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Jeon et al.

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(54) **APPARATUS AND METHOD FOR MEASURING 3-DIMENSIONAL INTEROCULAR CROSSTALK**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 649 days.

(21) Appl. No.: **13/673,718**

(22) Filed: **Nov. 9, 2012**

(65) **Prior Publication Data**

US 2013/0113887 A1 May 9, 2013

Related U.S. Application Data

(60) Provisional application No. 61/557,421, filed on Nov. 9, 2011.

(51) **Int. Cl.**

H04N 13/02 (2006.01)
H04N 13/04 (2006.01)

(52) **U.S. Cl.**

CPC *H04N 13/0425* (2013.01)

(58) **Field of Classification Search**

CPC H04N 13/00; H04N 13/0246; H04N 13/0425
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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2012/0013602 A1* 1/2012 Lee et al. 345/419

* cited by examiner

Primary Examiner — Huy T Nguyen
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

An apparatus and method for measuring 3-dimensional (3D) interocular crosstalk is disclosed. A light sensor detects luminance of a stereoscopic image displayed in a display and outputs a luminance value indicating the detected luminance. A controller calculates 3D interocular crosstalk based on a gray difference and a residual luminance ratio.

19 Claims, 18 Drawing Sheets

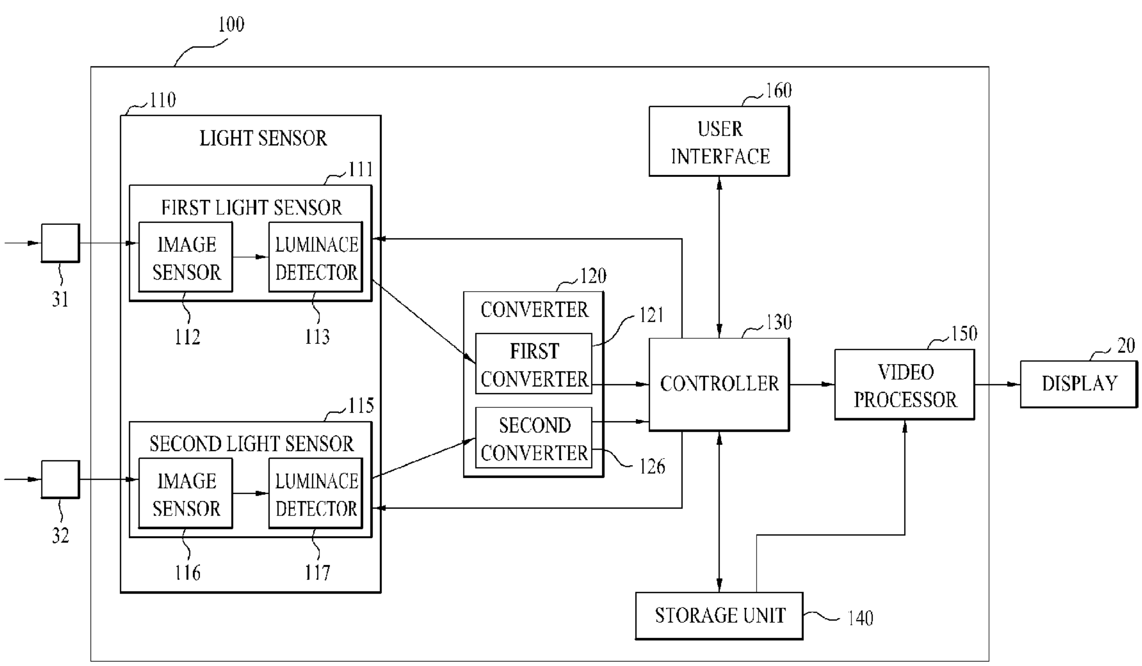


FIG. 1

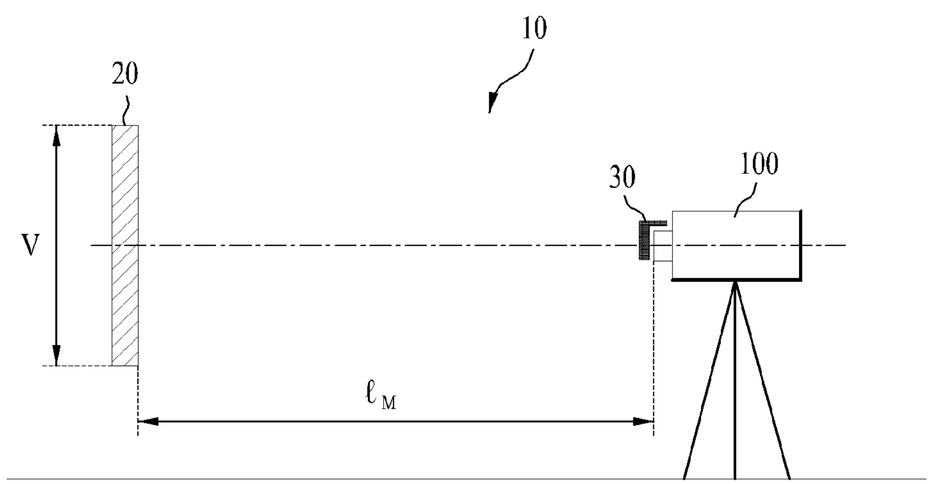


FIG. 2

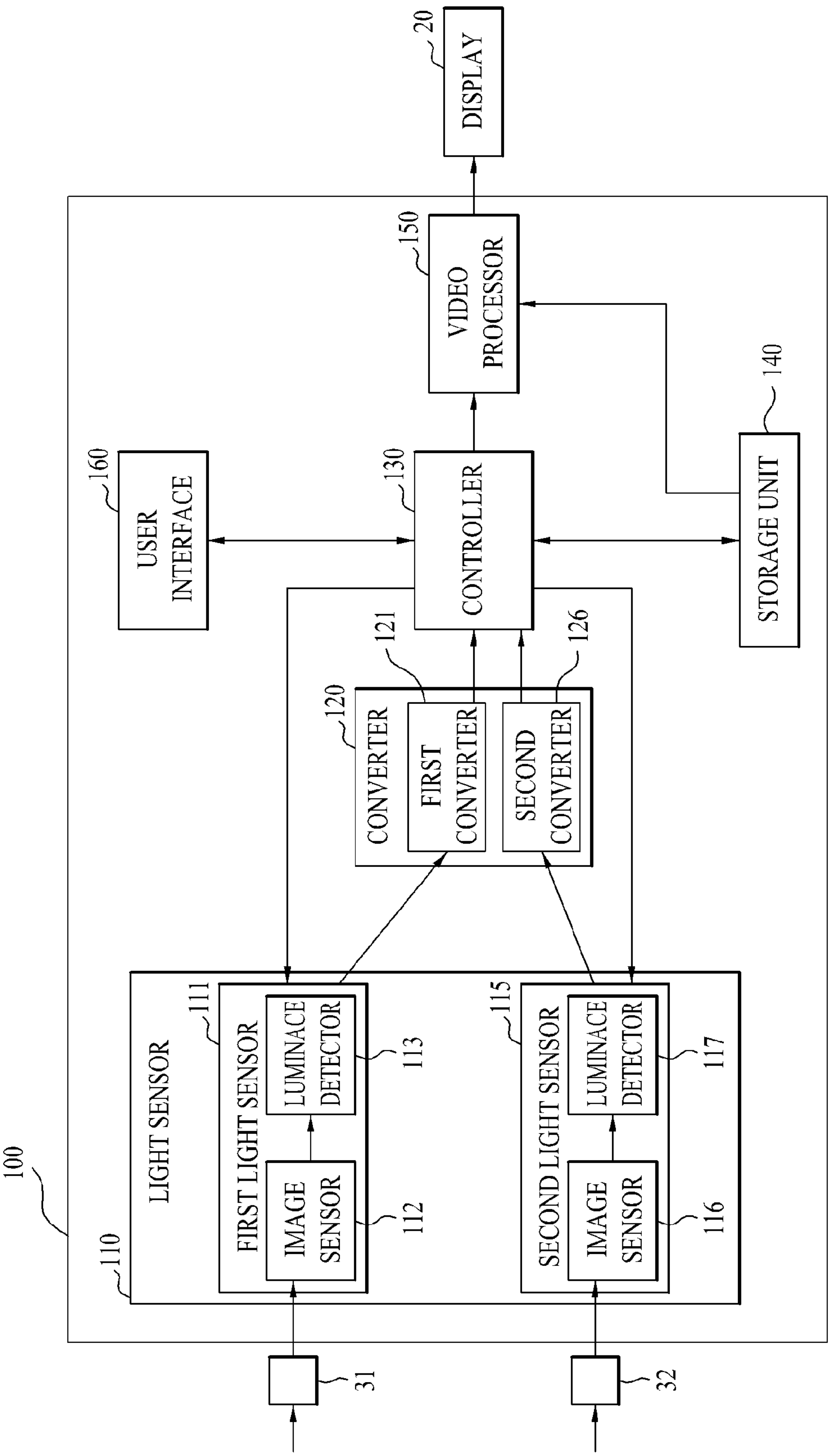

DISPLAY
20
VIDEO PROCESSOR
150
USER INTERFACE
160
CONTROLLER
130
STORAGE UNIT
140
CONVERTER
120
FIRST CONVERTER
121
SECOND CONVERTER
126
LIGHT SENSOR
110
FIRST LIGHT SENSOR
111
IMAGE SENSOR
112
LUMINACE DETECTOR
113
SECOND LIGHT SENSOR
115
IMAGE SENSOR
116
LUMINACE DETECTOR
117
100
31
32

FIG. 3

300

4	Gray to Gray 3D Crosstalk (%)										
5	Current (Left)	Previous (Right)									
6		Gray	G256	G223	G191	G159	G127	G95	G63	G31	G0
7		G255	-	4.84%	2.85%	1.17%	0.86%	-0.29%	-0.86%	1.11%	1.83%
8		G223	5.88%	-	5.82%	1.09%	0.40%	0.47%	-1.25%	0.28%	1.72%
9		G191	7.34%	4.02%	-	2.29%	0.26%	1.25%	-1.08%	0.06%	1.65%
10		G159	3.48%	0.62%	0.71%	-	0.33%	0.12%	0.72%	-0.27%	1.57%
11		G127	1.64%	2.38%	1.73%	4.60%	-	-0.30%	-0.64%	-1.39%	1.50%
12		G95	4.11%	-0.72%	-1.36%	1.02%	5.87%	-	6.20%	-2.47%	1.41%
13		G63	3.58%	-0.14%	-1.83%	-2.59%	-2.44%	-1.89%	-	-3.61%	1.56%
14		G31	0.93%	-0.35%	-3.93%	-3.91%	-4.69%	-10.69%	-12.42%	-	0.82%
15		G0	0.10%	-1.98%	-6.72%	-9.41%	-12.37%	-19.41%	-17.51%	-35.96%	-
16		AVG.	3.38%	0.55%	-0.80%	-0.99%	-1.81%	-4.35%	-3.71%	-6.20%	1.46%
17		MAX	7.34%	4.02%	5.82%	4.60%	5.87%	1.25%	6.20%	0.28%	1.72%

FIG. 4

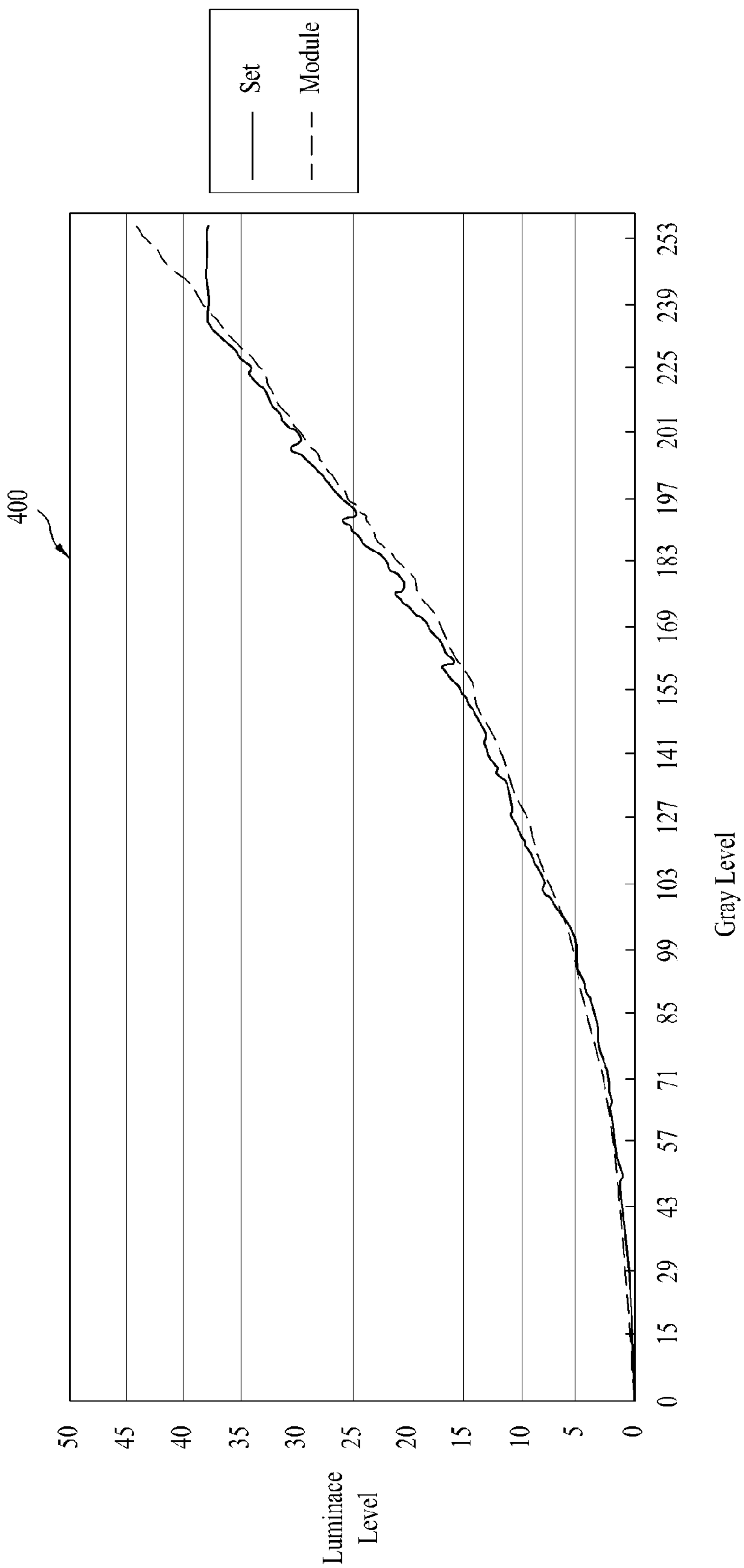

400
Set
Module
Luminace Level
50
45
40
35
30
25
20
15
10
5
0
0
15
29
43
57
71
85
99
103
127
141
155
169
183
197
201
225
239
253
Gray Level

