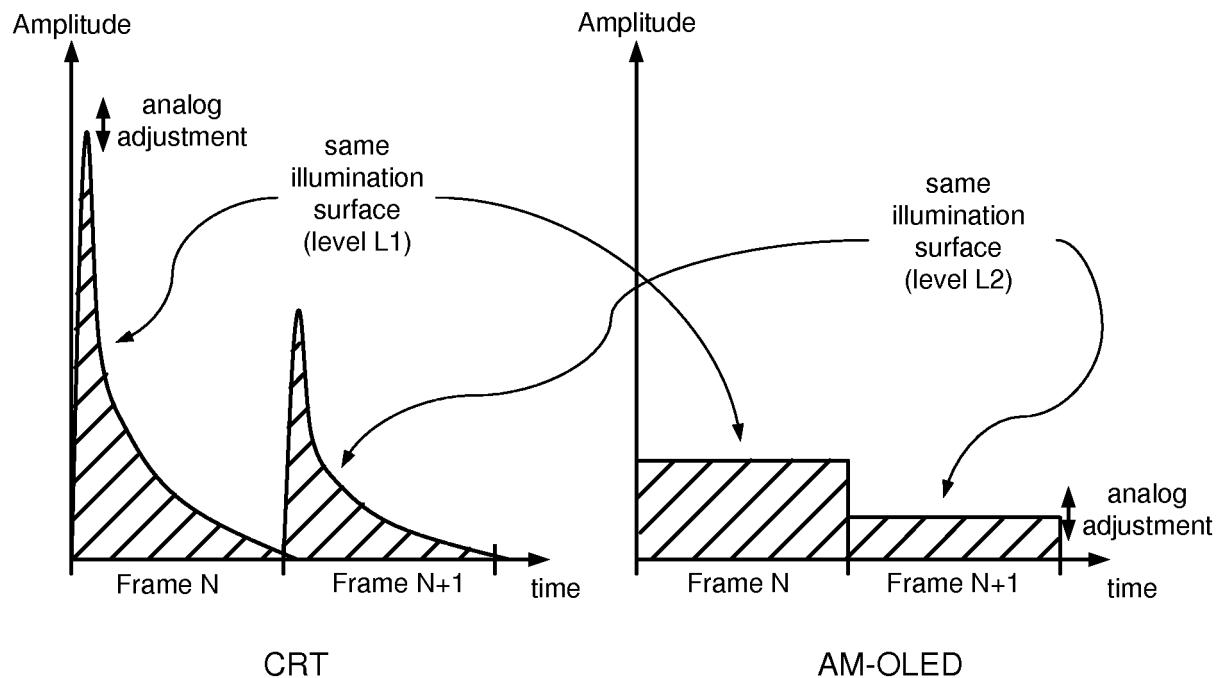


FIG.1

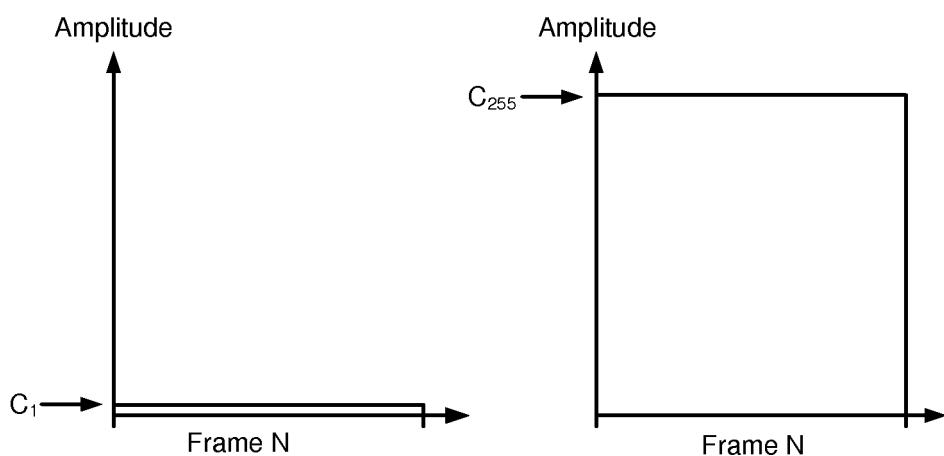


FIG.2

