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

(11) EP 3 413 294 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.12.2018 Bulletin 2018/50

(51) Int Cl.:
G09G 3/3225 *(2016.01)*

(21) Application number: **17174907.0**

(22) Date of filing: **08.06.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Vestel Elektronik Sanayi ve Ticaret A.S.**
45030 Manisa (TR)

(72) Inventors:
- **NIL, Metin**
  45030 Manisa (TR)
- **KIRISKEN, Barbaros**
  45030 Manisa (TR)
- **ÖZDEN, Özlem**
  45030 Manisa (TR)

(74) Representative: **Ascherl, Andreas et al**
KEHL, ASCHERL, LIEBHOFF & ETTMAYR
Patentanwälte - Partnerschaft
Emil-Riedel-Strasse 18
80538 München (DE)

(54) METHOD, CONTROLLER AND DISPLAY DEVICE OF RGB IMAGE CONTENT

(57) The present invention provides a method for controlling the display of RGB image content (109) with a display device (100) with at least one red subpixel (103) and one green subpixel (104) and one blue subpixel (105) and one white subpixel (106) per pixel (102) of the display device (100). The method comprises alternatingly converting (S1) the RGB image content (109) into RGBW image data (111) with a plurality of RGB to RGBW conversion algorithms, and displaying (S2) the RGBW image data (111) via the display device (100). Further, the invention provides a respective controller (107) and a display device (100).

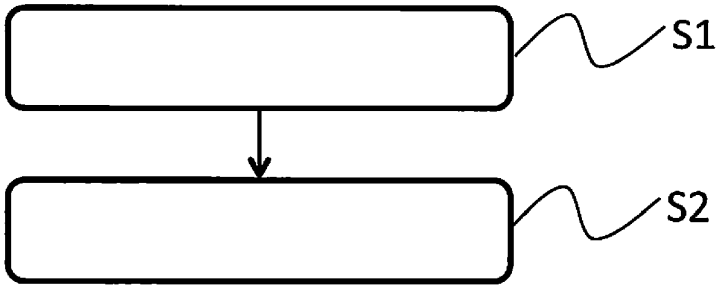

Fig. 1

EP 3 413 294 A1

Description

TECHNICAL FIELD

[0001] The invention relates to a method for controlling the display of RGB image content with a display device. Further, the present invention relates to a respective controller and a respective display device.

BACKGROUND

[0002] Although applicable to any display device that exhibits image sticking properties when provided with static image content, the present invention will mainly be described in conjunction with OLED displays.

[0003] Modern display devices may use a variety of different image panel technologies. One possible technology is the OLED technology that may use white OLED light sources with respective color filters. The color filters may e.g. be RGB color filters (red, green, blue). In addition, to enhance the image quality an additional white sub-pixel may be added to each pixel of such a display.

[0004] Sever image panel technologies suffer from a so called burn-in or image retention. Image retention refers to any image that "sticks" on a screen, even when the content changes. It usually appears as a faint ghost, and with most TVs this fades after certain amount of time. Burn-in is a form of image retention that lasts longer, and it is usually visible even when playing other content.

[0005] Burn-in and image retention are possible on virtually any display. Most cases of burn-in in e.g. televisions are a result of static images or on-screen elements displaying on the screen uninterrupted for many hours or days at a time - with brightness typically at peak levels. Such static images may be full screen static images or only static sections of otherwise non-static images. The static section may e.g. comprise a TV station logo or the like.

[0006] Accordingly, there is a need for reducing the image sticking tendency of displays.

SUMMARY OF THE INVENTION

[0007] The present invention provides a method with the features of claim 1, a controller with the features of claim 7 and a display device with the features of claim 13.

[0008] Therefore it is disclosed:

- A method for controlling the display of RGB image content with a display device with at least one red subpixel and one green subpixel and one blue subpixel and one white subpixel per pixel of the display device, the method comprising alternatingly converting the RGB image content into RGBW image data with a plurality of RGB to RGBW conversion algorithms, and displaying the RGBW image data via the display device.