FIG. 5

500

4	Gray to Gray 3D Crosstalk (%)										
5	Current (Left)	Previous (Right)									
6		Gray	G255	G223	G191	G159	G127	G95	G63	G31	G0
7		G255	-	1.24%	1.34%	0.76%	0.68%	-0.26%	-0.82%	1.09%	1.83%
8		G223	-1.50%	-	1.25%	0.43%	0.21%	0.30%	-0.88%	0.21%	1.28%
9		G191	-3.45%	-0.86%	-	0.40%	0.08%	0.52%	-0.52%	0.03%	0.88%
10		G159	-2.25%	-0.24%	-0.12%	-	0.05%	0.03%	0.22%	-0.09%	0.56%
11		G127	-1.29%	-1.26%	-0.54%	-0.64%	-	-0.03%	-0.11%	-0.29%	0.32%
12		G95	-3.64%	0.45%	0.56%	-0.24%	-0.60%	-	0.42%	-0.26%	0.16%
13		G63	-3.41%	0.10%	0.88%	0.80%	0.41%	0.13%	-	-0.13%	0.07%
14		G31	-0.92%	0.26%	2.04%	1.35%	0.97%	1.11%	0.45%	-	0.01%
15		G0	-0.10%	1.47%	3.56%	3.33%	2.67%	2.21%	0.81%	0.35%	-
16		AVG.	-2.07%	-0.01%	1.09%	0.77%	0.54%	0.06%	0.06%	-0.03%	0.47%
17		MAX	-0.10%	1.47%	3.56%	3.33%	2.67%	2.21%	0.81%	0.35%	1.28%