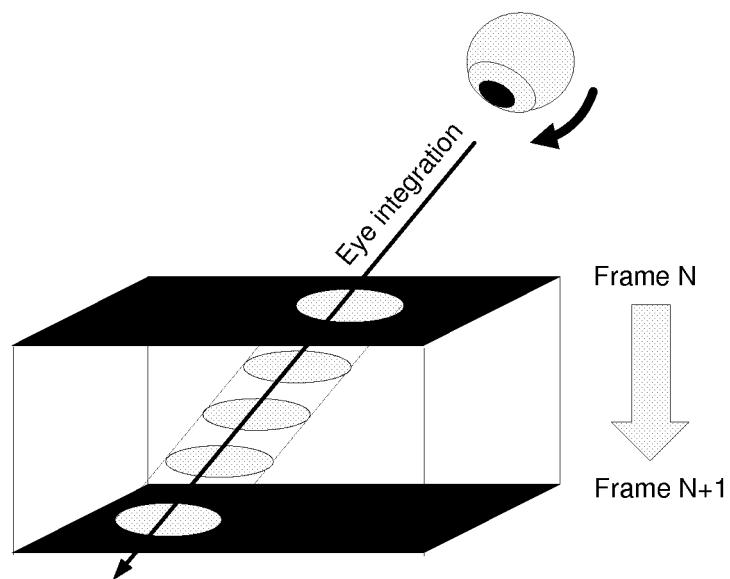


FIG.3

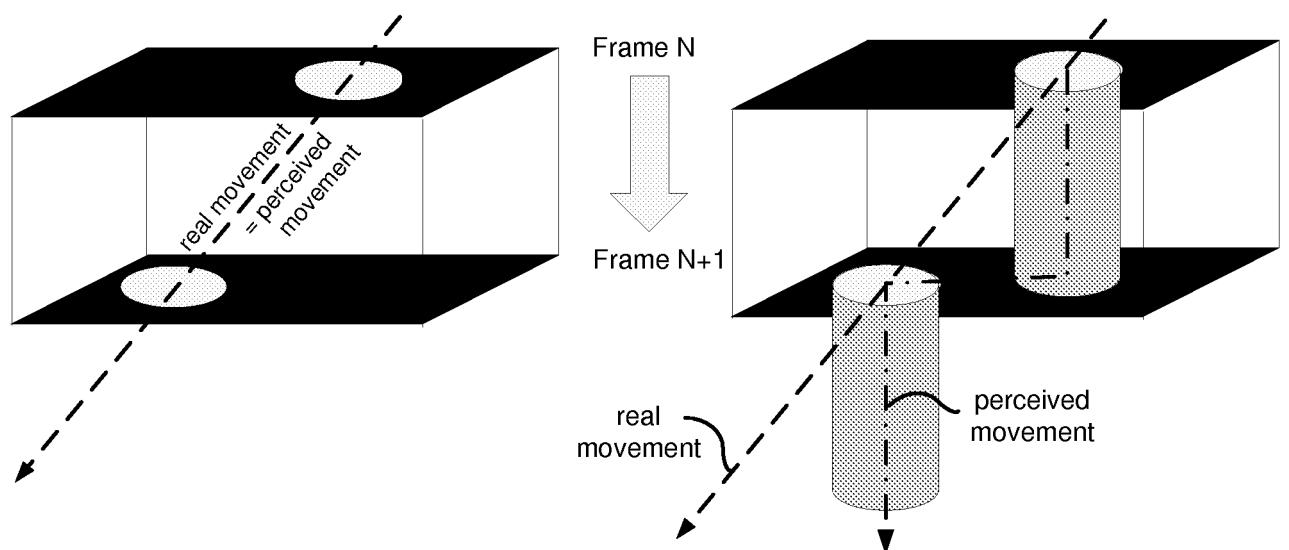


FIG.4

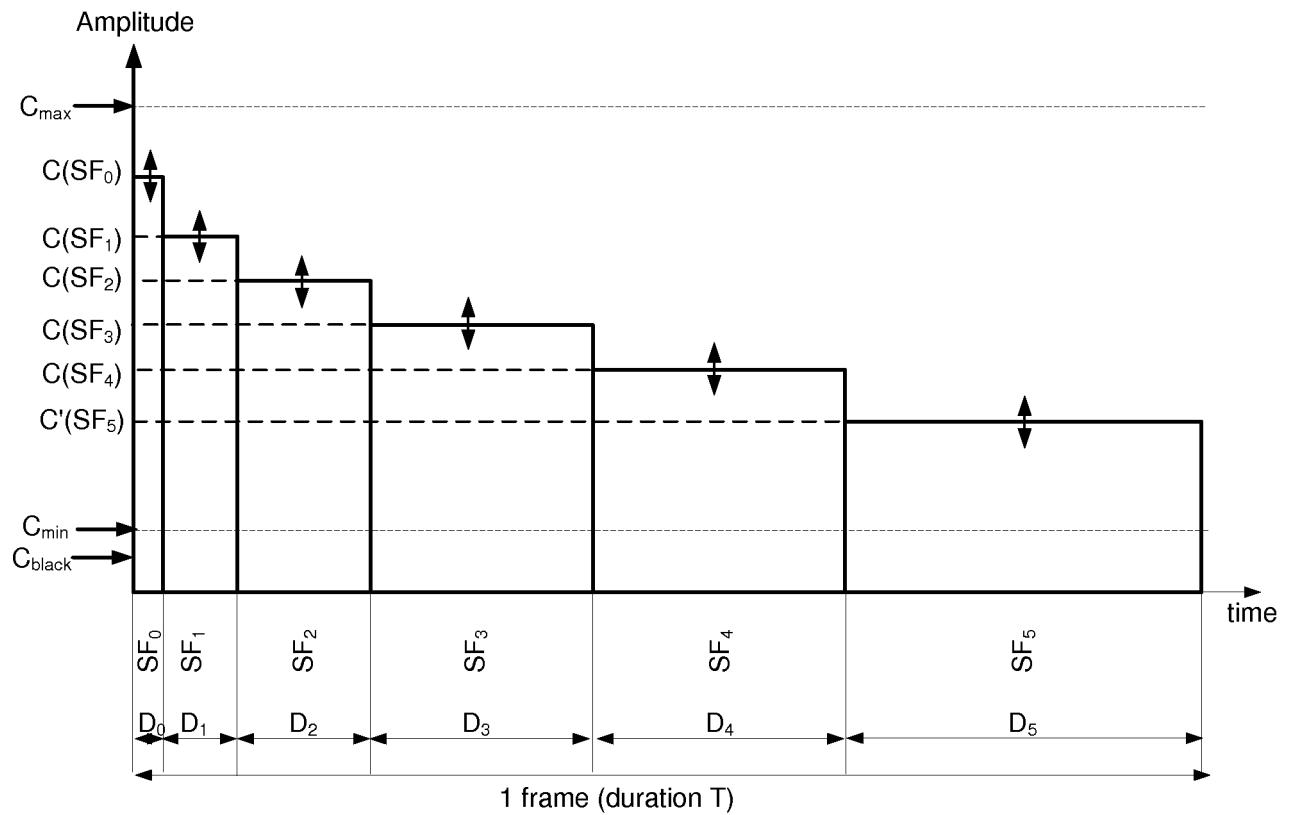