[0009] Further, it is disclosed:

- A controller for displaying RGB image content on a display device with at least one red subpixel and one green subpixel and one blue subpixel and one white subpixel per pixel of the display device, the controller comprising a data interface configured to receive the RGB image content, a converter unit configured to alternatingly convert the RGB image content into RGBW image data with a plurality of RGB to RGBW conversion algorithms, and an output interface for providing the RGBW image data to the display device.

[0010] Finally, it is disclosed:

- A display device comprising a controller according to the present invention, and a display panel coupled to the controller.

[0011] The present invention is based on the finding that image sticking may occur on virtually any type of display device if the static content is displayed long enough. Therefore, instead of providing physical modifications of the display device itself, the present invention focuses on modifying the control of the display device.

[0012] In modern OLED display panels a single pixel may be formed by four sub-pixels instead of three, one red subpixel, one green subpixel, one blue subpixel and an additional white subpixel. The addition of the white subpixel to form the so called RGBW pixel improves luminance and/or efficiency for any color display device that uses white light sources and color filters.

[0013] Usually the image data will however be provided only as RGB data (red, green, blue) for each pixel of the display device. A conversion of the RGB data to RGBW image data is therefore necessary to drive the RGBW pixels of

the display device based on the original RGB data or image content.

[0014] The present invention focuses on the conversion from RGB data to RGBW image data to prevent image sticking on the display device. For the conversion of RGB data to RGBW image data a variety of different conversion algorithms may be used. Every conversion algorithm will provide similar but slightly different conversion results. This means that a single RGB pixel may be converted to slightly different RGBW pixels by different conversion algorithms. However users will perceive no or almost no difference between the conversion results of the different algorithms.

[0015] The present invention takes advantage of the fact that different conversion algorithms will yield no perceptible differences but will still drive the subpixels of the RGBW pixels with different values or intensities.

[0016] With the method according to the present invention different conversion algorithms will be used in an alternating manner. This means that although no variations will be perceived by the users when viewing the image that is displayed on the display device, the single pixels or subpixels of the display device will permanently be driven with varying control signals.

[0017] Therefore, the tendency if image sticking of the display device will be reduced since no static control of the single pixels is performed even if a static content is shown on the display device.

[0018] Further embodiments of the present invention are subject of the further subclaims and of the following description, referring to the drawings.

[0019] In an embodiment, the method may comprise analyzing the RGB image content for the existence of areas of static content, converting the content of areas of the RGB image content that comprise non-static content into RGBW image data with a first predetermined conversion algorithm, and alternatingly converting only the content of areas of the RGB image content that comprise static content into RGBW image data with the plurality of RGB to RGBW conversion algorithms.

[0020] Analyzing the RGB image content for areas of static content allows identifying only the problematic section of the RGB image content that might eventually lead to image sticking or burn-in.

[0021] The different RGB to RGBW conversion algorithms may then be applied only to the identified problematic sections of the RGB image content.

[0022] Different RGB to RGBW conversion algorithms may have different computational costs. The areas of non-static content of the RGB image content may e.g. be converted into RGBW data with a highly efficient RGB to RGBW conversion algorithm that may be implemented with little computational costs.

[0023] The sections or areas of static content of the RGB image content may in contrast be alternatingly converted with different RGB to RGBW conversion algorithms.

[0024] The computational effort may therefore be reduced since computationally more expensive RGB to RGBW conversion algorithms are only applied where necessary.

[0025] The first RGB to RGBW conversion algorithm may e.g. comprise the following:

[0026] Assuming Ri, Gi, Bi are RGB color inputs, e.g. integers from 0 to 255, so Q = 255, and that the RGBW outputs are Wo, Ro, Go and Bo with values from 0 to 255:

M = max(Ri,Gi,Bi)
m = min(Ri,Gi,Bi)
Wo = if (m/M < 0.5) use ((m*M) / (M-m)) else M
Q = 255

$$K = (Wo + M) / m$$

$$Ro = floor([(K * Ri) - Wo] / Q)$$

$$Go = floor([(K * Gi) - Wo] / Q)$$

$$Bo = floor([(K * Bi) - Wo] / Q)$$

Wo may be: m, m^2 and -m^3+m^2+m

[0027] This algorithm is e.g. disclosed in "POWER-CONSTRAINED RGB-TO-RGBW CONVERSION FOR EMISSIVE DISPLAYS" by Chul Lee and Vishal Monga.

