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[Continued on next page]

(54) Title: METHOD AND DEVICE FOR CONTROLLING A LIGHTING UNIT

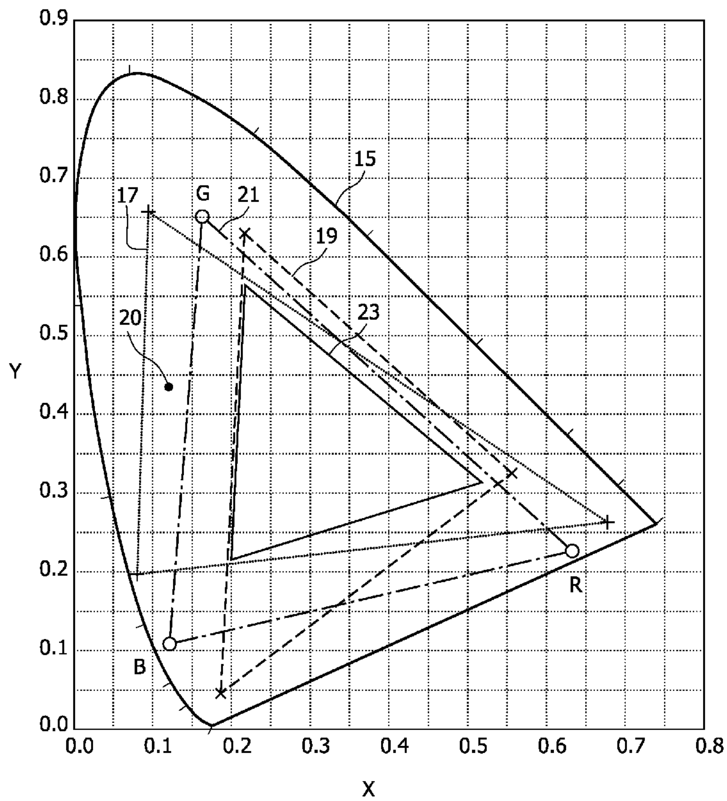

FIG. 2

(57) Abstract: The disclosure relates to a controller for a lighting unit as well as a method for controlling a lighting unit. The lighting unit has a plurality of differently colored primary light sources which may be controlled independently. To provide color uniformity between multiple lighting units, an input signal is evaluated with respect to a fixed color gamut by means of a comparator (31). The fixed gamut is chosen such that all or most lighting units can produce the colors therein. If the input signal relates to a value outside the fixed gamut, the input signal may be modified to a value inside. Then, color differences between adjacent lighting units may be avoided to a great extent.

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Method and device for controlling a lighting unit

TECHNICAL FIELD

The present disclosure relates to a controller for a lighting unit, which unit comprises at least a first and a second primary light source having mutually different spectra and being adapted to be individually controlled in response to an input signal, such that the color of the mixed output light is variable, the primary light sources spanning a maximum color gamut in a color space.

The disclosure further relates to a corresponding method for controlling a lighting unit.

TECHNICAL BACKGROUND

Such a controller is disclosed e.g. in US 7,230,222, wherein lighting unit has a red, a green, and a blue light emitting diode, LED. One problem associated with such lighting units is that, when multiple lighting units are used to illuminate a surface, all units do not respond uniformly to a given input signal, such that the human eye may experience color deviations over the surface.

This may be due to the fact that primary light sources can have slightly differing properties which means that lighting units may span slightly different gamuts in a color space. A color that can be produced by one lighting unit may therefore not be achievable for another unit. The properties of the primary light sources may further vary with varying temperature or due to ageing.

SUMMARY

One object of the present disclosure is to provide a simple and reliable arrangement that improves color uniformity when a surface is illuminated be a plurality of lighting units of the above-indicated type.

This object may be achieved by means of a controller of the above-indicated kind, wherein a fixed color gamut is defined for the controller, the fixed color gamut being smaller than the maximum color gamut, the controller comprises a comparator which is adapted to determine whether an input signal refers to a value within the fixed color gamut, and the controller is adapted to initiate an action if the input signal refers to a value outside the fixed color gamut.

By choosing a fixed color gamut which may be achieved by most lighting units, the lighting units can be controlled to produce colors that can be achieved by all or most lighting units which improves color uniformity.

The above-mentioned action may comprise modifying the input signal to a value within the fixed color gamut, e.g. by changing the input signal to the value on the color gamut boundary that is closest to input signal value.