FIG.5

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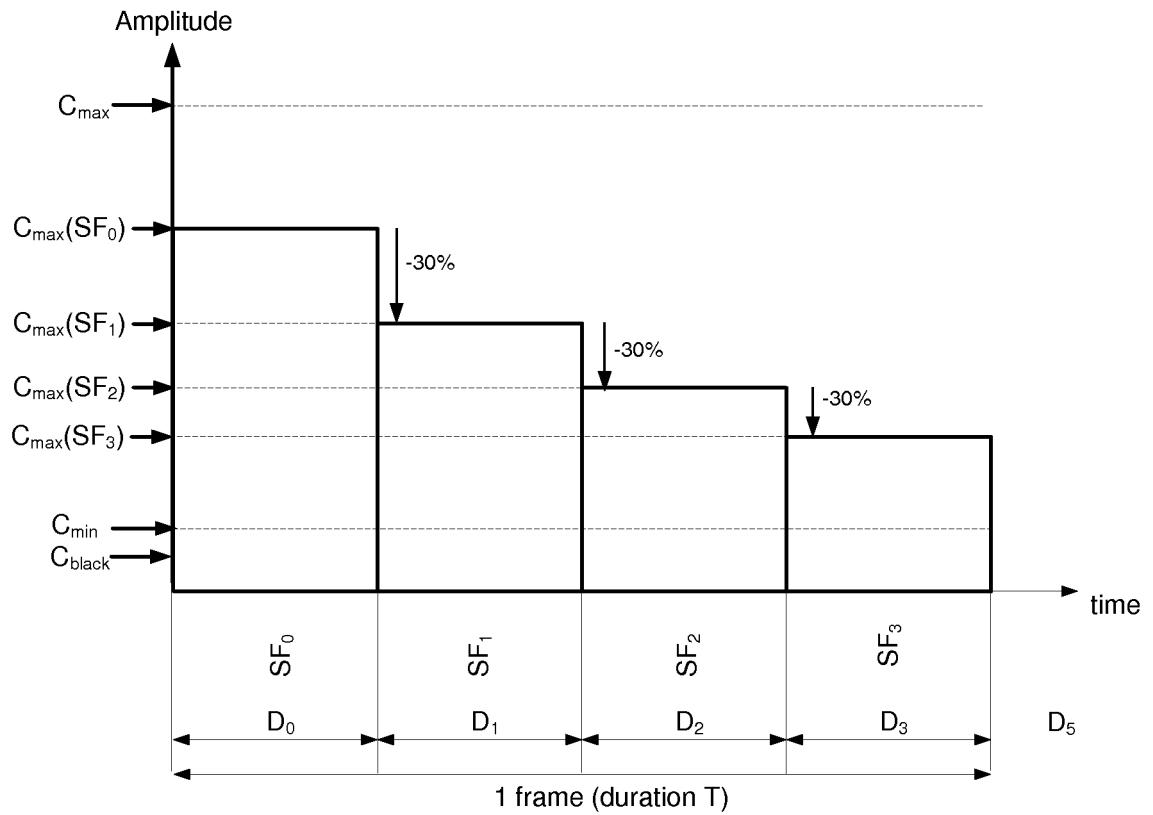