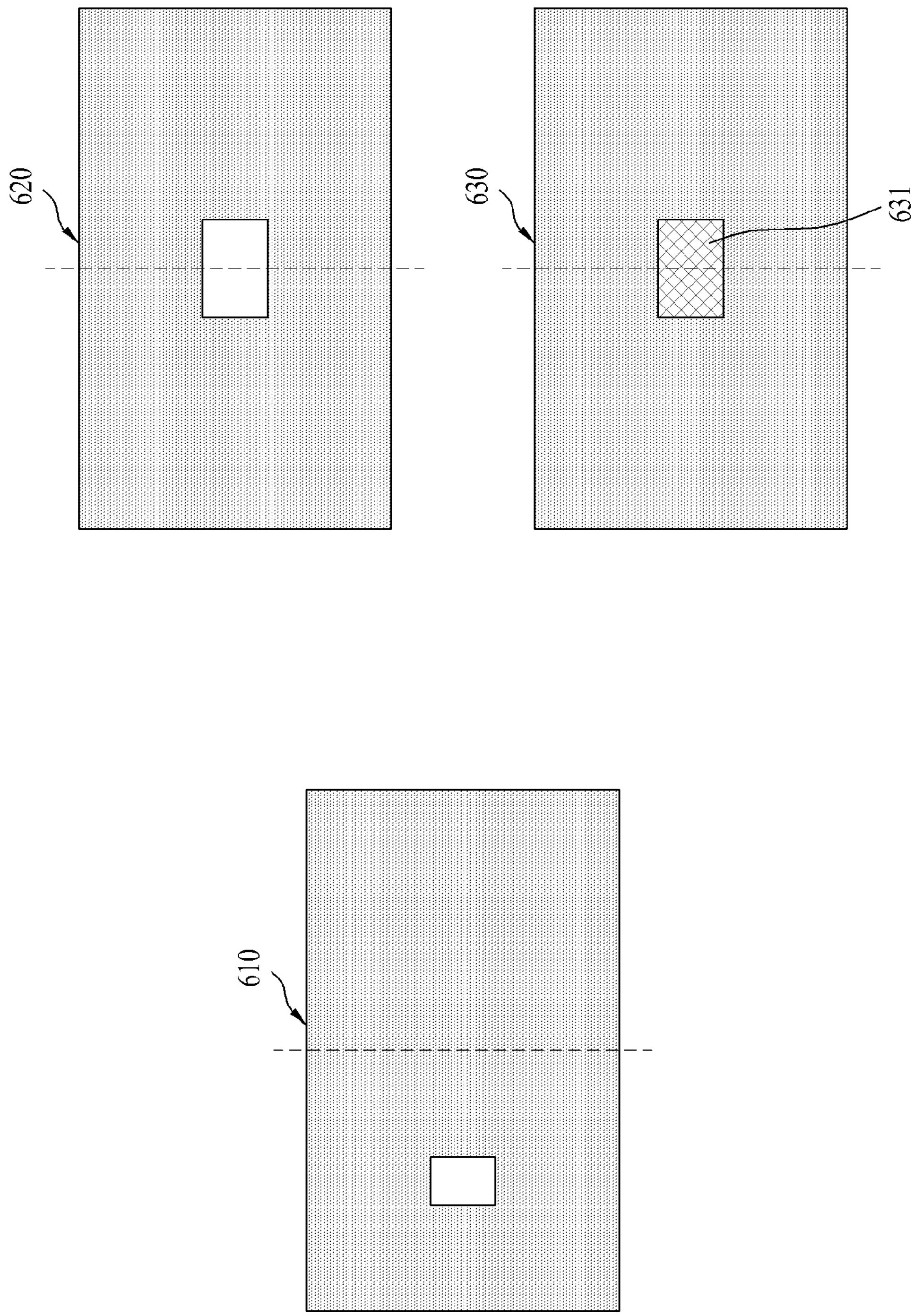


FIG. 6

FIG. 7

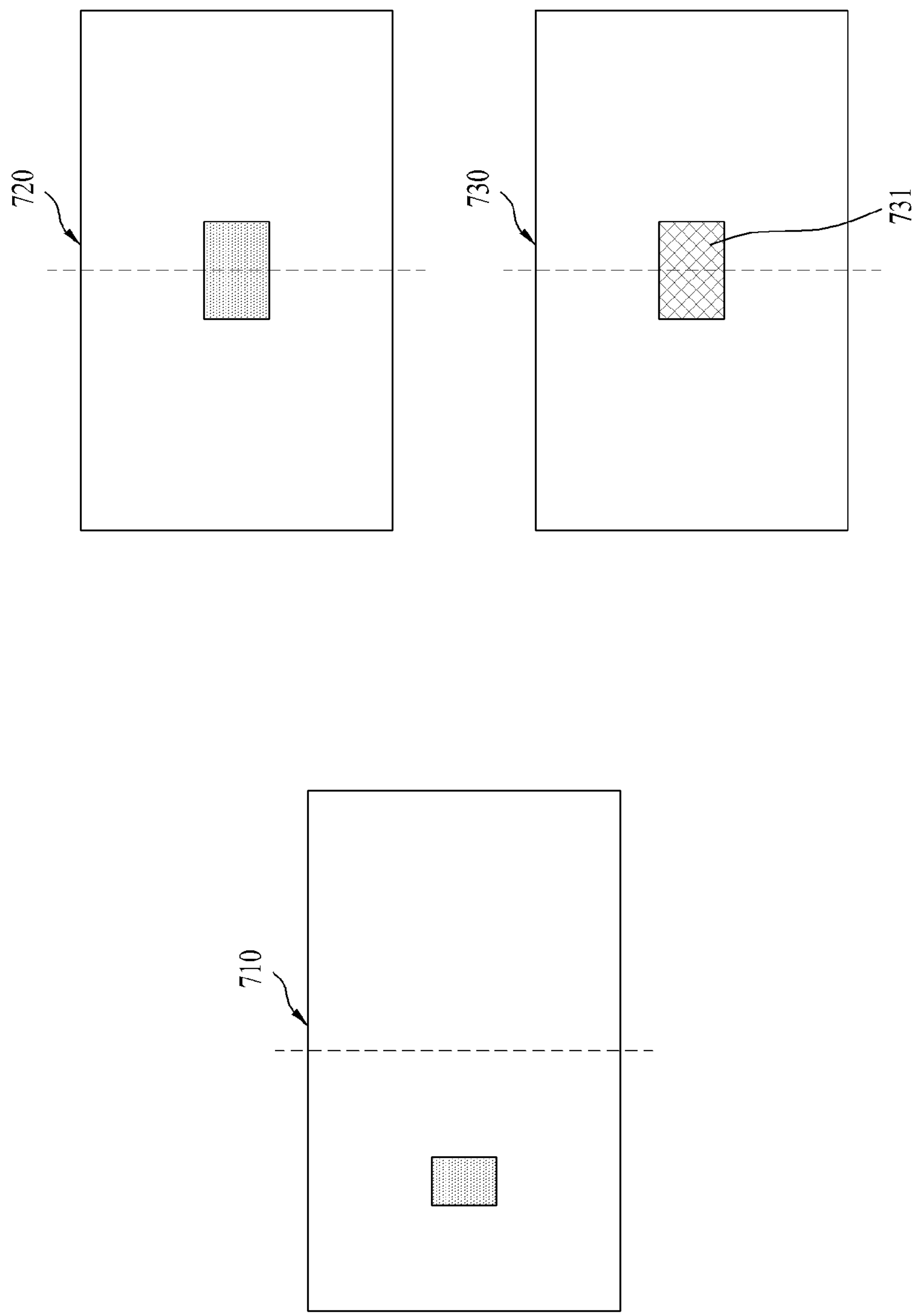


FIG. 8A

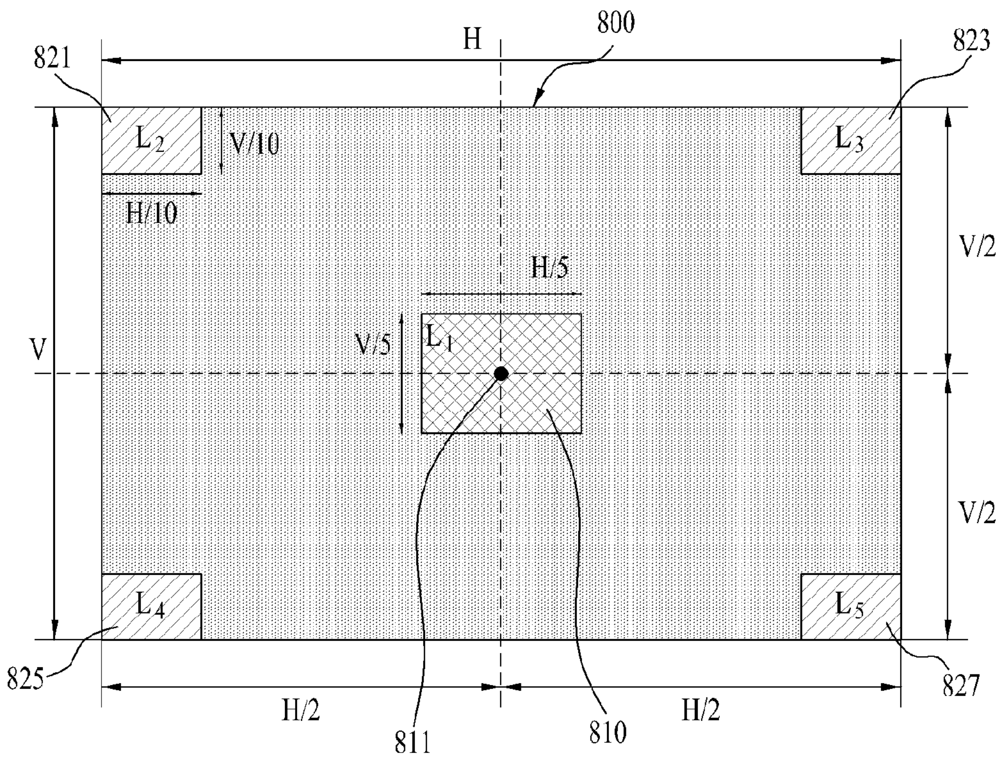

800
H
821
823
L_2
L_3
V/10
H/10
V/2
H/5
V
V/5
L_1
V/2
L_4
L_5
825
827
H/2
H/2
811
810

FIG. 8B

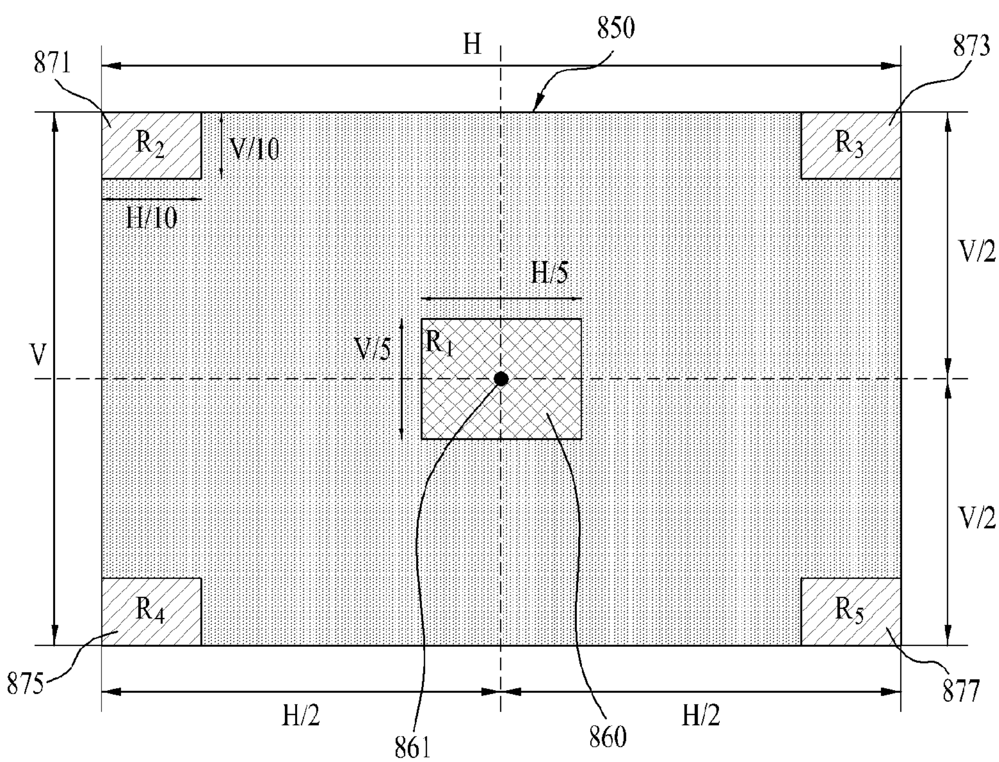

850
H
871
873
R_2
R_3
V/10
H/10
V/2
H/5
V
V/5
R_1
V/2
R_4
R_5
875
877
H/2
H/2
861
860

FIG. 9

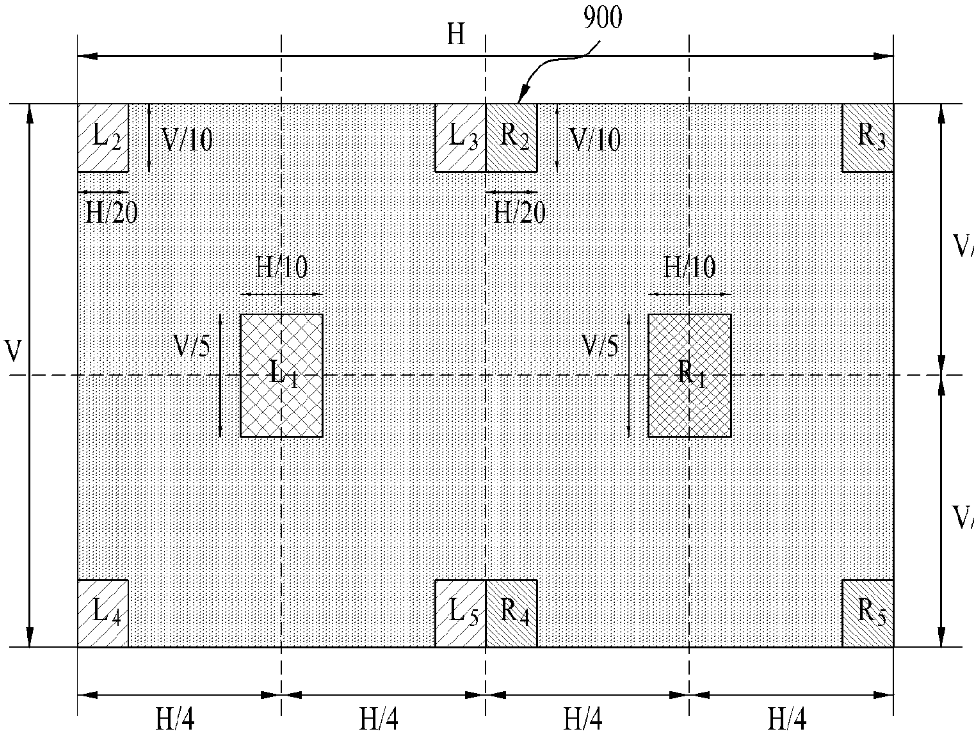

900
H
L2
V/10
L3
R2
V/10
R3
H/20
H/20
V/2
H/10
H/10
V/5
L1
V/5
R1
V
V/2
L4
L5
R4
R5
H/4
H/4
H/4
H/4

FIG. 10

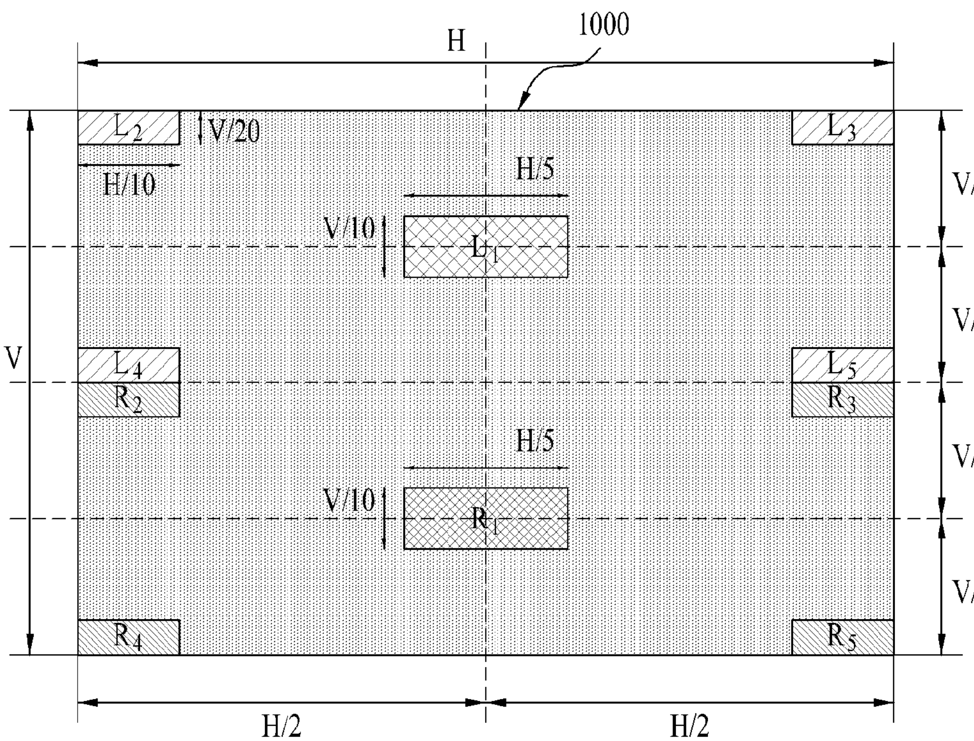

1000
H
L2
V/20
L3
H/10
H/5
V/4
V/10
L1
V/4
V
L4
R2
L5
R3
V/4
H/5
V/10
R1
V/4
R4
R5
H/2
H/2

FIG. 11A

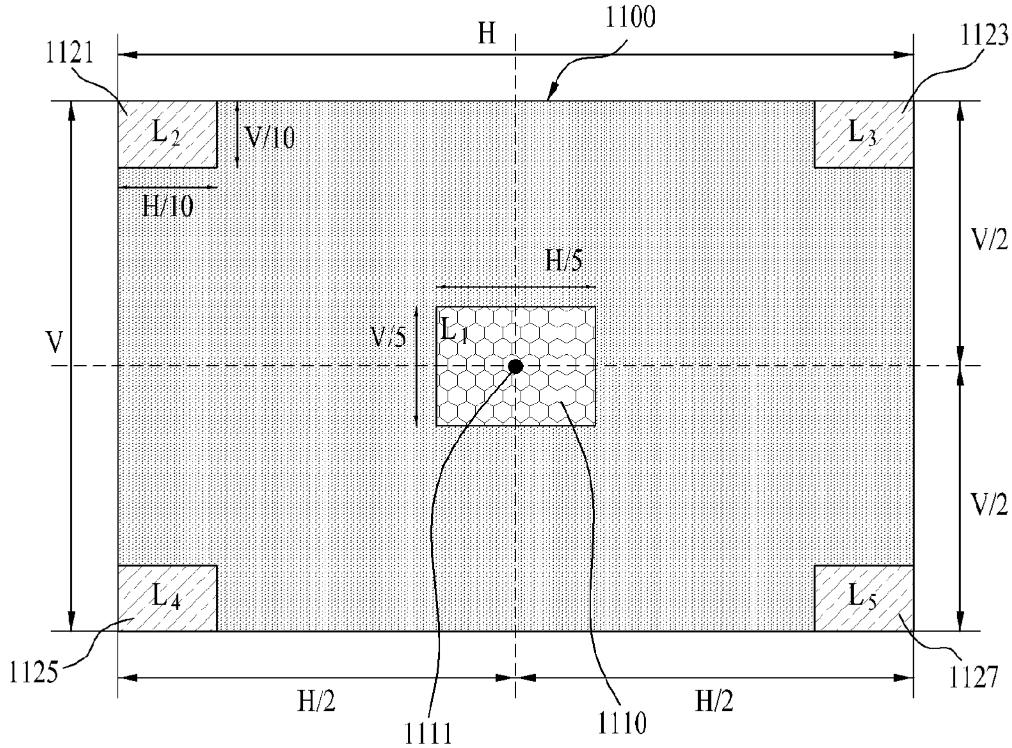


FIG. 11B

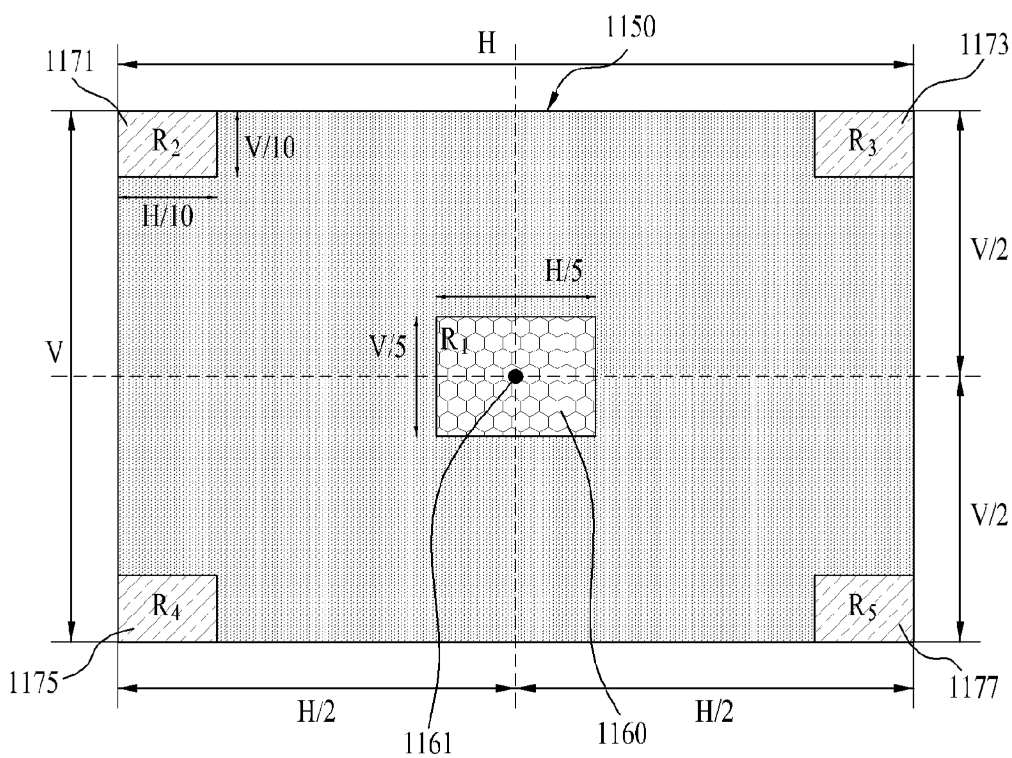


FIG. 12

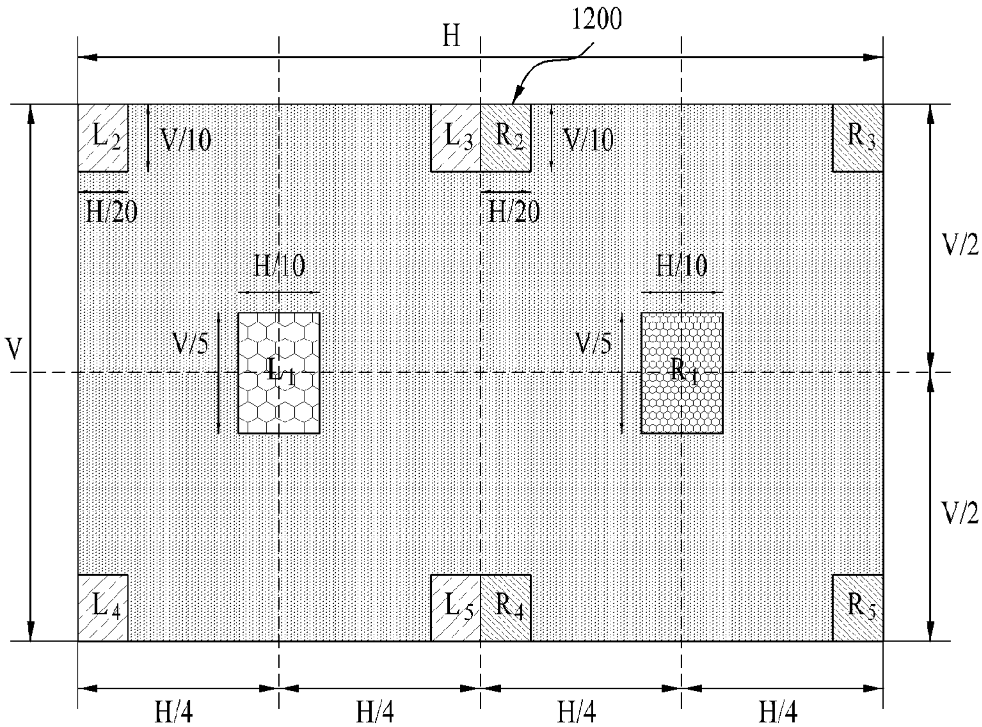

1200
H
L2
V/10
H/20
L3
R2
V/10
H/20
R3
H/10
H/10
V
V/5
L1
V/5
R1
V/2
V/2
L4
L5
R4
R5
H/4
H/4
H/4
H/4

FIG. 13

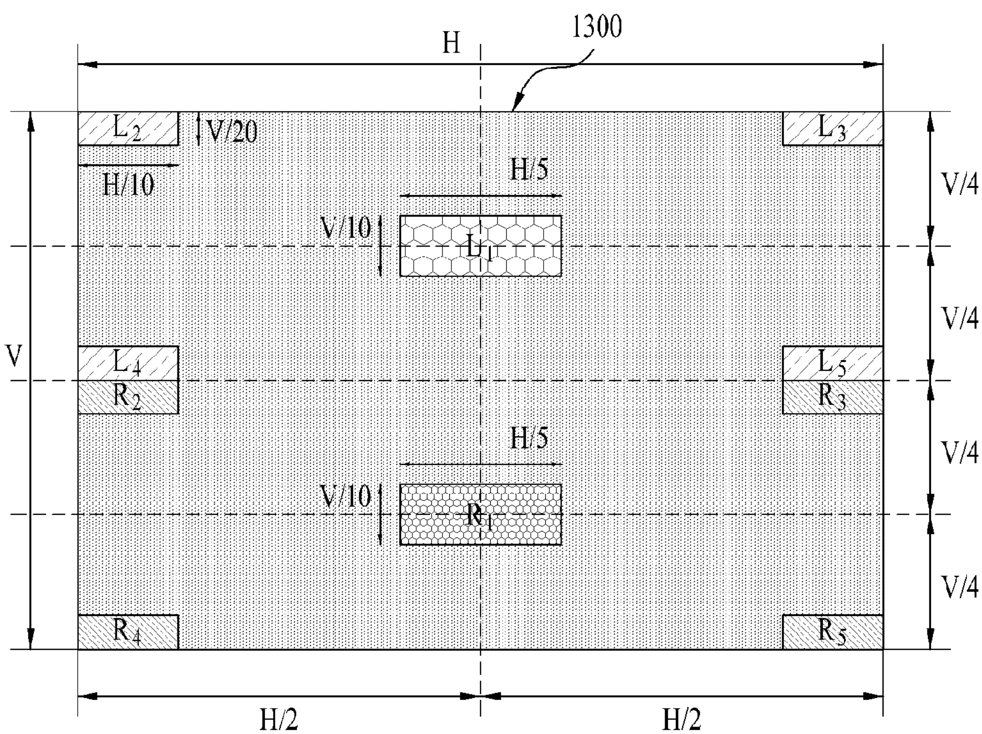

1300
H
L2
V/20
H/10
L3
H/5
V/10
L1
V/4
V/4
V
L4
R2
L5
R3
H/5
V/10
R1
V/4
V/4
R4
R5
H/2
H/2

FIG. 14A

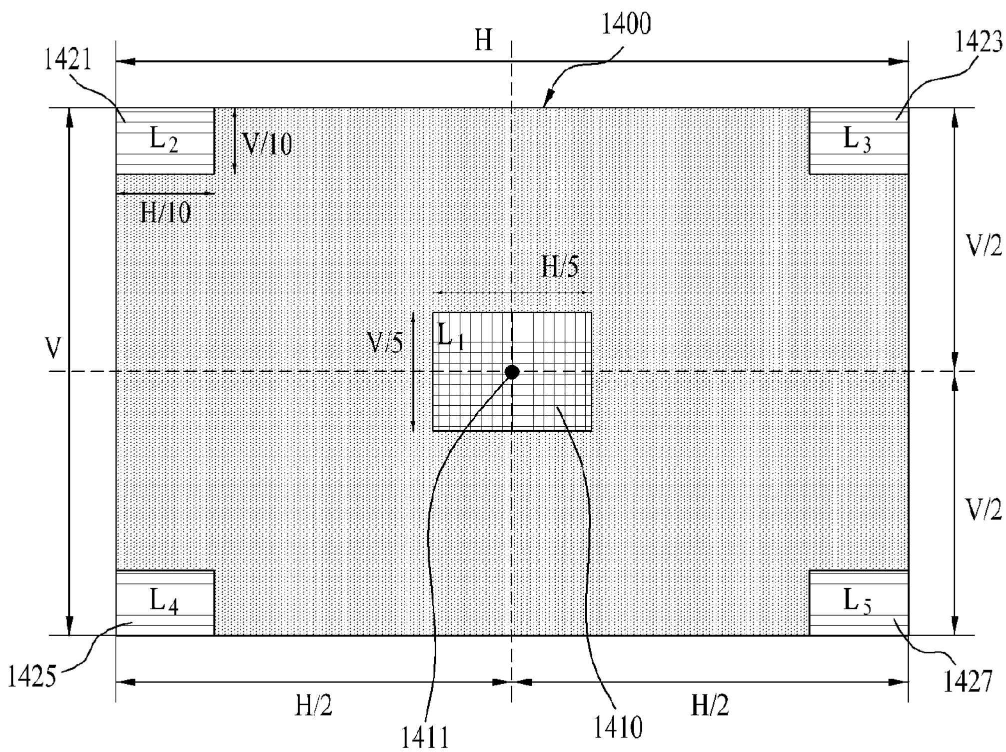


FIG. 14B

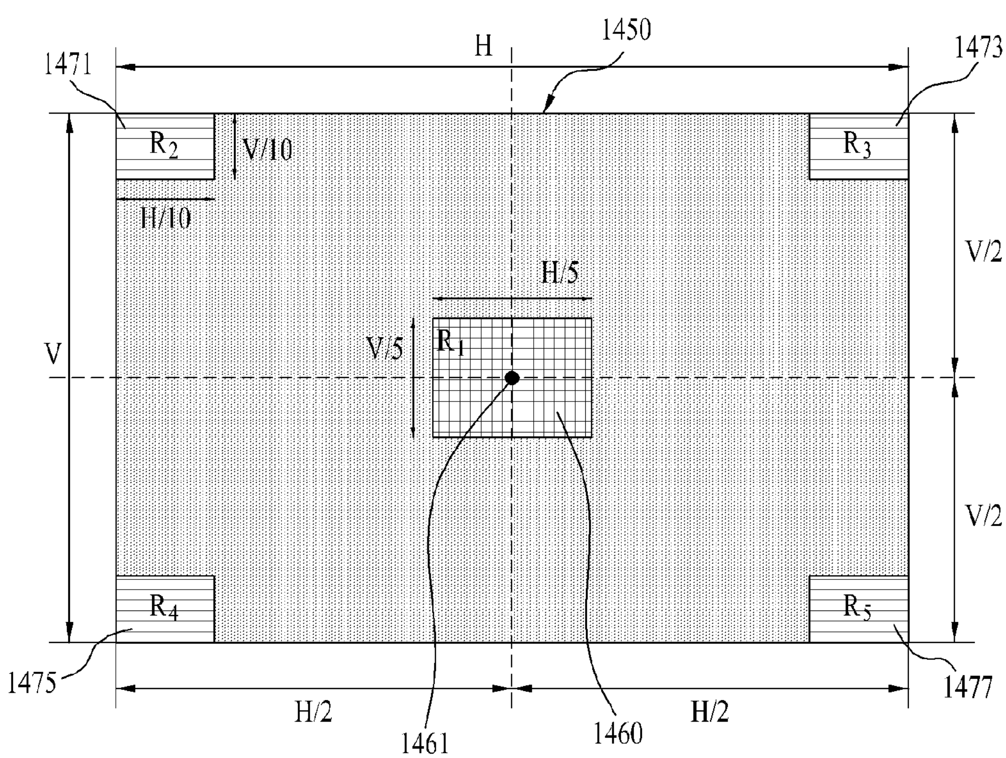


FIG. 15

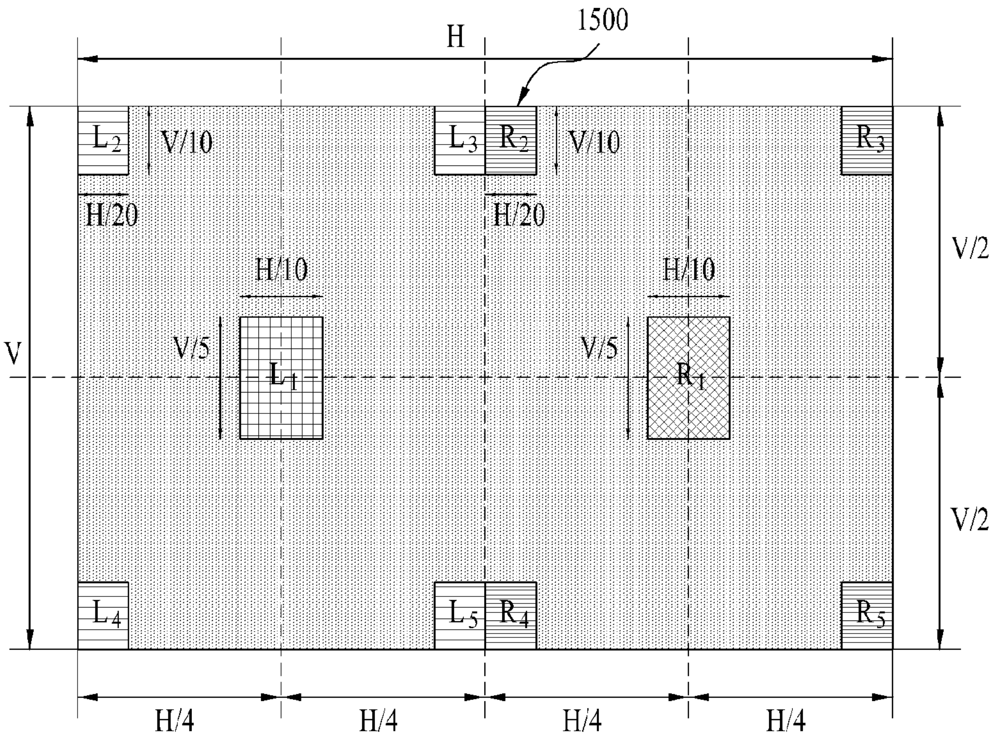

H
1500
L2
V/10
H/20
L3
R2
V/10
H/20
R3
V/2
H/10
H/10
V/5
L1
V/5
R1
V
V/2
L4
L5
R4
R5
H/4
H/4
H/4
H/4

FIG. 16

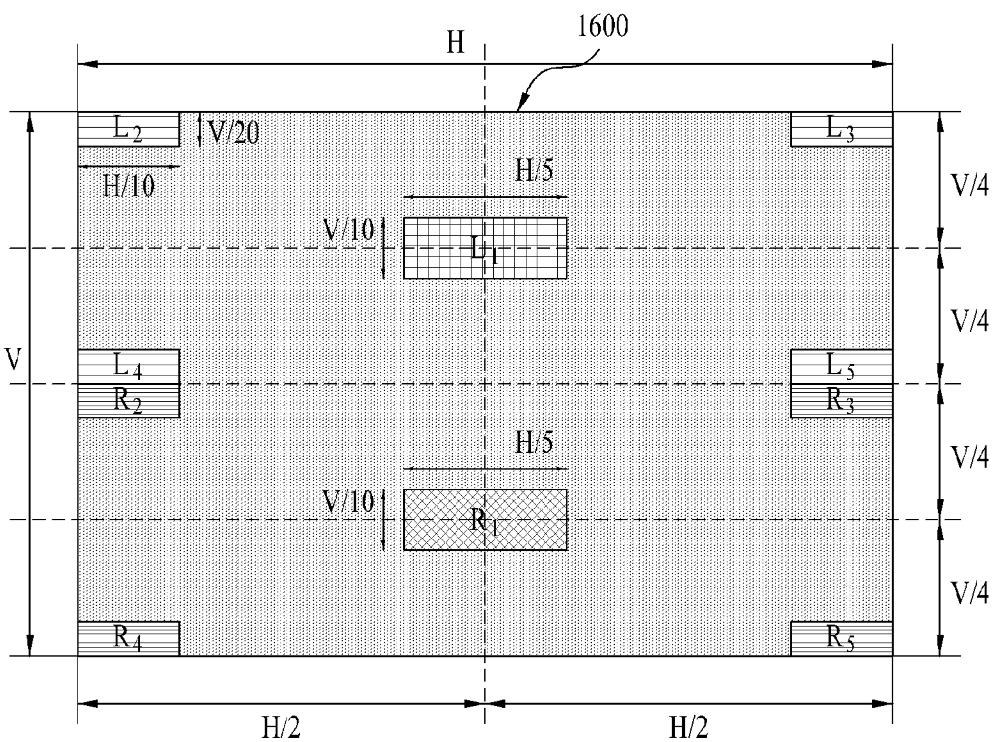

H
1600
L2
V/20
L3
H/10
H/5
V/4
V/10
L1
V/4
V
L4
R2
L5
R3
H/5
V/4
V/10
R1
V/4
R4
R5
H/2
H/2

FIG. 17A

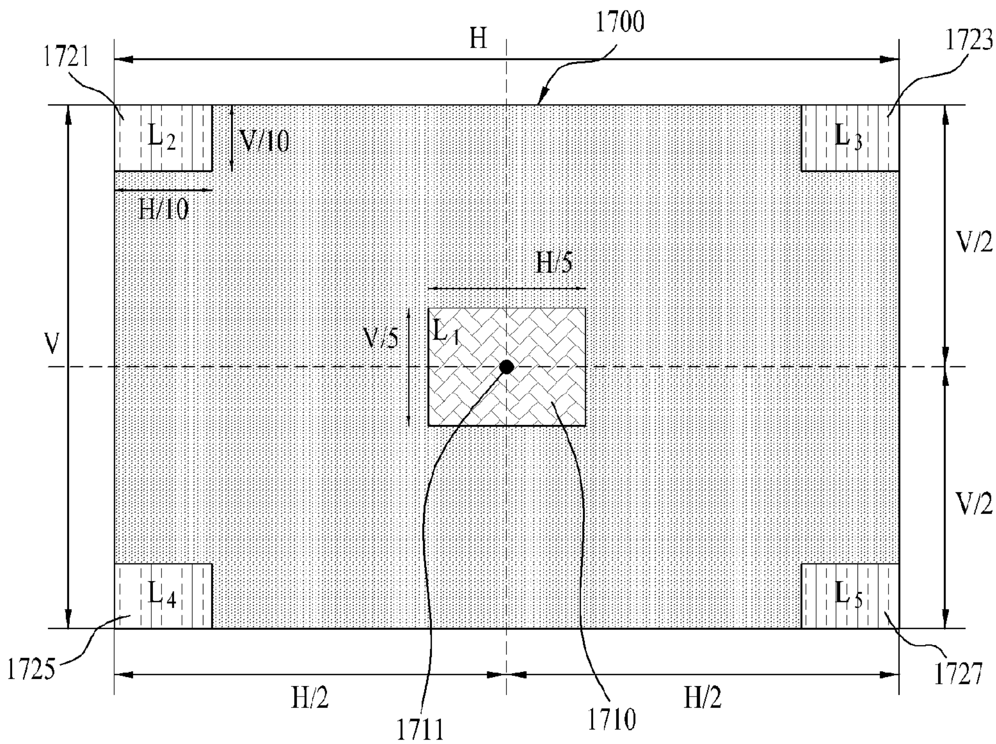


FIG. 17B

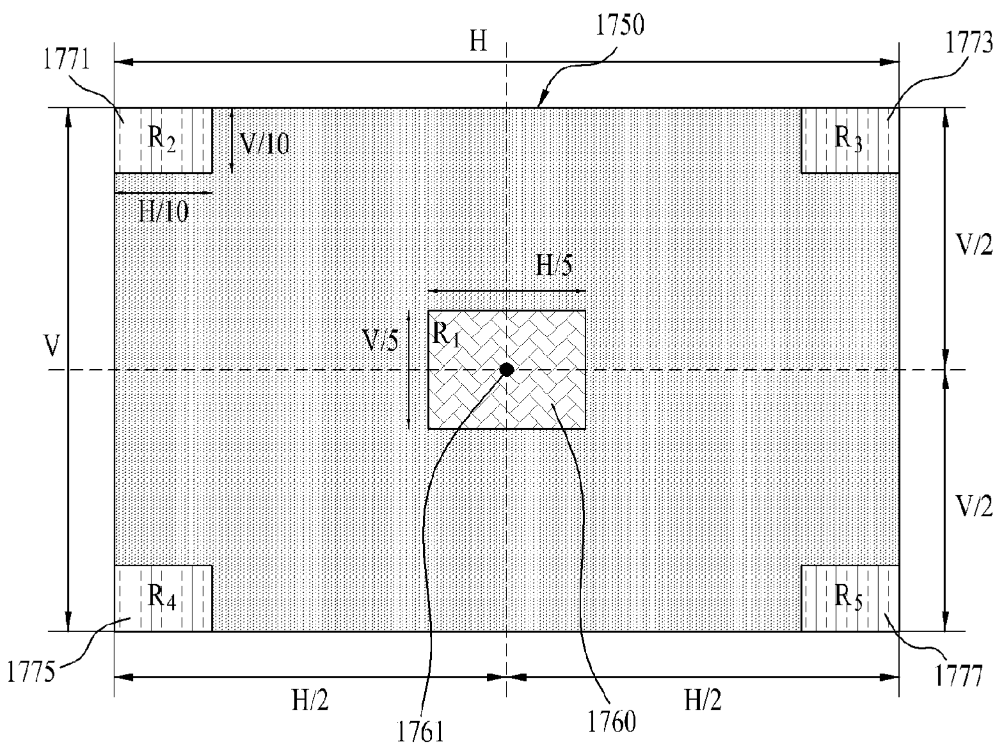
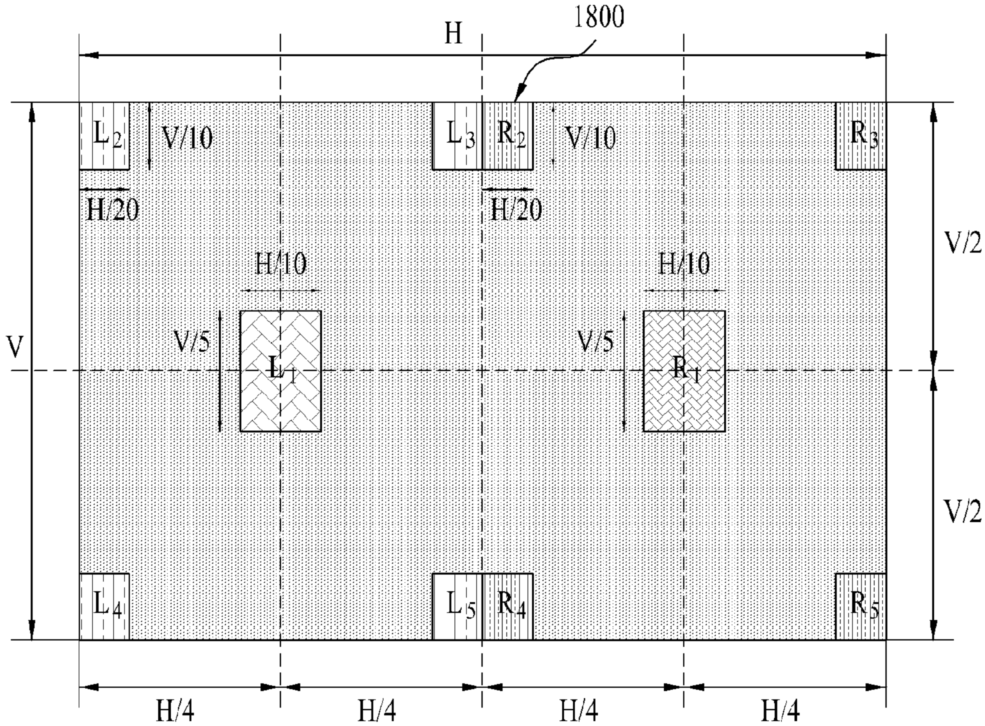
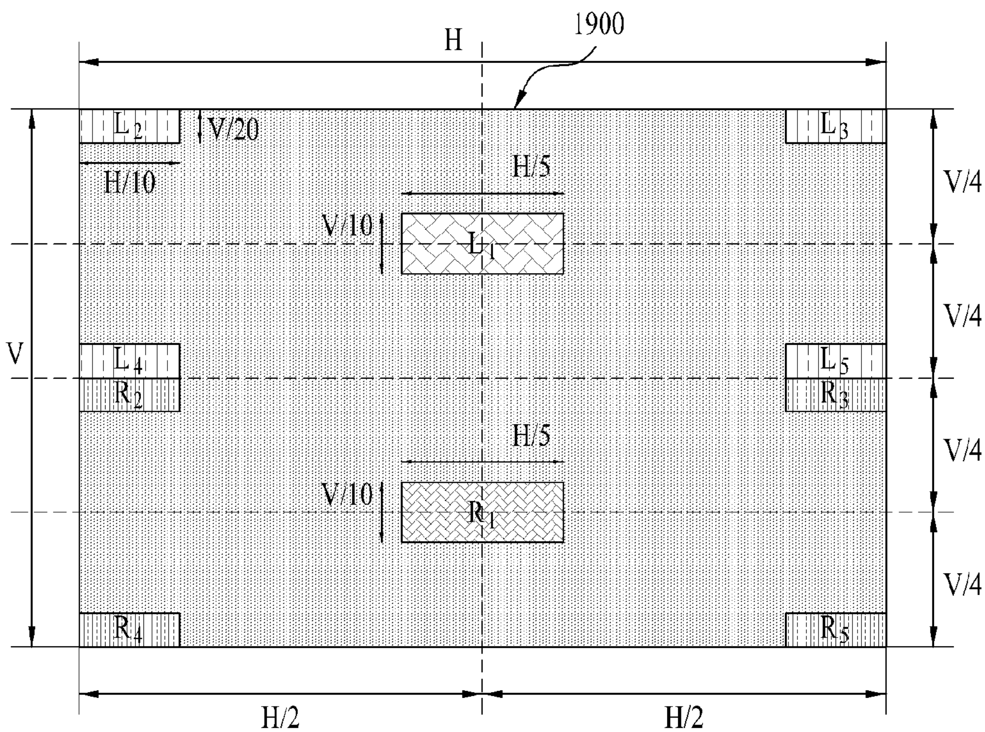


FIG. 18



1800
H
V
V/10
H/20
H/10
V/5
V/2
H/4
L1
L2
L3
L4
L5
R1
R2
R3
R4
R5

FIG. 19



1900
H
V
V/20
H/10
H/5
V/10
V/4
H/2
L1
L2
L3
L4
L5
R1
R2
R3
R4
R5

FIG. 20

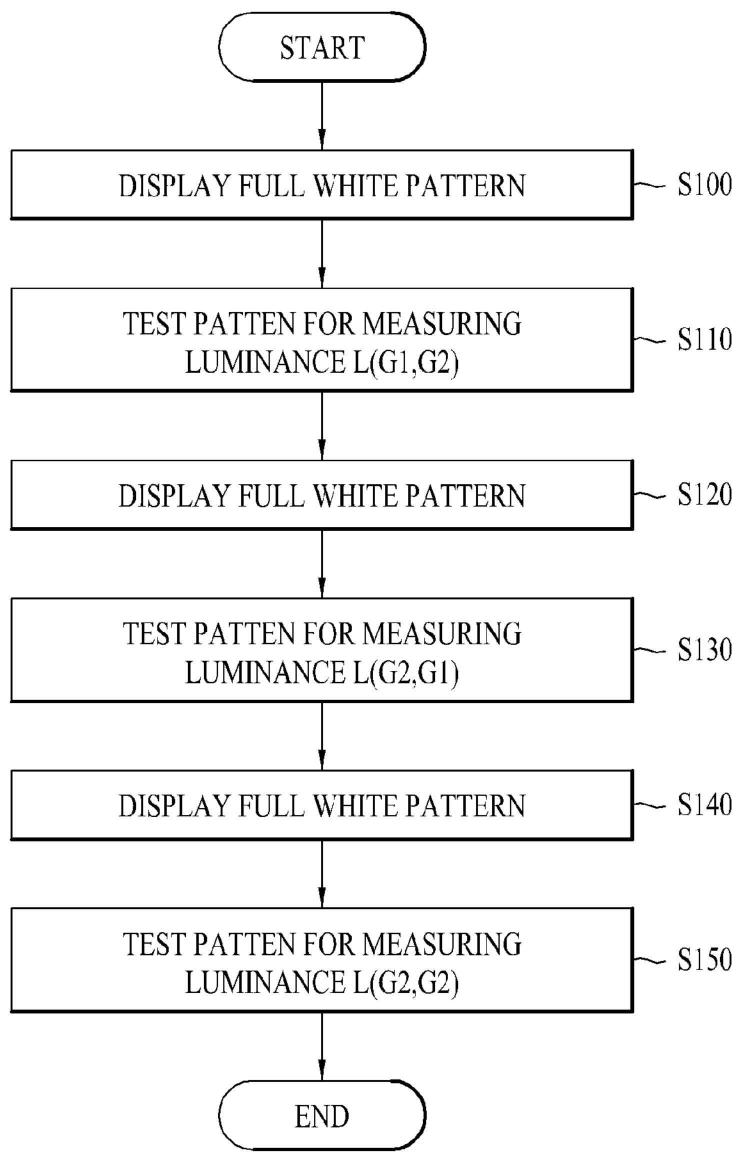

START
DISPLAY FULL WHITE PATTERN
S100
TEST PATTEN FOR MEASURING LUMINANCE L(G1,G2)
S110
DISPLAY FULL WHITE PATTERN
S120
TEST PATTEN FOR MEASURING LUMINANCE L(G2,G1)
S130
DISPLAY FULL WHITE PATTERN
S140
TEST PATTEN FOR MEASURING LUMINANCE L(G2,G2)
S150
END

FIG. 21

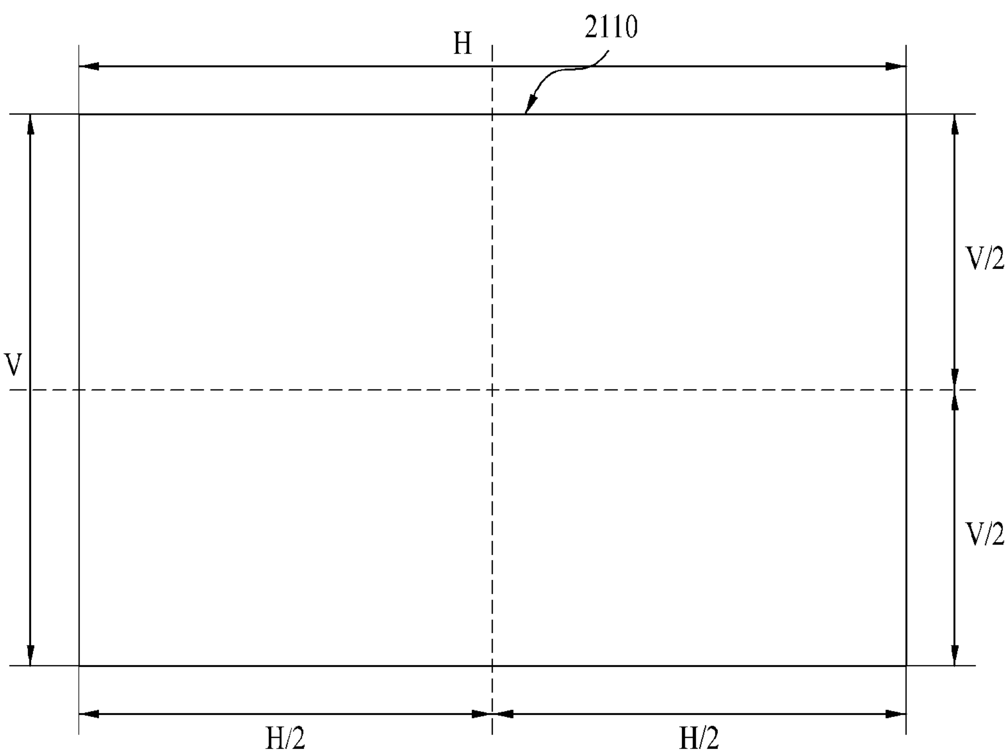


FIG. 22

2200

Gray to Gray 3D Crosstalk (%)										
Current (Left)	Previous (Right)									
			Gray_N	Gray_N-1	Gray_N-2	Gray_N-3	Gray_N-4	Gray_N-5	Gray_N-6	Gray_N-7
	Gray_N									
	Gray_N-1									
	Gray_N-2									
	Gray_N-3									
	Gray_N-4									
	Gray_N-5									
	Gray_N-6									
	Gray_N-7									

	AVG.	Peak.
Additive crosstalk		
Subtractivc crosstalk		

APPARATUS AND METHOD FOR MEASURING 3-DIMENSIONAL INTEROCULAR CROSSTALK

This application claims the benefit of U.S. Provisional Patent Application No. 61/557,421, filed on Nov. 9, 2011, which is hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus and a method for measuring 3-dimensional (3D) interocular crosstalk, and more particularly, to an apparatus and a method for measuring 3D interocular crosstalk, which is able to measure 3D interocular crosstalk of a stereoscopic image being processed to be presented in a display.

2. Discussion of the Related Art