As one alternative, the action may comprise cancelling the input signal, such that no light is output from the lighting unit.

As another alternative, the action may comprise generating a warning indication. The lighting unit may then try to produce the inputted color signal. However, the color signal may at the same time be adjusted at a higher level in the system.

Additionally at least one maximum flux may defined, and the comparator may compare the flux value of the input signal with the maximum flux, and reduce the flux value to the maximum flux should it exceed the maximum flux. This allows also improved brightness uniformity over an illuminated surface.

The primary light sources may be in the form of light emitting diodes, LEDs or incandescent lamps.

The controller may be adapted to control a plurality of lighting units.

The object is further achieved by means of a corresponding method for controlling a lighting unit, wherein a fixed color gamut is defined for a controller, the fixed color gamut being smaller than the maximum color gamut, it is determined whether an input signal refers to a value within the fixed color gamut, and an action is initiated if the input signal refers to a value outside the fixed color gamut.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1 illustrates schematically a lighting system which is used to illuminate a surface.

Fig 2 illustrates a color space wherein the color gamuts of three different lighting units are indicated.

Fig 3 shows a lighting unit with tree primary light sources, where a fixed color gamut is used.

DETAILED DESCRIPTION

Fig 1 illustrates schematically a lighting system 1 which is used to illuminate a surface 3. The lighting system 1 comprises an overall controller 5, which provides input signals to a number of lighting units 7, 9, 11, which each comprises a number of primary light sources with different colors. Typically each lighting unit, e.g. 7, may have a red, a green, and a blue (RGB) primary light source, even though other combinations are possible as will be described further later. In the context of the present disclosure it is sufficient that each unit comprises at least two primary light sources having different spectra. The primary light sources may be controlled individually, such that the color of the light produced by each lighting unit, being the sum of the light from the primary light sources, is variable.

In many cases it may be desirable to illuminate a surface 3 uniformly, such that each lighting unit 7, 9, 11 illuminates one portion each of the surface and with a reasonably uniformly colored light. However, also relatively small deviations in color between two units may be detected by the human eye, especially at boundaries 13 between two adjacent lighting units. This may disturb the impression that the surface 3 is illuminated by a single light source. The effect is particularly salient when the lighting units are used close to their gamut boundaries, as will be described later.

Fig 2 illustrates a color space wherein the color gamuts of three different lighting units are indicated in a CIE1931 color space 15. Each lighting unit has a red, a green, and a blue primary light source (RGB). The primary light sources of a first a second and a third lighting unit are indicated by the characters, “+”, “x” and “o”, respectively. As can be seen, e.g. the different green primary light sources produce slightly different wavelengths. The differences are exaggerated in fig 2 to facilitate the understanding of this disclosure. The differences imply that each lighting unit will have a slightly different gamut 17, 19, 21, as shown with the dotted, dashed and dash-dot lines of fig 2. Some input signals may therefore not be accurately produced by some lighting units, as those signals may relate to a color outside the gamut of that lighting unit, while other lighting units can respond accordingly. For instance, the color defined by the dot 20 in fig 2 may only be correctly produced by the first lighting unit 17. This means that color differences may occur as described above.

Even if the primary light sources were carefully chosen to achieve well matched lighting units, this could not ensure uniformly colored light as the primary light sources change their wavelengths with ageing and varying temperature.

The inventors have found that the human eye is much less sensitive to uniform color shifts than color differences between adjacent lighting units. Therefore, the use of a fixed color gamut has been introduced. The fixed gamut defines a color space that can be reproduced by all or most lighting units. By allowing the lighting units to operate based on the fixed color gamut color differences between adjacent lighting units may be avoided to a large extent. In fig 2, an example of a fixed color gamut 23 is indicated, which is a color space achievable by all three lighting units.

Fig 3 shows a lighting unit having a controller 24 and tree primary light sources 25, 27, 29, and where a fixed color gamut is used. The lighting unit receives an input signal x_1, y_1, which defines a color in a color space, and supplies energy to the primary light sources correspondingly. A fixed color gamut is defined for this lighting unit, and a comparator 31 tests whether the received input signal x_1, y_1 lies within the defined fixed gamut. The result of this test is fed to a control block 33, together with the input signal x_1, y_1.

The control block 33 may, if the received input signal refers to a value outside the fixed color gamut, carry out different actions as will now be described.