FIG.6

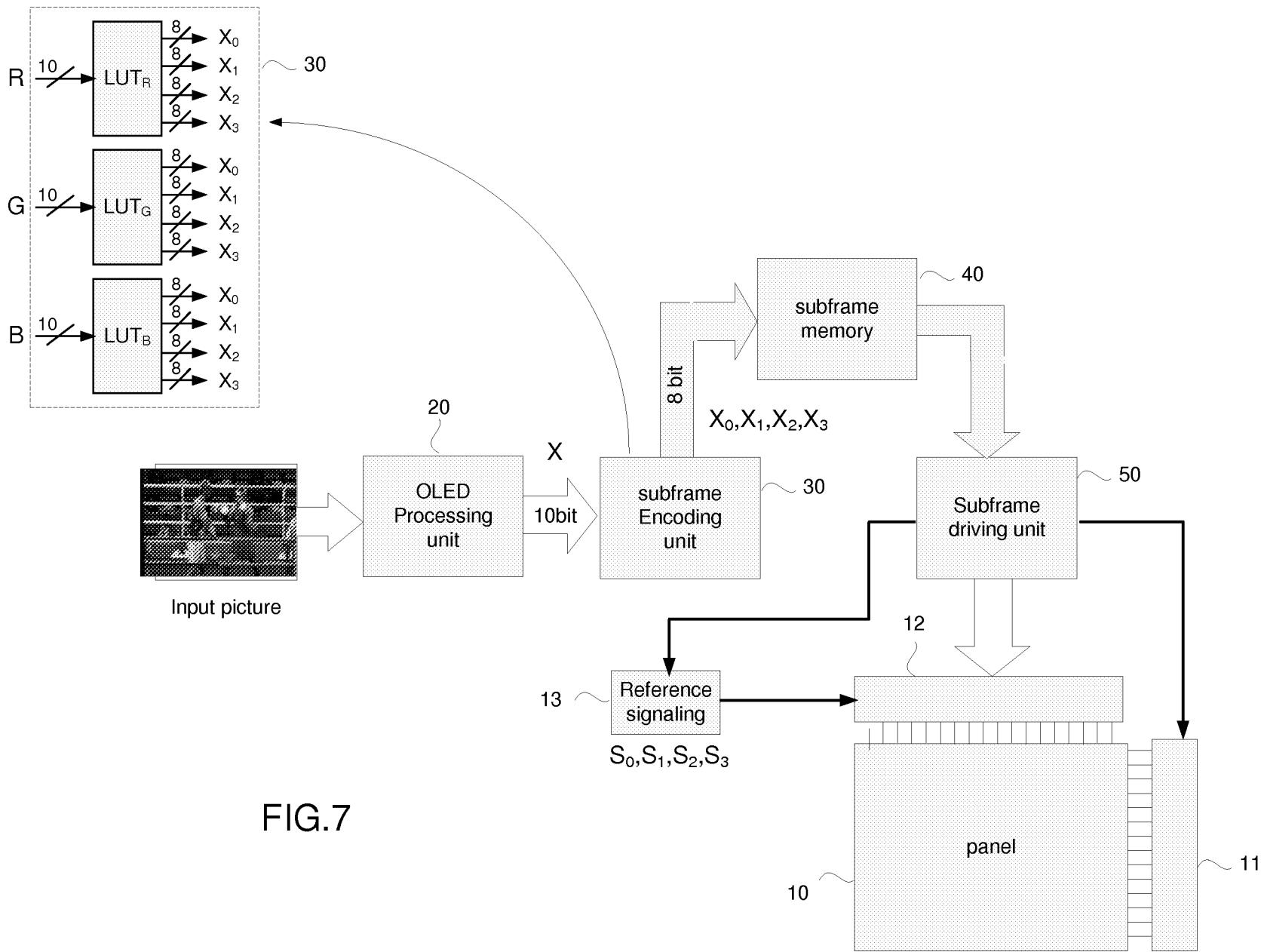