[0028] Any other RGB to RGBW conversion algorithms may be used for alternating the RGB to RGBW conversion algorithms.

[0029] In another embodiment, alternatingly converting may comprise changing the RGB to RGBW conversion algorithm for every image refresh performed by the display device.

[0030] The refresh rate in modern display devices may be tens or hundreds of image refreshes per second, for example 60, 120, 144, 200 or more refreshes per second or the like. This means that 60, 120, 144, 200 or more images will be drawn on the screen of the display device per second.

[0031] If another RGB to RGBW conversion algorithm is used for every single refresh, the users that view the display device will not be able to perceive such quick changes of the RGB to RGBW conversion algorithms. The users will only perceive a kind of averaged image on the display device.

[0032] In a further embodiment, alternatingly converting may comprise changing the RGB to RGBW conversion algorithm after a predetermined amount of time.

[0033] Image sticking or burn-in will not occur after only some seconds of displaying static content. Instead image sticking or burn-in will eventually occur after hours of displaying static content.

[0034] Therefore, instead of constantly switching RGB to RGBW conversion algorithms, the properties of the display may be taken into account and a predetermined time may be specified for switching between RGB to RGBW conversion algorithms.

[0035] In an embodiment, the method may comprise determining the predetermined amount of time based on an average brightness of the areas of static content of the RGB image content or based on the maximum brightness of the areas of static content of the RGB image content.

[0036] The duration of displaying static content that is necessary to provoke image sticking or burn-in depends strongly on the brightness of the displayed static content. If the brightness is low it will take much longer for the static content to burn-in than if the static content is very bright in relation to the brightness range of the display device.

[0037] Depending on the brightness, e.g. for a low brightness static content, it may even be decided not to change the RGB to RGBW conversion algorithms at all.

[0038] In another embodiment, the method may comprise shifting the colors of the converted RGBW image data such that saturated color levels are prevented.

[0039] In addition to alternatingly changing the used RGB to RGBW conversion algorithm, it is also possible to shift the color levels to prevent saturation of single pixels. This means that an area of static content in the RGB image content may be shown with reduced color levels. Instead e.g. of white colored the static content may e.g. be shown as light gray.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] For a more complete understanding of the present invention and advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings. The invention is explained in more detail below using exemplary embodiments which are specified in the schematic figures of the drawings, in which:

Fig. 1 shows a flow diagram of an embodiment of a method according to the present invention;

Fig. 2 shows a flow diagram of another embodiment of a method according to the present invention; and

Fig. 3 shows a block diagram of an embodiment of a display device according to the present invention.

[0041] In the figures like reference signs denote like elements unless stated otherwise.

DETAILED DESCRIPTION OF THE DRAWINGS

[0042] For sake of clarity the reference signs used in the description of apparatus-based Fig. 3 will also be used in the description of method-based Figs. 1 and 2.

[0043] Fig. 1 shows a flow diagram of an embodiment of a method for controlling the display of RGB image content 109 with a display device 100 with at least one red subpixel 103 and one green subpixel 104 and one blue subpixel 105 and one white subpixel 106 per pixel 102 of the display device 100.

[0044] The RGB image content 109 may be provided by any type of image or video source, e.g. an antenna receiver in the display device 100, an external media player or the like. The display device 100 may e.g. be a television set or a computer monitor or the like. The display device 100 may especially be an OLED display device 100 with RGBW pixels 102. RGBW pixels 102 each comprise four subpixels, the above mentioned red subpixel 103, green subpixel 104, blue subpixel 105 and white subpixel 106.

[0045] The method comprises alternatingly converting S1 the RGB image content 109 into RGBW image data 111

with different RGB to RGBW conversion algorithms. The number of RGB to RGBW conversion algorithms may be two or more, e.g. three or four, but is not limited to these examples.

[0046] By alternating the RGB to RGBW conversion algorithms that are used to convert the RGB image content 109 into RGBW image data 111, the control values that are provided to the single pixels 102 of the display device 100 will slightly change every time the RGB to RGBW conversion algorithm is changed even if the image content is static.