As a first option, the control block 33 may modify the input signal x_1, y_1 to a modified signal x_2, y_2 which is defined by the fixed color gamut. Typically, this may be done by changing the input signal to the value on the fixed color gamut boundary that is closest to the original input signal value. Alternatively, another value may be used, e.g. the closest value among a number of standardized set points.

A second option is to simply cancel the input signal, such that no light is output from the lighting unit in question.

A third option is to use the input signal unmodified and to generate a warning indication, which is fed back to the source of the input signal and informs the operator or device generating the input signal that the received signal does not lie within the fixed color gamut and that undesired effects, as described above, may arise. This warning may then cause the input signal to be changed at a higher level in the system.

In most cases thus, the control block 33 outputs a signal x_2, y_2, which may consist of the input signal or a modified version thereof. This signal may be used in a converter block 35 as a basis for achieving control signals R, G, B for the primary light sources 25, 27, 29, as is well known per se. In some cases PWM control blocks 37, 39, 41 may be used to deliver an accurate amount of energy to the primary light sources as a pulse ratio based on a DC value. The primary light sources may be light emitting diodes, LEDs, incandescent lamps or the like.

Even though RGB light sources are used in the above-described examples, other combinations of primary light sources are possible. For instance a white light source may be added to provide an RGBW unit, or the red light source may be supported by an amber light source to provide an RGBA unit.

In addition to the fixed color gamut a maximum flux may be defined for the lighting unit. The comparator may then compare the flux value of the input signal with the maximum flux. If the latter is exceeded, the flux value may be reduced accordingly. The maximum flux may be uniform over the color gamut, or may vary over the same.
The control unit and comparator may be provided in an overall control unit, cf. 5 of fig 1, and the above described controller may thus be adapted to control a plurality of lighting units.

In summary, the disclosure relates to a controller for a lighting unit as well as a method for controlling a lighting unit. The lighting unit has a plurality of differently colored primary light sources which may be controlled independently. To provide color uniformity between multiple lighting units, an input signal is evaluated with respect to a fixed color gamut by means of a comparator. The fixed gamut is chosen such that all or most lighting units can produce the colors therein. If the input signal relates to a value outside the fixed gamut, the input signal may be modified to a value inside the fixed gamut. Then, color differences between adjacent lighting units may be avoided to a great extent.

The invention is not restricted to the above-described embodiments, and may be altered in different ways within the scope of the appended claims.

CLAIMS:

1. A controller (24) for a lighting unit, which unit comprises at least a first and a second primary light source (25, 27, 29) having mutually different spectra and being adapted to be individually controlled in response to an input signal (x_1, y_1), such that the color of the mixed output light is variable, the primary light sources spanning a maximum color gamut (17, 19, 21) in a color space (15), wherein

- a fixed color gamut (23) is defined for the controller, the fixed color gamut being smaller than the maximum color gamut,
- the controller comprises a comparator (31) which is adapted to determine whether an input signal refers to a value within the fixed color gamut, and
- the controller is adapted to initiate an action if the input signal refers to a value outside the fixed color gamut.

2. A controller according to claim 1, wherein the action comprises modifying the input signal (x_1, y_1) to a value (x_2, y_2) within the fixed color gamut.

3. A controller according to claim 2, wherein the input signal is changed to the value on the color gamut boundary that is closest to input signal value.

4. A controller according to claim 1, wherein the action comprises cancelling the input signal, such that no light is output from the lighting unit.

5. A controller according to claim 1, wherein the action comprises generating a warning indication.

6. A controller according to any of the preceding claims, wherein additionally at least one maximum flux is defined, the comparator compares the flux value of the input signal with the maximum flux, and reduces the flux value to the maximum flux if the flux value is exceeded.

7. A controller according to any of the preceding claims, which is adapted to control primary light sources in the form of light emitting diodes, LEDs.

8. A controller according to any of claims 1-6, which is adapted to control primary light sources in the form of incandescent lamps.

9. A controller according to any of the preceding claims, wherein the controller is adapted to control a plurality of lighting units.

10. A method for controlling a lighting unit, which comprises at least a first and a second primary light source having mutually different spectra and being adapted to be individually controlled in response to an input signal, such that the color of the output light is variable, the light sources spanning a maximum color gamut, wherein

- a fixed color gamut is defined for the controller, the fixed color gamut being smaller than the maximum color gamut,
- it is determined whether an input signal refers to a value within the fixed color gamut, and
- an action is initiated if the input signal refers to a value outside the fixed color gamut.