Analog broadcast environments have been rapidly transitioned to digital broadcast environments. Thus, the amount of content for digital broadcasts has been considerably increased. In addition, as content for digital broadcasts, content for displaying a three-dimensional (3D) image signal as a 3D image has been produced in addition to content for displaying a 2-dimensional (2D) image signal as a 2D image.

A technique of displaying a 3D image uses the principle of binocular disparity so as to enable a viewer to perceive a 3D effect and includes a glasses method, a non-glasses method, and a full-3D method. A user may need to wear a separate device (or 3D glasses) such as polarized glasses and shutter glasses in the glass method.

Stereoscopic displays separate the left and right images using 3D glasses. When the left and right images are not separated perfectly, an unwanted ghost image appears at the other side, which is called 3D interocular crosstalk.

3D displays with high interocular crosstalk level cause some trouble such as dizziness, sickness, etc.

Therefore, it is one of the most important factors in 3D display to measure exact 3D crosstalk level quantitatively.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to an apparatus and a method for measuring 3-dimensional (3D) interocular crosstalk that substantially obviate one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide an apparatus and a method for measuring 3D interocular crosstalk, which is able to measure 3D interocular crosstalk considering pixel distribution of real video contents.

Another object of the present invention is to provide an apparatus and a method for measuring 3D interocular crosstalk, which is able to measure 3D interocular crosstalk considering gray-to-gray (G2G) conditions.

Another object of the present invention is to provide an apparatus and a method for measuring 3D interocular crosstalk, which is able to provide 3D interocular crosstalk measurement setup and condition.

Another object of the present invention is to provide an apparatus and a method for measuring 3D interocular crosstalk, which is able to provide 3D interocular crosstalk measurement formula.

Another object of the present invention is to provide an apparatus and a method for measuring 3D interocular crosstalk, which is able to provide 3D interocular crosstalk measurement patterns.

Another object of the present invention is to provide an apparatus and a method for measuring 3D interocular crosstalk, which is able to provide 3D interocular crosstalk measurement report.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, an apparatus for measuring 3-dimensional (3D) interocular crosstalk includes a light sensor configured to detect luminance of a stereoscopic image displayed in a display and output a luminance value indicating the detected luminance, and a controller configured to calculate 3D interocular crosstalk based on a gray difference and a residual luminance ratio, wherein the gray difference is calculated based on gray levels of a first view image and a second view image included in the stereoscopic image and the residual luminance ratio is calculated based on the luminance value.

The stereoscopic image is displayed in a glasses method or a non-glasses method.

The light sensor detects luminance of the stereoscopic image passing 3D glasses.

The gray difference is multiplied by the residual luminance ratio to calculate the 3D interocular crosstalk.

The gray difference is calculated further based on the display's Gamma (γ) value.