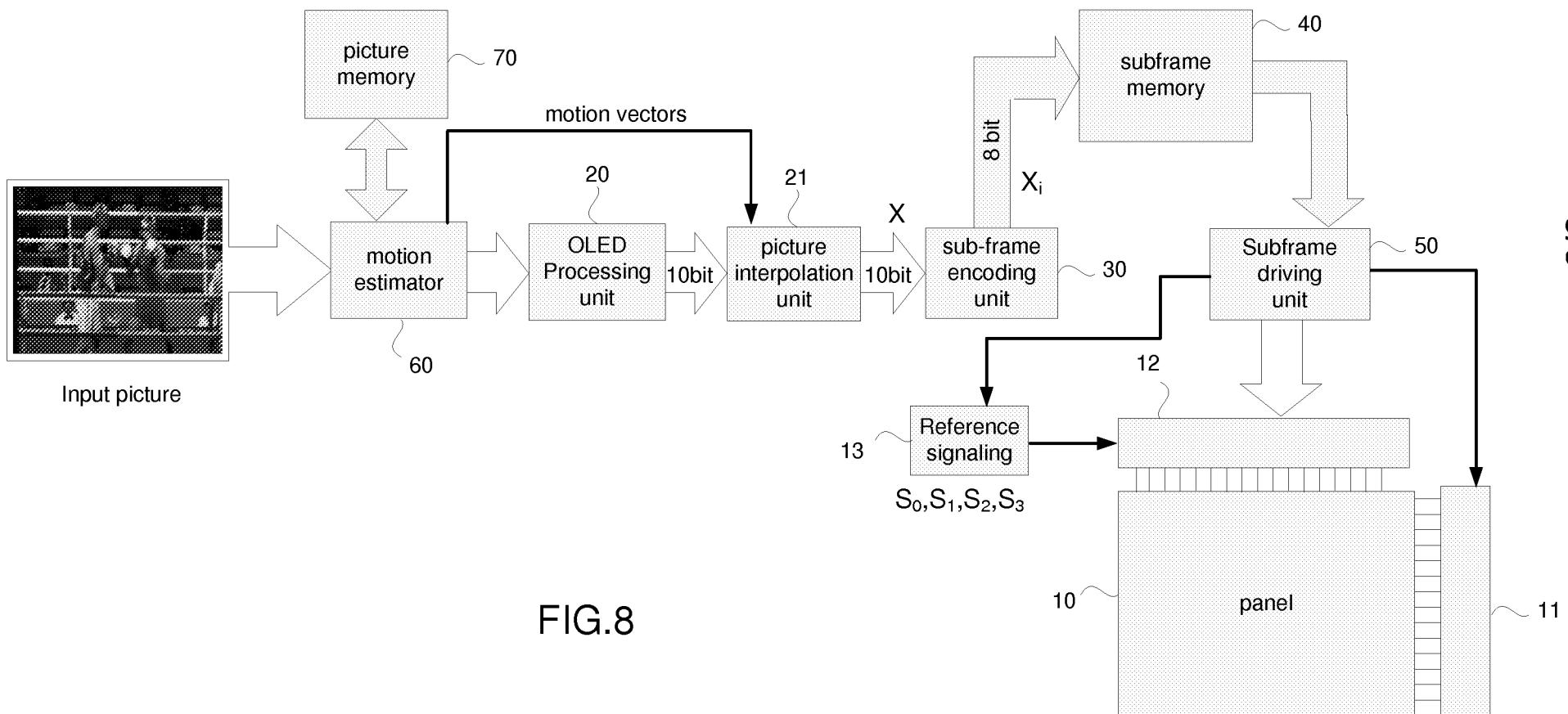