11. A method according to claim 10, wherein the action comprises modifying the input signal to a value within the fixed color gamut.

12. A method according to claim 11, wherein the input signal is changed to the value on the color gamut boundary that is closest to input signal value.

13. A method according to claim 10, wherein the action comprises cancelling the input signal, such that no light is output from the lighting unit.

14. A method according to claim 10, wherein the action comprises generating a warning indication.

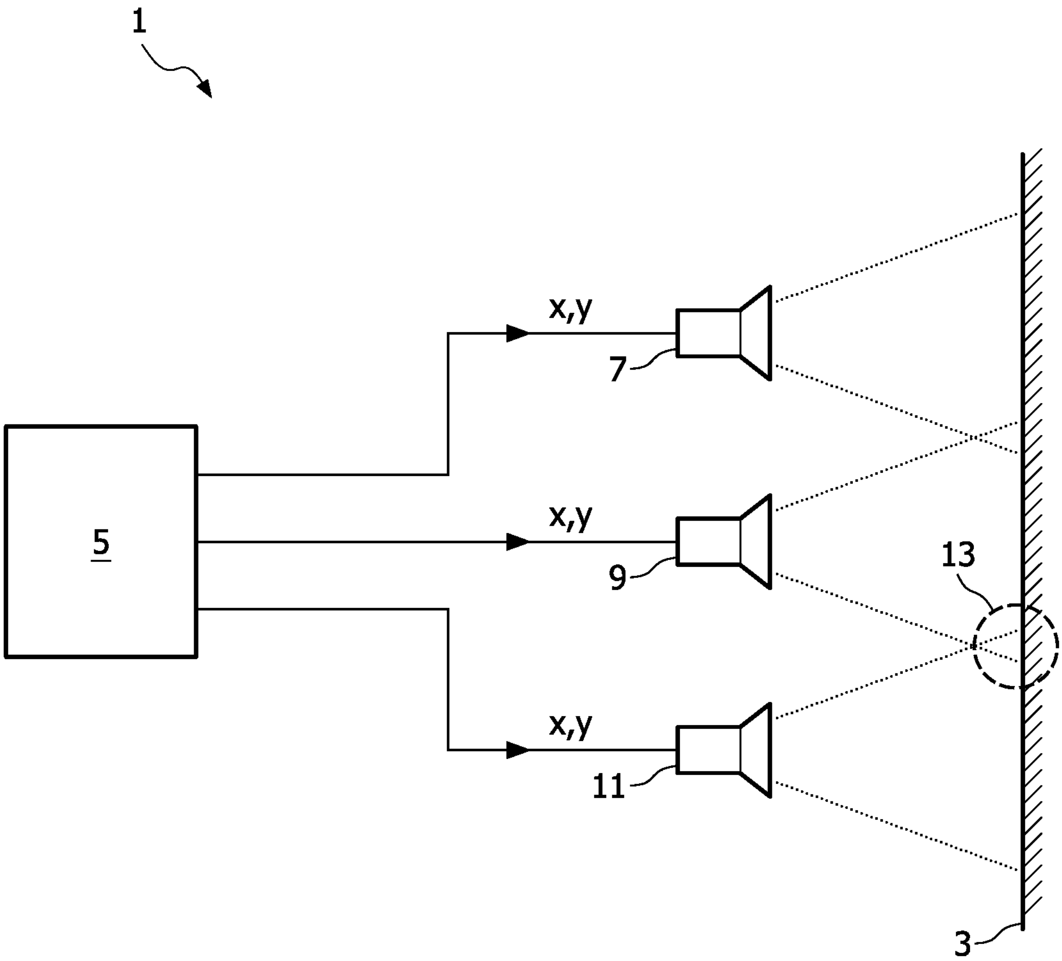

FIG. 1

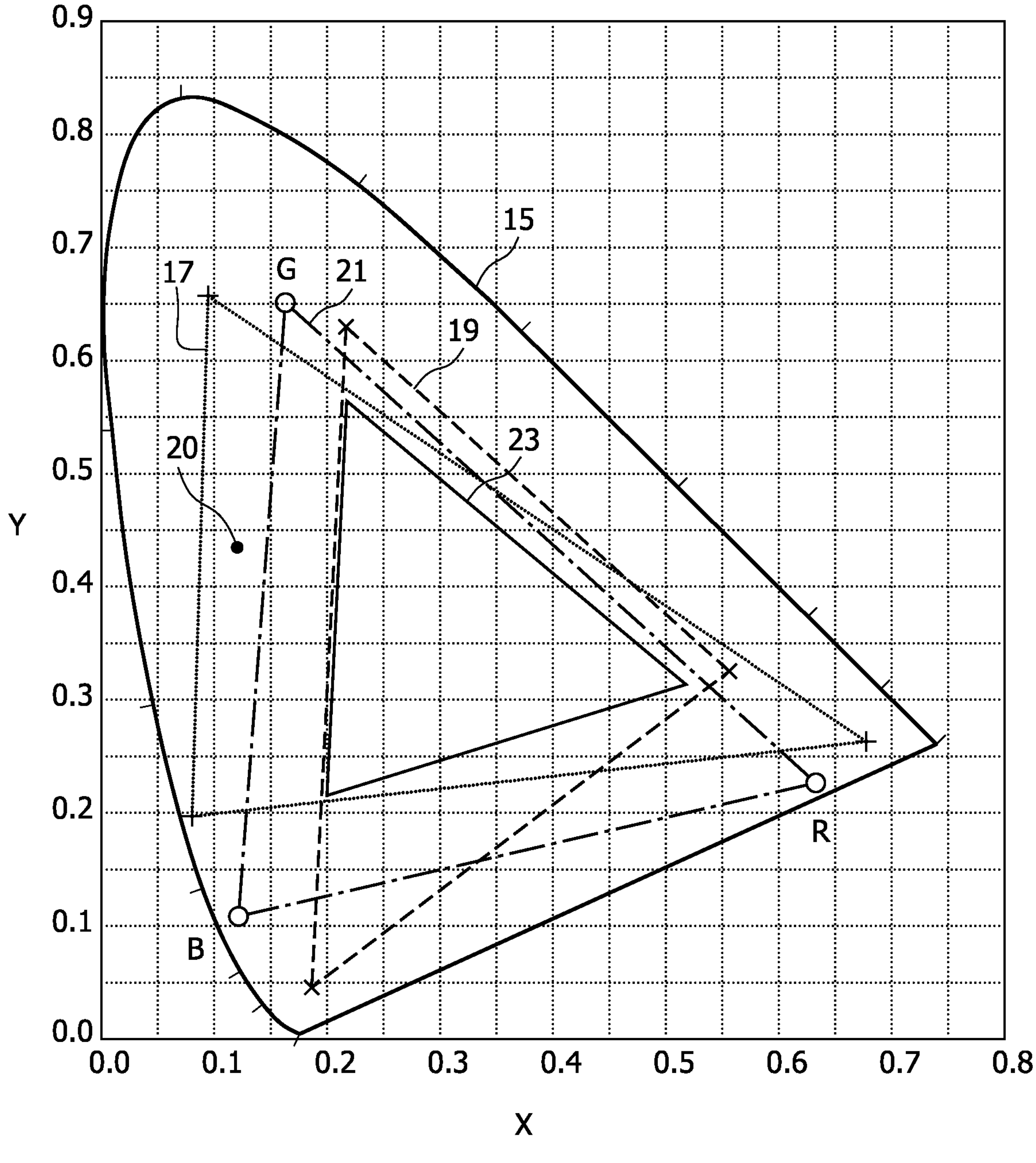
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Y
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
X
15
17
G
21
19
20
23
R
B