[0047] The method in addition comprises displaying S2 the RGBW image data 111 via the display device 100.

[0048] With the above described scheme of the method according to the present invention image sticking or burn-in may advantageously be reduced or eliminated for the display device 100.

[0049] Fig. 2 shows a flow diagram of another embodiment of a method for controlling the display of RGB image content 109 with a display device 100. The method of Fig. 2 is based on the method of Fig. 1.

[0050] The method of Fig. 2 further comprises analyzing S3 the RGB image content 109 for the existence of areas of static content. Such areas may e.g. be station logos of TV stations or the like. The detection of static content may span over a specific period of time. If for example static content is only detected in some frames, like e.g. less than 100 frames, or for less than a specific amount of time, like e.g. 1 minute, the static area may be part of e.g. a movie and will soon change. It is therefore only necessary to handle static areas that exist in the displayed image for a certain amount of time.

[0051] Step S1 comprises alternatingly converting S11 only the content of areas of the RGB image content 109 that comprise static content into RGBW image data 111 with the plurality of RGB to RGBW conversion algorithms.

[0052] Further, the method comprises converting S4 the content of areas of the RGB image content 109 that comprise non-static content into RGBW image data 111 with a first predetermined conversion algorithm.

[0053] Alternatingly converting comprises optionally changing S12 the RGB to RGBW conversion algorithm for every image refresh performed by the display device 100 or alternatively changing the RGB to RGBW conversion algorithm after a predetermined amount of time. The predetermined amount of time may be determined based on an average brightness of the areas of static content of the RGB image content 109 or based on the maximum brightness of the areas of static content of the RGB image content 109.

[0054] Finally, the method comprises as optional step shifting S5 the colors of the converted RGBW image data 111 such that saturated color levels are prevented.

[0055] Fig. 3 shows a block diagram of an embodiment of a display device 100. The display device 100 comprises a controller 107 and a display panel 101 that is controlled by the controller 107.

[0056] The display panel 101 is provided as a so called RGBW panel 101, e.g. an OLED RGBW panel 101. The display panel 101 comprises a plurality of pixels 102. One pixel 102 is shown in detail and it is understood, that the other pixels may be provided analogously. The pixel 102 comprises one red subpixel 103, one green subpixel 104, one blue subpixel 105 and one white subpixel 106 that are controlled by controller 107.

[0057] The controller 107 comprises a data interface 108 for receiving the RGB image content 109. The RGB image content 109 is then provided to a converter unit 110 that alternatingly converts the RGB image content 109 into RGBW image data 111 with a plurality of different RGB to RGBW conversion algorithms. The RGBW image data 111 is then provided via output interface 112 to the pixels 102.

[0058] The converter unit 110 may analyze the RGB image content 109 for the existence of areas of static content. If such areas exist, the content of areas of the RGB image content 109 that comprise non-static content may be converted by the converter unit 110 into RGBW image data 111 with a fixed first predetermined conversion algorithm. Only the content of areas of the RGB image content 109 that comprise static content may be alternatingly converted by the converter unit 110 into RGBW image data 111 with the plurality of RGB to RGBW conversion algorithms.

[0059] The converter unit 110 may e.g. change the RGB to RGBW conversion algorithm for every image refresh performed by the display device 100. Alternatively, the converter unit 110 may change the RGB to RGBW conversion algorithm after a predetermined amount of time.

[0060] In Fig. 3 the converter unit 110 comprises an optional brightness extractor 113 for determining an average brightness or a maximum brightness of the areas of static content of the RGB image content 109. The converter unit 110 may then determine the predetermined amount of time based on the average brightness or based on the maximum brightness.

[0061] Finally, the converter unit 110 may be configured to shift the colors of the converted RGBW image data 111 such that saturated color levels are prevented.

[0062] Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations exist. It should be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration in any way. Rather, the foregoing summary and detailed description will provide those skilled in the art with a convenient road map for implementing at least one exemplary embodiment, it being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope as set forth in the appended claims and their legal equivalents. Generally, this application is intended to cover any adaptations or variations of the specific embodiments discussed herein.