The gray difference is calculated by the following equation (1),

$$D_{G1,G2} = \left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}$$

The following equation (1)

wherein, in the equation (1), G**1** is the first view image's gray level, G**2** is the second view image's gray level, $D_{G1,G2}$ means the gray difference, and Γ is the display's Gamma (γ) value.

The residual luminance ratio is calculated by the following equation (2),

$$R_{G1,G2} = \frac{L_{G1,G2} - L_{G2,G2}}{L_{G2,G1} - L_{G2,G2}}$$

The following equation (2)

wherein, in the equation (2), G**1** is the first view image's gray level, G**2** is the second view image's gray level, $L_{G1,G2}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an observed image and the second view image is for an unobserved image, $L_{G2,G1}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an unobserved image and the second view image is for an observed image, $L_{G2,G2}$ is a luminance value indicating the luminance detected by the light sensor when the stereoscopic image includes two second view images and one of the two second view images is for an observed image and another is for an unobserved image, and $R_{G1,G2}$ means the residual luminance ratio.

The controller calculates the 3D interocular crosstalk using the following equation (3) or the following equation (4),

$$X_{LO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{LO,G1,G2} - L_{LO,G2,G2}}{L_{LO,G2,G1} - L_{LO,G2,G2}} \times 100\% \quad \text{Equation (3)}$$

$$X_{RO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{RO,G1,G2} - L_{RO,G2,G2}}{L_{RO,G2,G1} - L_{RO,G2,G2}} \times 100\% \quad \text{Equation (4)}$$

wherein, in the equation (3) and the equation (4), G**1** is the first view image's gray level, G**2** is the second view image's gray level, Γ is the display's Gamma (γ) value, $L_{LO,G1,G2}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an observed image on a left lens of 3D glasses and the second view image is for an unobserved image on the left lens, $L_{LO,G2,G1}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an unobserved image on left lens and the second view image is for an observed image on the left lens, $L_{LO,G2,G2}$ is a luminance value indicating the luminance detected by the light sensor when the stereoscopic image includes two second view images and one of the two second view images is for an observed image on the left lens and another is for an unobserved image on the left lens, $L_{RO,G1,G2}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an observed image on a right lens of the 3D glasses and the second view image is for an unobserved image on the right lens, $L_{RO,G2,G1}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an unobserved image on right lens and the second view image is for an observed image on the right lens, $L_{RO,G2,G2}$ is a luminance value indicating the luminance detected by the light sensor when the stereoscopic image includes two second view images and one of the two second view images is for an observed image on the right lens and another is for an unobserved image on the right lens, and $X_{LO,G1,G2}$ and $X_{RO,G1,G2}$ means the influence of G**2** to G**1**, which are measured on the left lens and right lens, respectively.