FIG. 2

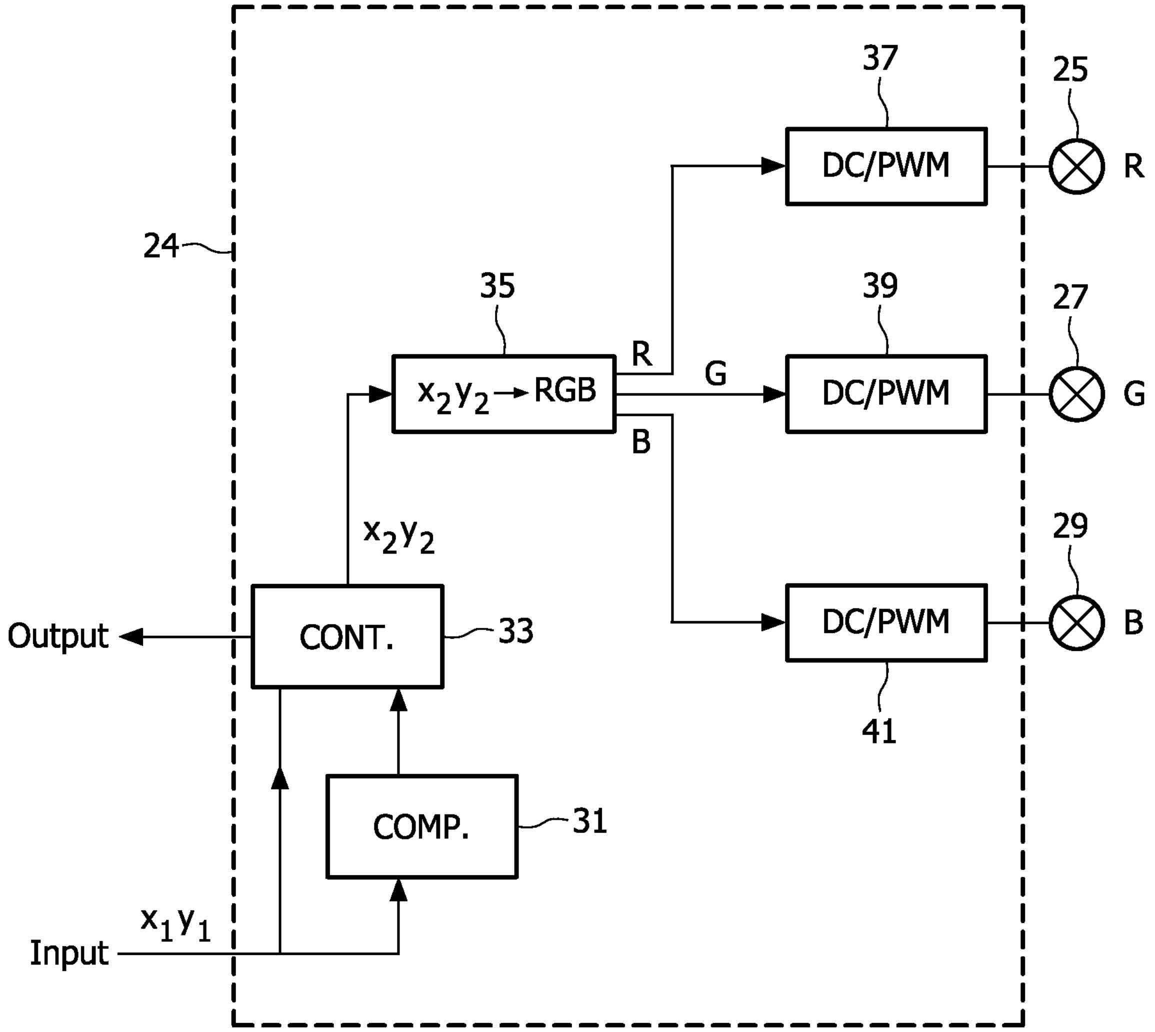
37
25
DC/PWM
R
24
35
39
27
R
G
x2y2→RGB
DC/PWM
G
B
29
x2y2
Output
CONT.
33
DC/PWM
B
41
COMP.
31
x1y1
Input

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/054638

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B33/08

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)
H05B

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/033667 A (VIP 1 APS; KRAUSE CHRISTIAN [DK]) 29 March 2007 (2007-03-29) abstract page 2, lines 5-15 page 7, lines 5-20 page 9, line 15 - page 11, line 25 page 12, line 20 - page 14, line 10 figures 1-7 -----	1-14
X	US 2006/098077 A1 (DOWLING KEVIN J [US]) 11 May 2006 (2006-05-11) paragraphs [0012], [0031], [0088], [0091], [0098] - [0101], [0109], [0133], [0138] - [0148], [0153] figures 1,4,5,7,8 ----- -/--	1-14

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21 April 2009	28/04/2009

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/054638

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/062446 A1 (ASHDOWN IAN [CA]) 24 March 2005 (2005-03-24) abstract paragraphs [0001] - [0008], [0011], [0020], [0024] - [0030] figures 1-3,5	1-14
X	US 2006/152524 A1 (MILLER MICHAEL E [US] ET AL) 13 July 2006 (2006-07-13) paragraphs [0032], [0033], [0039], [0042], [0043], [0045], [4748] - [0052], [0056] figures 1-5	1-14
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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