[0063] Thus the present invention provides a method for controlling the display of RGB image content 109 with a display device 100 with at least one red subpixel 103 and one green subpixel 104 and one blue subpixel 105 and one white subpixel 106 per pixel 102 of the display device 100. The method comprises alternatingly converting (S1) the RGB image content 109 into RGBW image data 111 with a plurality of RGB to RGBW conversion algorithms, and displaying (S2) the RGBW image data 111 via the display device 100. Further, the invention provides a respective controller 107 and a display device 100.

List of reference signs

[0064]

100	display device
101	panel
102	pixel
103, 104, 105, 106	subpixel
107	controller
108	data interface
109	RGB image content
110	converter unit
111	RGBW image data
112	output interface
113	brightness extractor

S1, S2, S3, S4, S5, S11, S12, S13 method steps

Claims

1. Method for controlling the display of RGB image content (109) with a display device (100) with at least one red subpixel (103) and one green subpixel (104) and one blue subpixel (105) and one white subpixel (106) per pixel (102) of the display device (100), the method comprising:

   alternatingly converting (S1) the RGB image content (109) into RGBW image data (111) with a plurality of RGB to RGBW conversion algorithms, and
   displaying (S2) the RGBW image data (111) via the display device (100).

2. Method according to claim 1, comprising
   analyzing (S3) the RGB image content (109) for the existence of areas of static content,
   converting (S4) the content of areas of the RGB image content (109) that comprise non-static content into RGBW image data (111) with a first predetermined conversion algorithm, and
   alternatingly (S11) converting only the content of areas of the RGB image content (109) that comprise static content into RGBW image data (111) with the plurality of RGB to RGBW conversion algorithms.

3. Method according to any one of the preceding claims, wherein alternatingly converting comprises changing (S12) the RGB to RGBW conversion algorithm for every image refresh performed by the display device (100).

4. Method according to any one of the preceding claims 1 and 2, wherein alternatingly converting comprises changing the RGB to RGBW conversion algorithm after a predetermined amount of time.

5. Method according to claims 2 and 4, comprising determining (S13) the predetermined amount of time based on an average brightness of the areas of static content of the RGB image content (109) or based on the maximum brightness of the areas of static content of the RGB image content (109).

6. Method according to any one of the preceding claims, comprising shifting (S5) the colors of the converted RGBW image data (111) such that saturated color levels are prevented.

7. Controller (107) for displaying RGB image content (109) on a display device (100) with at least one red subpixel (103) and one green subpixel (104) and one blue subpixel (105) and one white subpixel (106) per pixel (102) of the

display device (100), the controller (107) comprising:

a data interface (108) configured to receive the RGB image content (109),
a converter unit (110) configured to alternatingly convert the RGB image content (109) into RGBW image data (111) with a plurality of RGB to RGBW conversion algorithms, and
an output interface (112) for providing the RGBW image data (111) to the display device (100).

8. Controller (107) according to claim 7, wherein the converter unit (110) is configured to analyze the RGB image content (109) for the existence of areas of static content, convert the content of areas of the RGB image content (109) that comprise non-static content into RGBW image data (111) with a first predetermined conversion algorithm, and alternatingly convert only the content of areas of the RGB image content (109) that comprise static content into RGBW image data (111) with the plurality of RGB to RGBW conversion algorithms.

9. Controller (107) according to any one of the preceding claims 7 and 8, wherein when alternatingly converting the converter unit (110) is configured to change the RGB to RGBW conversion algorithm for every image refresh performed by the display device (100).

10. Controller (107) according to any one of the preceding claims 7 and 8, wherein when alternatingly converting the converter unit (110) is configured to change the RGB to RGBW conversion algorithm after a predetermined amount of time.

11. Controller (107) according to claims 8 and 10, comprising a brightness extractor (113) configured to determine an average brightness or a maximum brightness of the areas of static content of the RGB image content (109), and wherein the converter unit (110) is configured to determine the predetermined amount of time based on the average brightness or based on the maximum brightness.

12. Controller (107) according to any one of the preceding claims 7 to 11, wherein the converter unit (110) is configured to shift the colors of the converted RGBW image data (111) such that saturated color levels are prevented.