The gray level includes at least one of a red gray level, a green gray level or a blue gray level.

An image pattern of the first view image includes 4% sized window box pattern and four box patterns of 1% sized window.

The 4% sized window box pattern are located at the center of the first view image and each of the four box patterns of 1% sized window is located at the corners of the first view image.

The sum of gray level of the 4% sized window box pattern and the four box patterns of 1% sized window is a maximum gray level.

An image pattern of the stereoscopic image is determined according to a display mode.

The display mode includes at least one of a gray mode, a red color mode, a green color mode or a blue color mode.

The controller generates 3D interocular crosstalk measurement report including at least one of measured 3D interocular crosstalk values of each of gray pairs (G**1**, G**2**), an average value of additive and subtractive interocular crosstalk or a peak value of additive and subtractive interocular crosstalk, wherein G**1** is the first view image's gray level and G**2** is the second view image's gray level.

In another aspect of the present invention, a method of measuring a three-dimensional (3D) interocular crosstalk includes displaying a full white pattern image, displaying a first stereoscopic image including a first view image for an observed image and a second view image for an unobserved image, displaying the full white pattern image, displaying a second stereoscopic image including the first view image for an unobserved image and the second view image for an observed image, displaying a full white pattern image, and displaying a third stereoscopic image including two second view image.

The method further includes detecting a first luminance of the displayed first stereoscopic image, detecting a second luminance of the displayed second stereoscopic image, detecting a third luminance of the displayed third stereoscopic image, and calculating 3D interocular crosstalk based on the detected first luminance, the detected second luminance and the detected third luminance.

The 3D interocular crosstalk is calculated further based on gray levels of the first view image and the second view image.

The 3D interocular crosstalk is calculated further based on a display's Gamma (γ) value.

The 3D interocular crosstalk is calculated by the following equation (5) or the following equation (6),

$$X_{LO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{LO,G1,G2} - L_{LO,G2,G2}}{L_{LO,G2,G1} - L_{LO,G2,G2}} \times 100\% \quad \text{Equation (5)}$$

$$X_{RO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{RO,G1,G2} - L_{RO,G2,G2}}{L_{RO,G2,G1} - L_{RO,G2,G2}} \times 100\% \quad \text{Equation (6)}$$

wherein, in the equation (5) and the equation (6), G**1** is the first view image's gray level, G**2** is the second view image's gray level, Γ is the display's Gamma (γ) value, $L_{LO,G1,G2}$ is a luminance value indicating the luminance of the first stereoscopic image detected on a left lens of 3D glasses, $L_{LO,G2,G1}$ is a luminance value indicating the luminance of the second stereoscopic image detected on the left lens, $L_{LO,G2,G2}$ is a luminance value indicating the luminance of the third stereoscopic image detected on the left lens, $L_{RO,G1,G2}$ is a luminance value indicating the luminance of the first stereoscopic image detected on a right lens of the 3D glasses, $L_{RO,G2,G1}$ is a luminance value indicating the luminance of the second stereoscopic image detected on the right lens, $L_{RO,G2,G2}$ is a luminance value indicating the luminance of the third stereoscopic image detected on the right lens, and $X_{LO,G1,G2}$ and $X_{RO,G1,G2}$ means the influence of G**2** to G**1**, which are measured on the left lens and right lens, respectively.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

FIG. **1** is a diagram schematically showing the configuration of an exemplary embodiment of a crosstalk measurement setup according to the present invention;

FIG. **2** is a block diagram showing the configuration of an exemplary embodiment of an apparatus for measuring 3D interocular crosstalk according to the present invention;

FIG. **3** is a diagram showing a table presenting an exemplary embodiment of residual luminance ratio term of LCD TV;

FIG. **4** is a diagram showing a graph presenting an exemplary embodiment of display's gamma characteristics;

FIG. **5** is a diagram showing a table presenting an exemplary embodiment of measured 3D interocular crosstalk of a LCD TV;

FIG. **6** is a diagram for explaining additive interocular crosstalk phenomenon;

FIG. **7** is a diagram for explaining subtractive interocular crosstalk phenomenon;

FIG. **8**A to **8**B are diagrams showing an exemplary embodiment of image pattern for measuring 3D interocular crosstalk in a gray mode;

FIG. **9** is a diagram showing an exemplary embodiment of side by side format of image pattern for measuring 3D interocular crosstalk in a gray mode;

FIG. **10** is a diagram showing an exemplary embodiment of top and bottom format of image pattern for measuring 3D interocular crosstalk in a gray mode;

FIG. **11**A to **11**B are diagrams showing an exemplary embodiment of image pattern for measuring 3D interocular crosstalk in a red color mode;

FIG. **12** is a diagram showing an exemplary embodiment of side by side format of image pattern for measuring 3D interocular crosstalk in a red color mode;

FIG. **13** is a diagram showing an exemplary embodiment of top and bottom format of image pattern for measuring 3D interocular crosstalk in a red color mode;

FIG. **14**A to **14**B are diagrams showing an exemplary embodiment of image pattern for measuring 3D interocular crosstalk in a green color mode;

FIG. **15** is a diagram showing an exemplary embodiment of side by side format of image pattern for measuring 3D interocular crosstalk in a green color mode;

FIG. **16** is a diagram showing an exemplary embodiment of top and bottom format of image pattern for measuring 3D interocular crosstalk in a green color mode;

FIG. **17**A to **17**B are diagrams showing an exemplary embodiment of image pattern for measuring 3D interocular crosstalk in a blue color mode;

FIG. **18** is a diagram showing an exemplary embodiment of side by side format of image pattern for measuring 3D interocular crosstalk in a blue color mode;

FIG. **19** is a diagram showing an exemplary embodiment of top and bottom format of image pattern for measuring 3D interocular crosstalk in a blue color mode;

FIG. **20** is a flowchart illustrating an exemplary embodiment of a method for measuring 3D interocular crosstalk according to the present invention;

FIG. **21** is a diagram for explaining a method for measuring 3D interocular crosstalk according to the present invention; and

FIG. **22** is a diagram showing a table presenting 3D interocular crosstalk measurement report.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Hereinafter, the exemplary embodiments of the present disclosure will be described with reference to the accompanying drawings. The configuration and action of the present disclosure shown in the drawings and described with reference to the drawings will be described as at least one embodiment; however, the technical idea and the core configuration and action of the present disclosure are not limited thereto.

Although the terms used in the present disclosure are selected from generally known and widely used terms in consideration of function in the present disclosure, terms used herein may be varied depending on operator's intention or customs in the art, emergence new technology, or the like. Also, some of the terms mentioned in the description of the present disclosure have been selected by the applicant at his or her discretion, the detailed meanings of which are described in relevant parts of the description herein. Therefore, the terms used in the present disclosure should be defined not based on the names of the terms but based on the meanings of the terms and the detailed description of the present disclosure.

FIG. **1** is a diagram schematically showing the configuration of an exemplary embodiment of a crosstalk measurement setup according to the present invention.

Referring to FIG. **1**, the crosstalk measurement system **10** according to the present invention may include a display **20**, 3-dimensional (3D) Glasses **30** and a crosstalk measurement device **100**. The crosstalk measurement system **10** may measure the characteristics of the display **20**.

The display **20** may be a stereoscopic display. The display **20** may process a stereoscopic image and display the stereoscopic image in the glass method. The stereoscopic image may be output from the crosstalk measurement device **100**.

The 3D Glasses **30** may include at least one of polarized glasses or shutter glasses. The 3D Glasses **30** separates a stereoscopic image presented in the display **20** into a left image and a right image. The left image and the right image passing from the 3D Glasses **30** are entered to the crosstalk measurement device **100**.

The crosstalk measurement device **100** may be an apparatus for measuring 3D interocular crosstalk according to the present invention.

The distance l_M between the display **20** and the crosstalk measurement device **100** may be determined based on the viewing distance of the display **20**. Also, the distance l_M may be determined based on the height V of the display **20**.

The crosstalk measurement device **100** may locate at the front of the display **20**. The 3D glasses may be placed between the display **20** and the crosstalk measurement device **100** and locate near to the crosstalk measurement device **100**.

FIG. **2** is a block diagram showing the configuration of an exemplary embodiment of an apparatus for measuring 3D interocular crosstalk according to the present invention.

Referring to FIG. **2**, the crosstalk measurement device **100** according to the present invention may include a light sensor **110**, an analog-to-digital (A/D) converter **120**, a controller **130**, a storage unit **140**, a video processor **150** and a user interface **160**.

The light sensor **110** may be detect luminance of an image passing the 3D glasses and output an analog luminance signal. The image may be presented in the display **20**. The light sensor **110** may include an image sensor **112**, **116** and a luminance detector **113**, **117**. The image sensor **112**, **116** may detect luminance of an image passing the 3D glasses and output a sensor output signal including information about the luminance. The image sensor **112**, **116** may be a Charge Coupled Device (CCD) image sensor.

The luminance detector **113**, **117** may detect luminance information included in the sensor output signal and may generate the analog luminance signal representative of the detected luminance information.

The light sensor **110** may include a first light sensor **111** and a second light sensor **115**. The first light sensor **111** may detect luminance of a left image passing the left lens of the 3D glasses **30**. The second light sensor **115** may detect luminance of a right image passing the right lens of the 3D glasses **30**.

The A/D converter **120** may be used to convert the signals from the light sensor **110**. The A/D converter **120** may convert the analog luminance signal to a digital form to generate a digital luminance signal representative of the detected luminance information. The A/D converter **120** may include a first A/D converter **121** for converting the signals from the first light sensor **111** and a second A/D converter **126** for converting the signals from the second light sensor **115**.

The controller **130** may calculate an interocular crosstalk based on a luminance value. The luminance value may be the luminance value of an image passing the 3D glasses and the value of the luminance detected by the light sensor **110**. The luminance value may be indicated by the digital luminance signal from A/D converter **120**.

The controller **130** may generates at least one of measured interocular crosstalk values of each gray pairs (G**1**, G**2**), an average value of additive and subtractive interocular crosstalk or a peak value of additive and subtractive interocular crosstalk.

The controller **130** may control image patterns for measuring 3D interocular crosstalk to be displayed in a display **20**. The image pattern displayed in a display **20** may be selected according to a display mode. The image pattern displayed in a display **20** may be changed according to the change of the display mode. The display mode may include at least one of a gray mode or a color mode. The color mode may include a red color mode, a green color mode or a blue color mode.

The controller **130** may generate 3D interocular crosstalk measurement report. The controller **130** may generate 3D interocular crosstalk measurement report for every display mode. The 3D interocular crosstalk measurement report may include at least one of measured interocular crosstalk values of each gray pairs (G**1**, G**2**), an average value of additive and subtractive interocular crosstalk or a peak value of additive and subtractive interocular crosstalk.

The controller **130** may execute commands and performs operation related to the crosstalk measurement device **100**. For example, the controller **130** may control input and output between components of the crosstalk measurement device **100** and reception and processing of data, using the commands searched from the storage unit **140**. The controller **130** may be implemented on a single chip, a plurality of chips, or a plurality of electric elements. For example, a dedicated or embedded processor, a single purpose processor, a controller, an ASIC, etc. may be used for the controller **130**. The controller **130** may include at least one processor.

The controller **130** may detect a user action and control the crosstalk measurement device **100** based on the detected user action. The user action may include selection of a physical button of the crosstalk measurement device **100** or a remote controller, implementation of a prescribed touch gesture or selection of a soft button on a touch screen display, implementation of a prescribed spatial gesture recognized from an image captured from a capture device, and implementation of prescribed speaking recognized through voice recognition with respect to a voice signal received by a sound sensor. The controller **130** may interpret the user action as at least one implementable command. The controller **130** may control the components of the crosstalk measurement device **100** in response to the at least one interpreted command. That is, the controller **130** may control input and output between the components of the crosstalk measurement device **100** and reception and processing of data, using the at least one command.

The controller **130** may execute computer code together with an Operating System (OS) and generates and uses data. The OS is generally known and a detailed description thereof will not be given. For example, the OS may be a Windows series OS, UNIX, Linux, Palm OS, DOS, Android, and Mac OS. The OS, other computer code, and data may be included in the storage unit **140** which operates in association with the controller **130**.

The storage unit **140** may store image patterns for measuring 3D interocular crosstalk.

The storage unit **140** generally provides a place for storing program code and data used by the crosstalk measurement device **100**. For example, the storage unit **140** may be implemented as a Read Only Memory (ROM), a Random Access Memory (RAM), or a hard disk drive. The program code and data may be stored in a removable storage medium and, if necessary, may be loaded to or installed in the crosstalk measurement device **100**. The removable storage medium includes a CD-ROM, PC card, a memory card, a floppy disc, a magnetic tape, or a network component.

The video processor **150** may process a video signal and output to the processed video signal to a display. The display may be the display **20**. The display may include a PDP TV and a LCD TV.

The user interface **160** may be receives a user action and output the received user action to the controller **130**.

FIG. **3** is a diagram showing a table presenting an exemplary embodiment of residual luminance ratio term of LCD TV.

Referring to FIG. **3**, the controller **130** may calculate an interocular crosstalk by the following equation 1 or the following equation 2.

$$X_{LO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{LO,G1,G2} - L_{LO,G2,G2}}{L_{LO,G2,G1} - L_{LO,G2,G2}} \times 100\% \qquad \text{Equation 1}$$

$$X_{RO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{RO,G1,G2} - L_{RO,G2,G2}}{L_{RO,G2,G1} - L_{RO,G2,G2}} \times 100\% \qquad \text{Equation 2}$$

In the above equation 1 and 2, 3D interocular $X_{LO,G1,G2}$ and $X_{RO,G1,G2}$ means the influence of unobserved gray level G**2** to the observed gray level G**1**, which are measured on the left and right lenses, respectively. G**1** and G**2** may be a value between a minimum gray value and a maximum gray value. In some embodiments, the minimum gray level may be 0 and the maximum gray level may be 255.

$L_{LO,G1,G2}$ is a luminance value observed on the left lenses of 3D glasses **30**, when the observed side's gray levels is G**1** and the unobserved side's gray level is G**2**. $L_{RO,G1,G2}$ is a luminance value observed on the right lenses of 3D glasses, when the observed side's gray level is G**1** and the unobserved side's gray level is G**2**.

Γ is a display's γ value, which may be set to a specific one for the optimum performance.

The negative and positive signs of measured 3D crosstalk mean additive and subtractive crosstalk, respectively. The negative and positive values may be specified in the measurement report.