FIG.7



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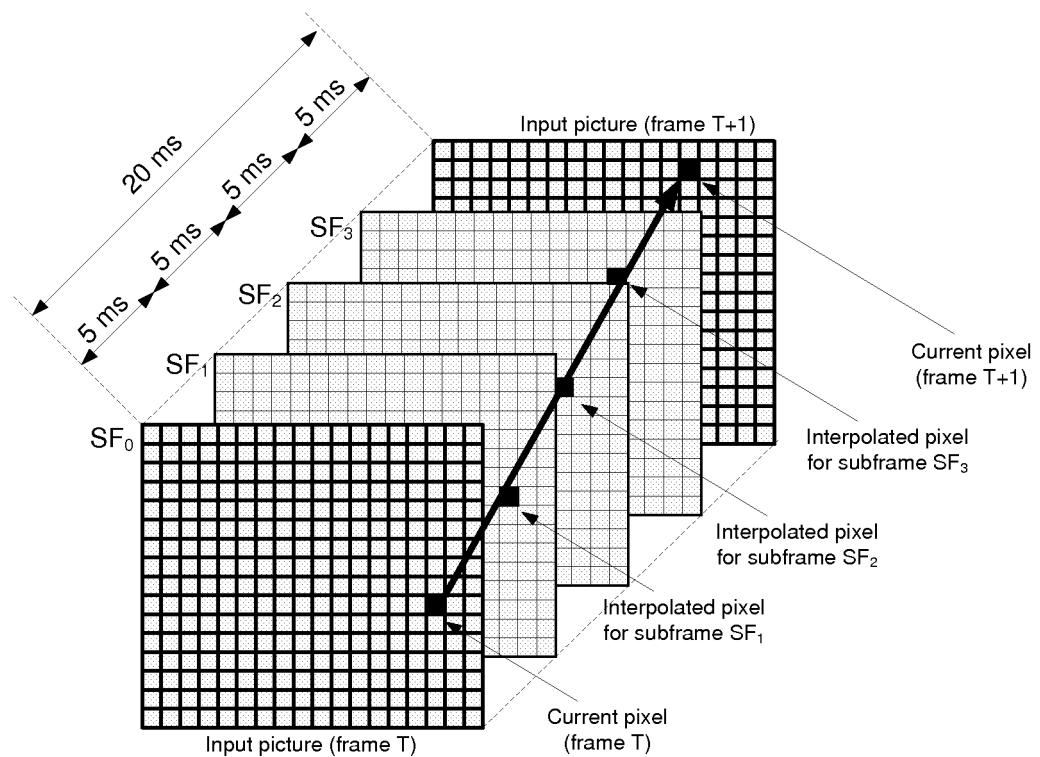


FIG.9

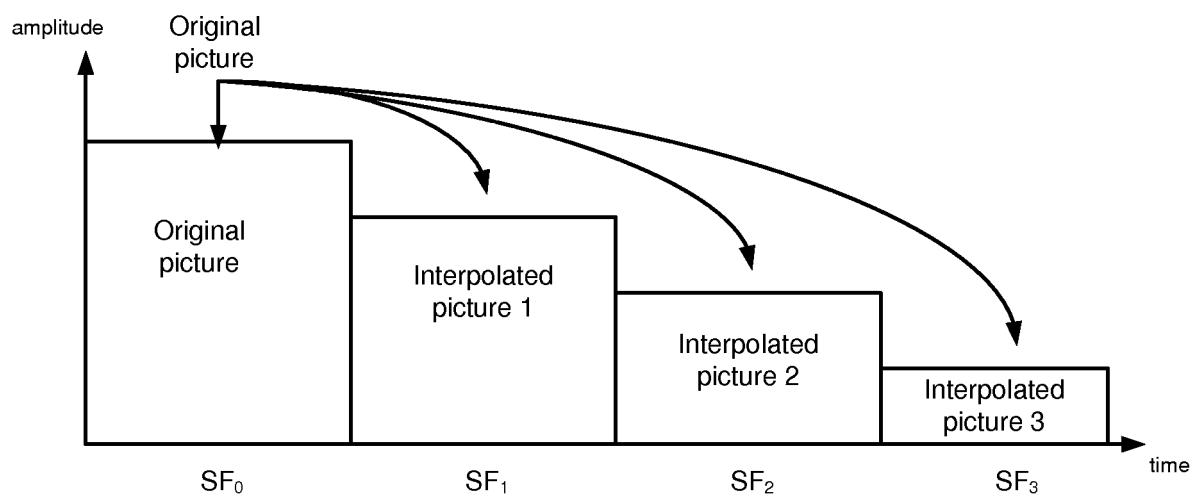


FIG.10

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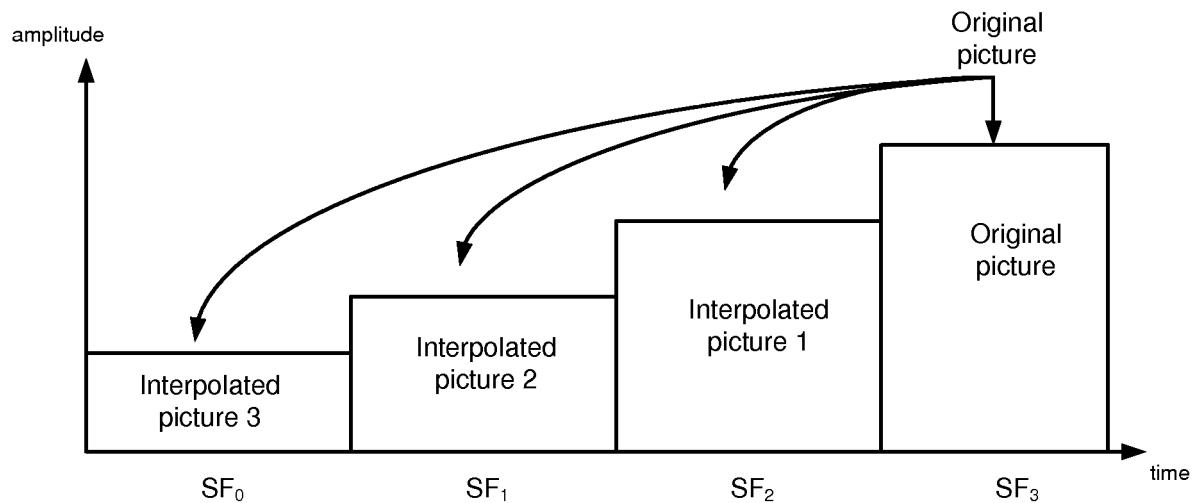