13. Display device (100) comprising:

a controller (107) according to any one of the preceding claims 7 to 12, and
a display panel (101) coupled to the controller (107).

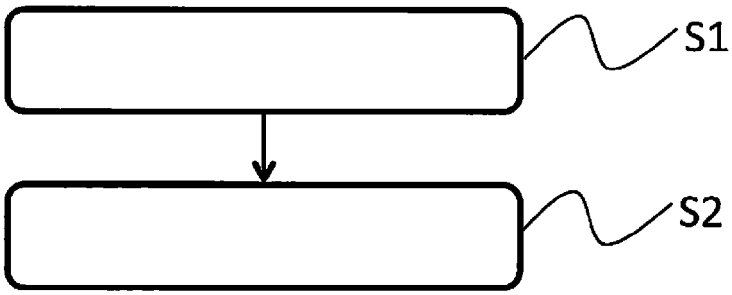

Fig. 1

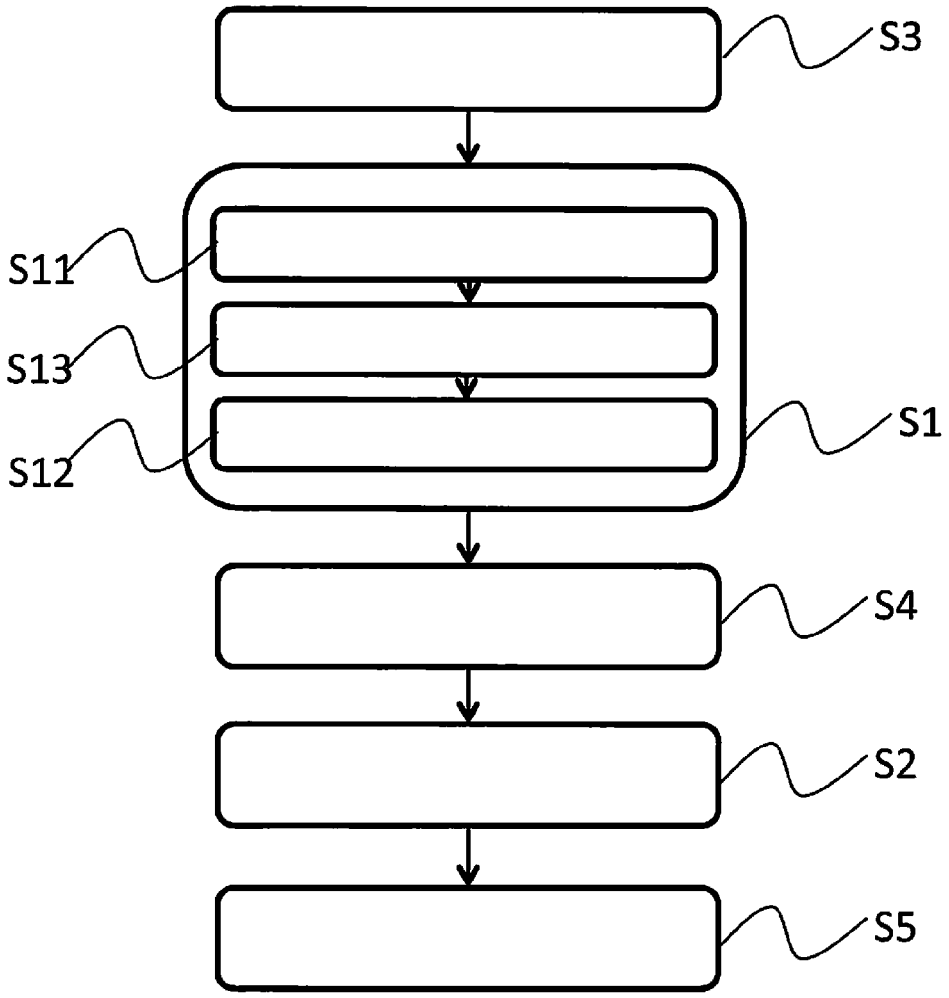

Fig. 2

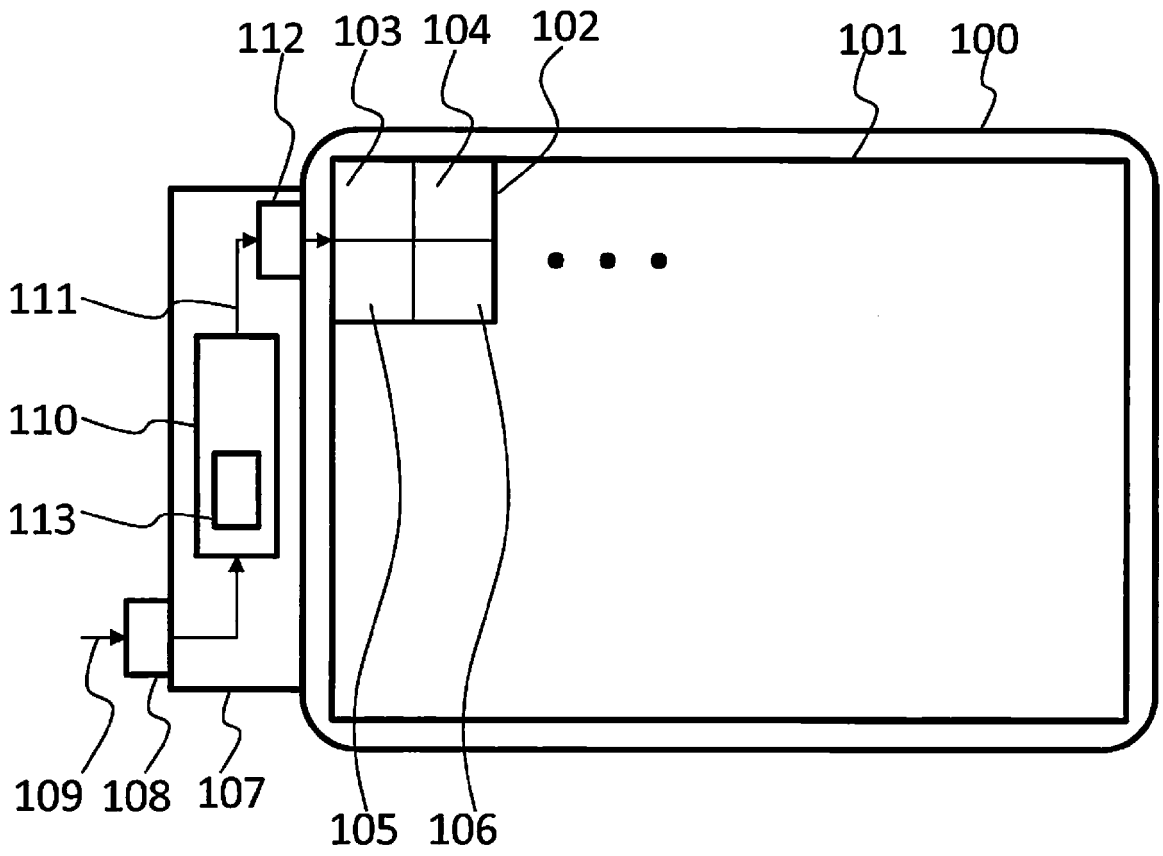

Fig. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 17 4907

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2015/187277 A1 (MAEYAMA KOICHI [JP] ET AL) 2 July 2015 (2015-07-02) * paragraphs [0106], [0220] - [0248]; figures 47-56 *	1-13	INV. G09G3/3225
A	EP 3 098 803 A1 (LG DISPLAY CO LTD [KR]) 30 November 2016 (2016-11-30) * paragraphs [0007], [0042] *	1,2,7,8	

TECHNICAL FIELDS SEARCHED (IPC)

G09G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14 November 2017	Vázquez del Real, S

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
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 17 4907

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-11-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015187277 A1	02-07-2015	JP 2015125356 A	06-07-2015
		KR 20150077285 A	07-07-2015
		US 2015187277 A1	02-07-2015
EP 3098803 A1	30-11-2016	CN 106205485 A	07-12-2016
		EP 3098803 A1	30-11-2016
		KR 20160139678 A	07-12-2016
		US 2016351115 A1	01-12-2016

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82