The equation 1 and 2 contain a gray-difference term and a residual luminance ratio term. The gray-difference term is

$$\left(\left(\frac{G2}{255}\right)^{\gamma}-\left(\frac{G1}{255}\right)^{\gamma}\right)$$

and the residual luminance ratio term is

$$\frac{L_{LO,G1,G2}-L_{LO,G2,G2}}{L_{LO,G2,G1}-L_{LO,G2,G2}}\times 100\% \text{ and } \frac{L_{RO,G1,G2}-L_{RO,G2,G2}}{L_{RO,G2,G1}-L_{RO,G2,G2}}\times 100\%$$

Denominator ($L_{LO/RO,G1,G2}-L_{LO/RO,G2,G2}$) of the residual luminance ratio term is the difference of original luminance, gray G**1** and gray G**2**. Numerator ($L_{LO/RO,G2,G1}-L_{LO/RO,G2,G2}$) of the residual luminance ratio term is the difference of residual luminance, gray G**1** and gray G**2**.

A table **300** shown in the FIG. **3** presents an example of measured residual luminance ratio term of a LCD TV. In table **300**, there are cases in which the measured residual luminance ratio is large when the difference of gray levels, G**1** and G**2**, is small. For an example, when G**1**=G**127** and G**2**=G**159**, the measured residual luminance ratio is 4.60% and when G**1**=G**127** and G**2**=G**223**, the measured residual luminance ratio is 2.38%.

When the residual luminance ratio of some 3D TV sets is measured, it could not explain the Gray-to-Gray (G2G) 3D crosstalk phenomenon quantitatively. A user may feel 3D interocular crosstalk more severely when the difference of gray levels, G**1** and G**2**, was large. However, the measured residual luminance ratio was large when the difference of gray levels, G**1** and G**2**, was small. Therefore other terms in the gray to gray condition is proposed in the present invention.

When the difference of gray levels, G**1** and G**2**, increases, the crosstalk phenomenon may be observed more severely. So, the present invention proposes the gray difference term, which is multiplied by residual luminance ratio term to calculate 3D interocular crosstalk.

The suggested gray difference term is based on the display's gamma value, which represents displayed image's characteristics.

FIG. **4** is a diagram showing a graph presenting an exemplary embodiment of display's gamma characteristics.

Referring to FIG. **4**, a graph **400** presents an example of display's gamma characteristics. The display's luminance has non-linear characteristics depending on input gray levels, as shown in the graph **400**. The brightness level of the input gray level may be changed according to the change of the display's gamma value.

Therefore, by calculating 3D interocular crosstalk based on display's gamma, the present invention can reflect output characteristics accurately in calculating 3D interocular crosstalk and can calculate 3D interocular crosstalk adaptively according to the type of a display.

FIG. **5** is a diagram showing a table presenting an exemplary embodiment of measured 3D interocular crosstalk of a LCD TV.

Referring to FIG. **5**, a table **500** represents an example of measured 3D crosstalk of a LCD TV using the equation 1. There are additive interocular crosstalk and subtractive interocular crosstalk as shown in the table **500**.

FIG. **6** is a diagram for explaining additive interocular crosstalk phenomenon.

Referring to FIG. **6**, the additive interocular crosstalk occurs when the observed luminance $L_{LO/RO,G1,G2}$ is larger than that of both eye's condition $L_{LO/RO,G2,G2}$, which increases image's gray level where it occurs as shown in FIG. **6**. An image **610** is a stereoscopic image with a side by side format. When the stereoscopic image **610** is displayed in the display **20**, an image **620** is a left observed image of the displayed stereoscopic image **610** and an image **630** is a right observed image of the displayed stereoscopic image **610**. The additive interocular crosstalk **631** occurs in the right observed image **630**.

FIG. **7** is a diagram for explaining subtractive interocular crosstalk phenomenon.

Referring to FIG. **7**, the subtractive interocular crosstalk occurs when the observed luminance $L_{LO/RO,G1,G2}$ is smaller than that of both eye's condition $L_{LO/RO,G2,G2}$, which decreases image's gray level where it occurs as shown in FIG. **6**.

An image **710** is a stereoscopic image with a side by side format. When the stereoscopic image **710** is displayed in the display **20**, an image **720** is a left observed image of the displayed stereoscopic image **710** and an image **730** is a right observed image of the displayed stereoscopic image **710**. The subtractive interocular crosstalk **731** occurs in the right observed image **730**.

Conventional interocular crosstalk formula only considers additive case. The present invention may include subtractive interocular crosstalk case as well as additive interocular crosstalk case.

FIG. **8**A to **8**B are diagrams showing an exemplary embodiment of image pattern for measuring 3D interocular crosstalk in a gray mode.

Referring to FIG. **8**A to **8**B, the present invention provides the image pattern for measuring 3D interocular crosstalk. The image pattern may be stored in the storage unit **140** and processed by the video processor **150** and displayed in the display **20**. Hereinafter, the image pattern for measuring 3D interocular crosstalk is named as a measurement pattern.

The measurement pattern of the present invention may be characterized in that a condition in which all pairs of interocular crosstalk should be measured at the same Average Picture Level (APL) condition is satisfied.

The measurement pattern of the present invention may be characterized in that a condition in which both a LCD TV and a PDP TV control display brightness depending on APL is satisfied.

The measurement pattern of the present invention may be characterized in that a condition in which as the APL of measurement pattern varies, the interocular crosstalk value changes is satisfied.

The measurement pattern of the present invention may be characterized in that a condition in which left and right images have the same APL is satisfied.

As an exemplary embodiment of the measurement pattern of the present invention, both left and right images of the measurement pattern include one 4% sized window box and four 1% sized window boxes.

The four 1% sized window boxes may be set to keep the APL of measurement pattern constant. In some embodiments, The sum of gray level of the 4% sized window box and the four 1% sized window box may be set to 255(max. gray level).

For an example, if the gray level of the 4% sized window box is 100, the gray level of each 1% sized window box is set to 155.

The luminance for measuring 3D interocular crosstalk is measured at the screen center. The center of the 4% sized window box may be placed at the screen center.

An image pattern **800** shown in the FIG. **8**A may be the measurement pattern for measuring $L_{LO,G1,G2}$ of the gray mode and may be a left image of a stereoscopic image. The image pattern **800** includes a 4% sized window box **810** and a four 1% sized window boxes **821**, **823**, **825**, **827**.

The center **811** of the 4% sized window box **810** may be placed at the screen center. The gray level of the 4% sized window box **810** is a gray level (G**1**, G**1**, G**1**). Hereinafter, Gray level (G**1**, G**2**, G**3**) means red gray level of G**1**, green gray level of G**2**, blue gray level of G**3**. G**1**, G**2** and G**3** may be a value between a minimum gray value and a maximum gray value.

The four 1% sized window boxes **821**, **823**, **825**, **827** are placed in the corner of the screen. The 1% sized window **821** is located at the up-left of the screen and the 1% sized window **823** is located at the up-right of the screen. The 1% sized window **825** is located at the down-left of the screen and the 1% sized window **827** is located at the down-right of the screen. The gray levels of the four 1% sized window boxes **821**, **823**, **825**, **827** are gray level (**255**–G**1**, **255**–G**1**, **255**–G**1**).

An image pattern **850** shown in the FIG. **8**B may be the measurement pattern for measuring $L_{RO,G1,G2}$ of the gray mode and may be a right image of a stereoscopic image. The image pattern **850** includes a 4% sized window box **860** and a four 1% sized window boxes **871**, **873**, **875**, **877**.

The center **861** of the 4% sized window box **860** may be placed at the screen center. The gray level of the 4% sized window box **860** is a gray level (G**2**, G**2**, G**2**).

The four 1% sized window boxes **871**, **873**, **875**, **877** are placed in the corner of the screen. The 1% sized window **871** is located at the up-left of the screen and the 1% sized window **873** is located at the up-right of the screen. The 1% sized window **875** is located at the down-left of the screen and the 1% sized window **877** is located at the down-right of the screen. The gray levels of the four 1% sized window boxes **871**, **873**, **875**, **877** are gray level (**255**–G**2**, **255**–G**2**, **255**–G**2**).

FIG. **9** is a diagram showing an exemplary embodiment of side by side format of image pattern for measuring 3D interocular crosstalk in a gray mode and FIG. **10** is a diagram showing an exemplary embodiment of top and bottom format of image pattern for measuring 3D interocular crosstalk in a gray mode.

Referring to FIG. **9** and FIG. **10**, an image pattern **900** is a stereoscopic image with a side by side format for the image pattern **800** and the image pattern **850**. An image pattern **1000** is a stereoscopic image with a top and bottom format for the image pattern **800** and the image pattern **850**.

FIG. **11**A to **11**B are diagrams showing an exemplary embodiment of image pattern for measuring 3D interocular crosstalk in a red color mode.

Referring to FIG. **11**A to **11**B, an image pattern **1100** may be the measurement pattern for measuring $L_{LO,G1,G2}$ of the red color mode and a left image of a stereoscopic image. The image pattern **1100** includes a 4% sized window box **1110** and a four 1% sized window boxes **1121**, **1123**, **1125**, **1127**.

The center **1111** of the 4% sized window box **1110** may be placed at the screen center. The gray level of the 4% sized window box **1110** is a gray level (G**1**, **0**, **0**).

The four 1% sized window boxes **1121**, **1123**, **1125**, **1127** are placed in the corner of the screen. The 1% sized window **1121** is located at the up-left of the screen and the 1% sized window **1123** is located at the up-right of the screen. The 1% sized window **1125** is located at the down-left of the screen and the 1% sized window **1127** is located at the down-right of the screen. The gray levels of the four 1% sized window boxes **1121**, **1123**, **1125**, **1127** are gray level (**255**–G**1**, **255**, **255**).

An image pattern **1150** may be the measurement pattern for measuring $L_{RO,G1,G2}$ of the red color mode and a right image of a stereoscopic image. The image pattern **1150** includes a 4% sized window box **1160** and a four 1% sized window boxes **1171**, **1173**, **1175**, **1177**.

The center **1161** of the 4% sized window box **1160** may be placed at the screen center. The gray level of the 4% sized window box **1160** is a gray level (G**2**, **0**, **0**).

The four 1% sized window boxes **1171**, **1173**, **1175**, **1177** are placed in the corner of the screen. The 1% sized window **1171** is located at the up-left of the screen and the 1% sized window **1173** is located at the up-right of the screen. The 1% sized window **1175** is located at the down-left of the screen and the 1% sized window **1177** is located at the down-right of the screen. The gray levels of the four 1% sized window boxes **1171**, **1173**, **1175**, **1177** are gray level (**255**–G**2**, **255**, **255**).

FIG. **12** is a diagram showing an exemplary embodiment of side by side format of image pattern for measuring 3D interocular crosstalk in a red color mode and FIG. **13** is a diagram showing an exemplary embodiment of top and bottom format of image pattern for measuring 3D interocular crosstalk in a red color mode.

Referring to FIG. **12** and FIG. **13**, an image pattern **1200** is a stereoscopic image with a side by side format for the image pattern **1100** and the image pattern **1150**. An image pattern **1300** is a stereoscopic image with a top and bottom format for the image pattern **1100** and the image pattern **1150**.

FIG. **14**A to **14**B are diagrams showing an exemplary embodiment of image pattern for measuring 3D interocular crosstalk in a green color mode.

Referring to FIG. **14**A to **14**B, an image pattern **1400** may be the measurement pattern for measuring $L_{LO,G1,G2}$ of the green color mode and a left image of a stereoscopic image. The image pattern **1400** includes a 4% sized window box **1410** and a four 1% sized window boxes **1421**, **1423**, **1425**, **1427**.

The center **1411** of the 4% sized window box **1410** may be placed at the screen center. The gray level of the 4% sized window box **1410** is a gray level (**0**, G**1**, **0**).

The four 1% sized window boxes **1421**, **1423**, **1425**, **1427** are placed in the corner of the screen. The 1% sized window **1421** is located at the up-left of the screen and the 1% sized window **1423** is located at the up-right of the screen. The 1% sized window **1425** is located at the down-left of the screen and the 1% sized window **1427** is located at the down-right of the screen. The gray levels of the four 1% sized window boxes **1421**, **1423**, **1425**, **1427** are gray level (**255**, **255**–G**1**, **255**).

An image pattern **1450** may be the measurement pattern for measuring $L_{RO,G1,G2}$ of the green color mode and a right image of a stereoscopic image. The image pattern **1450** includes a 4% sized window box **1460** and a four 1% sized window boxes **1471**, **1473**, **1475**, **1477**.

The center **1461** of the 4% sized window box **1460** may be placed at the screen center. The gray level of the 4% sized window box **1460** is a gray level (**0**, G**2**, **0**).

The four 1% sized window boxes **1471**, **1473**, **1475**, **1477** are placed in the corner of the screen. The 1% sized window **1471** is located at the up-left of the screen and the 1% sized window **1473** is located at the up-right of the screen. The 1%

sized window **1475** is located at the down-left of the screen and the 1% sized window **1477** is located at the down-right of the screen. The gray levels of the four 1% sized window boxes **1471**, **1473**, **1475**, **1477** are gray level (**255**, **255**–G**2**, **255**).

FIG. **15** is a diagram showing an exemplary embodiment of side by side format of image pattern for measuring 3D interocular crosstalk in a green color mode and FIG. **16** is a diagram showing an exemplary embodiment of top and bottom format of image pattern for measuring 3D interocular crosstalk in a green color mode.

Referring to FIG. **15** and FIG. **16**, an image pattern **1500** is a stereoscopic image with a side by side format for the image pattern **1400** and the image pattern **1450**. An image pattern **1600** is a stereoscopic image with a top and bottom format for the image pattern **1400** and the image pattern **1450**.

FIG. **17**A to **17**B are diagrams showing an exemplary embodiment of image pattern for measuring 3D interocular crosstalk in a blue color mode.

Referring to FIG. **17**, an image pattern **1700** may be the measurement pattern for measuring $L_{LO,G1,G2}$ of the blue color mode and a left image of a stereoscopic image. The image pattern **1700** includes a 4% sized window box **1710** and a four 1% sized window boxes **1721**, **1723**, **1725**, **1727**.

The center **1411** of the 4% sized window box **1710** may be placed at the screen center. The gray level of the 4% sized window box **1710** is a gray level (**0**, **0**, G**1**).

The four 1% sized window boxes **1721**, **1723**, **1725**, **1727** are placed in the corner of the screen. The 1% sized window **1721** is located at the up-left of the screen and the 1% sized window **1723** is located at the up-right of the screen. The 1% sized window **1725** is located at the down-left of the screen and the 1% sized window **1727** is located at the down-right of the screen. The gray levels of the four 1% sized window boxes **1721**, **1723**, **1725**, **1727** are gray level (**255**, **255**, **255**–G**1**).

An image pattern **1750** may be the measurement pattern for measuring $L_{RO,G1,G2}$ of the blue color mode and a right image of a stereoscopic image. The image pattern **1750** includes a 4% sized window box **1760** and a four 1% sized window boxes **1771**, **1773**, **1775**, **1777**.

The center **1761** of the 4% sized window box **1760** may be placed at the screen center. The gray level of the 4% sized window box **1760** is a gray level (**0**, **0**, G**2**).