FIG.11

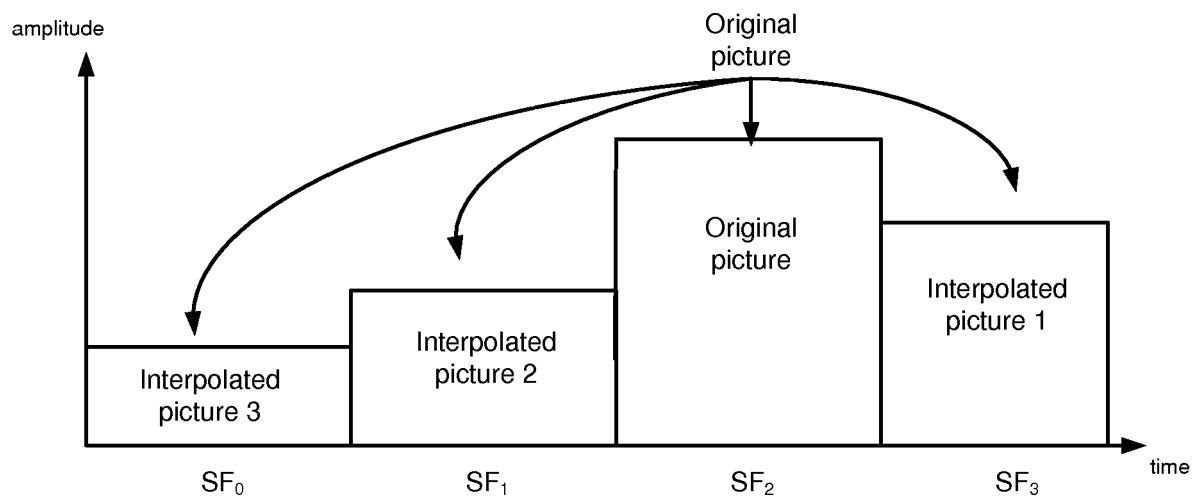


FIG.12

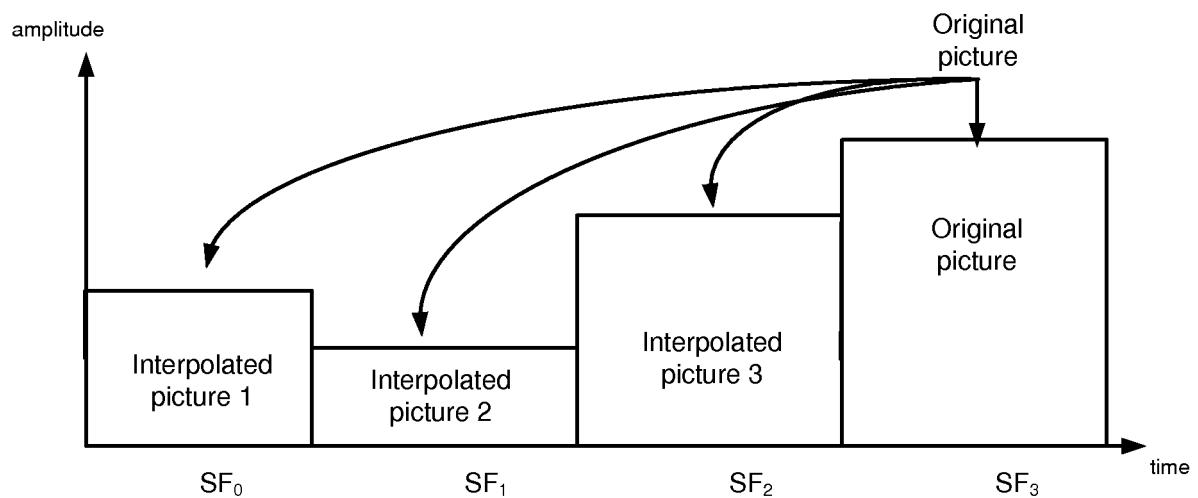


FIG.13

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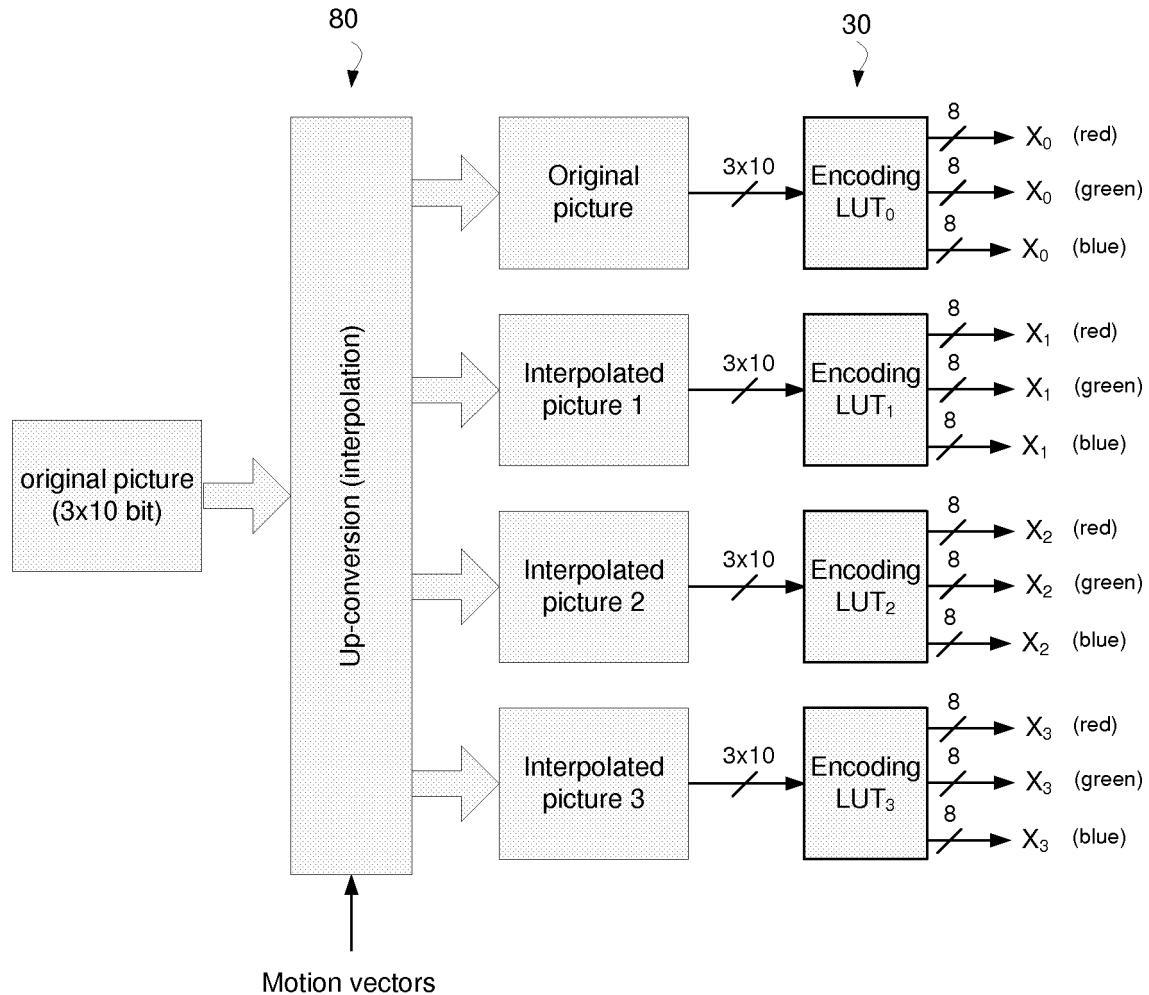


FIG.14

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/056386

A. CLASSIFICATION OF SUBJECT MATTER
INV. G09G3/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G09G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/145597 A1 (ITO AKIHIKO [JP]) 29 July 2004 (2004-07-29) figures 2-5,7,8,14 -----	1-11
X	EP 1 591 992 A (THOMSON LICENSING SA [FR]; THOMSON BRANDT GMBH [DE]) 2 November 2005 (2005-11-02) cited in the application figures 5,12 -----	1-11
A	EP 0 762 374 A (MOTOROLA INC [US]) 12 March 1997 (1997-03-12) figures 3,5 -----	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

5 September 2007

Date of mailing of the international search report

12/09/2007

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LE CHAPELAIN, B

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2007/056386

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