The four 1% sized window boxes **1771**, **1773**, **1775**, **1777** are placed in the corner of the screen. The 1% sized window **1771** is located at the up-left of the screen and the 1% sized window **1773** is located at the up-right of the screen. The 1% sized window **1775** is located at the down-left of the screen and the 1% sized window **1777** is located at the down-right of the screen. The gray levels of the four 1% sized window boxes **1771**, **1773**, **1775**, **1777** are gray level (**255**, **255**, **255**–G**2**).

FIG. **18** is a diagram showing an exemplary embodiment of side by side format of image pattern for measuring 3D interocular crosstalk in a blue color mode and FIG. **19** is a diagram showing an exemplary embodiment of top and bottom format of image pattern for measuring 3D interocular crosstalk in a blue color mode.

Referring to FIG. **18** and FIG. **19**, an image pattern **1800** is a stereoscopic image with a side by side format for the image pattern **1700** and the image pattern **1750**. An image pattern **1900** is a stereoscopic image with a top and bottom format for the image pattern **1700** and the image pattern **1750**.

FIG. **20** is a flowchart illustrating an exemplary embodiment of a method for measuring 3D interocular crosstalk according to the present invention and FIG. **21** is a diagram for explaining a method for measuring 3D interocular crosstalk according to the present invention.

Referring to FIG. **20** and FIG. **21**. The display **20** may display an image pattern **2110**, in step S**100**. The image pattern **2110** is for reducing measurement error caused by image sticking. The image pattern **2110** may be 100% sized full white pattern.

The crosstalk measurement device **100** may output the image pattern **2110** to the display **20**, in the step S**100**. The display **20** may display the output image pattern **2110**.

The display **20** may display a test pattern for measuring luminanceL (G**1**, G**2**), in step S**110**. The displayed test pattern may be one of the measurement pattern **800** shown in FIG. **8**A, the measurement pattern **850** shown in FIG. **8**B, the measurement pattern **1100** shown in FIG. **11**A, the measurement pattern **1150** shown in FIG. **11**B, the measurement pattern **1400** shown in FIG. **14**A, the measurement pattern **1450** shown in FIG. **14**B, the measurement pattern **1700** shown in FIG. **17**A or the measurement pattern **1750** shown in FIG. **17**B.

The crosstalk measurement device **100** may output the test pattern to the display **20**, in the step S**110**. The display **20** may display the output test pattern.

The crosstalk measurement device **100** may detect luminance of the test pattern displayed in display **20**, in the step s**110**. The crosstalk measurement device **100** generates a luminance value indicating the detected luminance of the text pattern.

The display **20** may display the image pattern **2110**, in step S**120**. The image pattern **2110** is for reducing measurement error caused by image sticking.

The crosstalk measurement device **100** may output the image pattern **2110** to the display **20**, in the step S**120**. The display **20** may display the output image pattern **2110**.

The display **20** may display a test pattern for measuring luminanceL (G**2**, G**1**) in step S**130**. The displayed test pattern may be one of the measurement pattern **800** shown in FIG. **8**A, the measurement pattern **850** shown in FIG. **8**B, the measurement pattern **1100** shown in FIG. **11**A, the measurement pattern **1150** shown in FIG. **11**B, the measurement pattern **1400** shown in FIG. **14**A, the measurement pattern **1450** shown in FIG. **14**B, the measurement pattern **1700** shown in FIG. **17**A or the measurement pattern **1750** shown in FIG. **17**B.

The crosstalk measurement device **100** may output the test pattern to the display **20**, in the step S**130**. The display **20** may display the output test pattern.

The crosstalk measurement device **100** may detect luminance of the test pattern displayed in display **20**, in the step s**130**. The crosstalk measurement device **100** generates a luminance value indicating the detected luminance of the text pattern.

The display **20** may display the image pattern **2110**, in step S**140**. The image pattern **2110** is for reducing measurement error caused by image sticking.

The crosstalk measurement device **100** may output the image pattern **2110** to the display **20**, in the step S**140**. The display **20** may display the output image pattern **2110**.

The display **20** may display a test pattern for measuring luminanceL (G**2**, G**2**) in step S**150**. The displayed test pattern may be one of the measurement pattern **800** shown in FIG. **8**A, the measurement pattern **850** shown in FIG. **8**B, the measurement pattern **1100** shown in FIG. **11**A, the measurement pattern **1150** shown in FIG. **11**B, the measurement pattern **1400** shown in FIG. **14**A, the measurement pattern **1450** shown in FIG. **14**B, the measurement pattern **1700** shown in FIG. **17**A or the measurement pattern **1750** shown in FIG. **17**B.

The crosstalk measurement device **100** may output the test pattern to the display **20**, in the step S**150**. The display **20** may display the output test pattern.

The crosstalk measurement device **100** may detect luminance of the test pattern displayed in display **20**, in the step s**150**. The crosstalk measurement device **100** generates a luminance value indicating the detected luminance of the text pattern.

The crosstalk measurement device **100** may calculate at least one of 3D interocular crosstalk $X_{LO,G1,G2}$ or 3D interocular crosstalk $X_{RO,G1,G2}$ using the luminance value generated in the step s**110**, the luminance value generated in the step s**130** and the luminance value generated in the step s**150**.

The crosstalk measurement device **100** may calculate the 3D interocular crosstalk $X_{LO,G1,G2}$ by the equation 1. The crosstalk measurement device **100** may calculate the 3D interocular crosstalk $X_{RO,G1,G2}$ by the equation 2.

In some embodiments, the display **20** may display a test pattern for measuring luminanceL (G**1**, G**1**) in step S**150**. The crosstalk measurement device **100** may calculate at least one of 3D interocular crosstalk $X_{LO,G1,G2}$ or 3D interocular crosstalk $X_{RO,G1,G2}$ using the luminance value generated in the step s**110**, the luminance value generated in the step s**130** and the luminance value indicating the detected luminance of the text pattern for measuring luminanceL (G**1**, G**1**). The crosstalk measurement device **100** may calculate the 3D interocular crosstalk $X_{LO,G1,G2}$ by the following equation 3.

$$X_{LO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{LO,G1,G2} - L_{LO,G1,G1}}{L_{LO,G2,G1} - L_{LO,G1,G1}} \times 100\% \quad \text{Equation 3}$$

The crosstalk measurement device **100** may calculate the 3D interocular crosstalk $X_{RO,G1,G2}$ by the following equation 4.

$$X_{RO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{RO,G1,G2} - L_{RO,G1,G1}}{L_{RO,G2,G1} - L_{RO,G1,G1}} \times 100\% \quad \text{Equation 4}$$

FIG. **22** is a diagram showing the table presenting 3D interocular crosstalk measurement report.

Referring to FIG. **22**, the interocular crosstalk measurement report according to the present invention may have a table type **2200**. The controller **130** may generate 3D interocular crosstalk measurement report table **2200** for every display mode.

The interocular crosstalk measurement report table **2200** may includes at least one of measured interocular crosstalk values of each gray pairs (G**1**, G**2**), an average value of additive and subtractive interocular crosstalk or a peak value of additive and subtractive interocular crosstalk.

As broadly described and embodied herein, the apparatus and the method for measuring 3D interocular crosstalk provides a measurement pattern of the gray mode or the color mode and measures 3D interocular crosstalk using the measurement pattern, and therefore, it is possible to measure 3D interocular crosstalk considering pixel distribution of real video contents and G2G conditions.

The apparatus and the method for measuring 3D interocular crosstalk calculate 3D interocular crosstalk based on display's gamma. Hence, the present invention can reflect output characteristics accurately in calculating 3D interocular crosstalk and can calculate 3D interocular crosstalk adaptively according to the type of a display.

Any reference in this specification to "one embodiment," "an embodiment," "example embodiment," etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. An apparatus for measuring 3-dimensional (3D) interocular crosstalk, comprising:

a light sensor configured to detect luminance of a stereoscopic image displayed in a display and output a luminance value indicating the detected luminance; and

a controller configured to calculate 3D interocular crosstalk based on a gray difference and a residual luminance ratio, wherein the gray difference is calculated based on gray levels of a first view image and a second view image included in the stereoscopic image and the residual luminance ratio is calculated based on the luminance value.

2. The apparatus according to claim **1**, wherein the stereoscopic image is displayed in a glasses method or a non-glasses method.

3. The apparatus according to claim **1**, wherein the light sensor detects luminance of the stereoscopic image passing 3D glasses.

4. The apparatus according to claim **1**, wherein the gray difference is multiplied by the residual luminance ratio to calculate the 3D interocular crosstalk.

5. The apparatus according to claim **1**, wherein the gray difference is calculated further based on the display's Gamma (γ) value.

6. The apparatus according to claim **1**, wherein the gray difference is calculated by the following equation (1),

$$D_{G1,G2} = \left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}$$

The following equation (1)

wherein, in the equation (1), G**1** is the first view image's gray level, G**2** is the second view image's gray level, $D_{G1,G2}$ means the gray difference, and Γ is the display's Gamma(γ) value.

7. The apparatus according to claim 1, wherein the residual luminance ratio is calculated by the following equation (2),

$$R_{G1,G2} = \frac{L_{G1,G2} - L_{G2,G2}}{L_{G2,G1} - L_{G2,G2}}$$

The following equation (2)

wherein, in the equation (2), G1 is the first view image's gray level, G2 is the second view image's gray level, $L_{G1,G2}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an observed image and the second view image is for an unobserved image, $L_{G2,G1}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an unobserved image and the second view image is for an observed image, $L_{G2,G2}$ is a luminance value indicating the luminance detected by the light sensor when the stereoscopic image includes two second view images and one of the two second view images is for an observed image and another is for an unobserved image, and $R_{G1,G2}$ means the residual luminance ratio.

8. The apparatus according to the claim 1, wherein the controller calculates the 3D interocular crosstalk using the following equation (3) or the following equation (4),

$$X_{LO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{LO,G1,G2} - L_{LO,G2,G2}}{L_{LO,G2,G1} - L_{LO,G2,G2}} \times 100\% \quad \text{Equation (3)}$$

$$X_{RO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{RO,G1,G2} - L_{RO,G2,G2}}{L_{RO,G2,G1} - L_{RO,G2,G2}} \times 100\% \quad \text{Equation (4)}$$

wherein, in the equation (3) and the equation (4), G1 is the first view image's gray level, G2 is the second view image's gray level, Γ is the display's Gamma(γ) value, $L_{LO,G1,G2}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an observed image on a left lens of 3D glasses and the second view image is for an unobserved image on the left lens, $L_{LO,G2,G1}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an unobserved image on left lens and the second view image is for an observed image on the left lens, $L_{LO,G2,G2}$ is a luminance value indicating the luminance detected by the light sensor when the stereoscopic image includes two second view images and one of the two second view images is for an observed image on the left lens and another is for an unobserved image on the left lens, $L_{RO,G1,G2}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an observed image on a right lens of the 3D glasses and the second view image is for an unobserved image on the right lens, $L_{RO,G2,G1}$ is a luminance value indicating the luminance detected by the light sensor when the first view image is for an unobserved image on right lens and the second view image is for an observed image on the right lens, $L_{RO,G2,G2}$ is a luminance value indicating the luminance detected by the light sensor when the stereoscopic image includes two second view images and one of the two second view images is for an observed image on the right lens and another is for an unobserved image on the right lens, and $X_{LO,G1,G2}$ and $X_{RO,G1,G2}$ means the influence of G2 to G1, which are measured on the left lens and right lens, respectively.

9. The apparatus according to the claim 1, wherein the gray level includes at least one of a red gray level, a green gray level or a blue gray level.

10. The apparatus according to the claim 1, wherein an image pattern of the first view image includes 4% sized window box pattern and four box patterns of 1% sized window.

11. The apparatus according to the claim 10, wherein the 4% sized window box pattern are located at the center of the first view image and each of the four box patterns of 1% sized window is located at the corners of the first view image.

12. The apparatus according to the claim 10, wherein the sum of gray level of the 4% sized window box pattern and the four box patterns of 1% sized window is a maximum gray level.

13. The apparatus according to the claim 1, wherein an image pattern of the stereoscopic image is determined according to a display mode.

14. The apparatus according to the claim 13, wherein the display mode includes at least one of a gray mode, a red color mode, a green color mode or a blue color mode.

15. The apparatus according to the claim 1, wherein the controller generates 3D interocular crosstalk measurement report including at least one of measured 3D interocular crosstalk values of each of gray pairs (G1, G2), an average value of additive and subtractive interocular crosstalk or a peak value of additive and subtractive interocular crosstalk, wherein G1 is the first view image's gray level and G2 is the second view image's gray level.

16. A method of measuring a three-dimensional (3D) interocular crosstalk, comprising:

displaying a full white pattern image;

displaying a first stereoscopic image including a first view image for an observed image and a second view image for an unobserved image;

displaying the full white pattern image;

displaying a second stereoscopic image including the first view image for an unobserved image and the second view image for an observed image;

displaying a full white pattern image;

displaying a third stereoscopic image including two second view image;

detecting a first luminance of the displayed first stereoscopic image;

detecting a second luminance of the displayed second stereoscopic image;

detecting a third luminance of the displayed third stereoscopic image; and

calculating 3D interocular crosstalk based on the detected first luminance, the detected second luminance and the detected third luminance.

17. The method according to the claim 16, wherein the 3D interocular crosstalk is calculated further based on gray levels of the first view image and the second view image.

18. The method according to the claim 16, wherein the 3D interocular crosstalk is calculated further based on a display's Gamma (γ) value.

19. The method according to the claim 16, wherein the 3D interocular crosstalk is calculated by the following equation (5) or the following equation (6),

$$X_{LO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{LO,G1,G2} - L_{LO,G2,G2}}{L_{LO,G2,G1} - L_{LO,G2,G2}} \times 100\% \quad \text{Equation (5)}$$

$$X_{RO,G1,G2} = \left(\left(\frac{G2}{255}\right)^{\gamma} - \left(\frac{G1}{255}\right)^{\gamma}\right) \times \frac{L_{RO,G1,G2} - L_{RO,G2,G2}}{L_{RO,G2,G1} - L_{RO,G2,G2}} \times 100\% \quad \text{Equation (6)}$$

wherein, in the equation (5) and the equation (6), G**1** is the first view image's gray level, G**2** is the second view image's gray level, Γ is the display's Gamma(γ) value, $L_{LO,G1,G2}$ is a luminance value indicating the luminance of the first stereoscopic image detected on a left lens of **3**D glasses, $L_{LO,G2,G1}$ is a luminance value indicating the luminance of the second stereoscopic image detected on the left lens, $L_{LO,G2,G2}$ is a luminance value indicating the luminance of the third stereoscopic image detected on the left lens, $L_{RO,G1,G2}$ is a luminance value indicating the luminance of the first stereoscopic image detected on a right lens of the 3D glasses, $L_{RO,G2,G1}$ is a luminance value indicating the luminance of the second stereoscopic image detected on the right lens, $L_{RO,G2,G2}$ is a luminance value indicating the luminance of the third stereoscopic image detected on the right lens, and $X_{LO,G1,G2}$ and $X_{RO,G1,G2}$ means the influence of G**2** to G**1**, which are measured on the left lens and right lens, respectively.

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