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(54) **BACKLIGHT UNIT, DISPLAY APPARATUS HAVING THE SAME AND METHOD OF INSPECTING THE SAME**

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G09G 3/36 (2006.01)

(52) **U.S. Cl.** **345/102**; 345/87

(58) **Field of Classification Search** 345/87, 345/102, 156, 204
See application file for complete search history.

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(57) **ABSTRACT**

A backlight unit includes light source groups, a converter, a compensator, a detector and a protector. Each of the light source groups includes a light source, and the converter boosts an input voltage to a driving voltage that is supplied to the light source groups. The compensator is connected to the light source groups and compensates a deviation between currents fed back to the compensator from each of the light source groups. The detector is connected between the compensator and the light source groups and detects a maximum voltage from among feedback voltages fed back to the compensator from each of the light source groups. The protector is connected to the detector and receives the maximum voltage, and compares the maximum voltage to a reference voltage to generate a compared result. The protector outputs a protection signal to the converter based on the compared result.

20 Claims, 4 Drawing Sheets

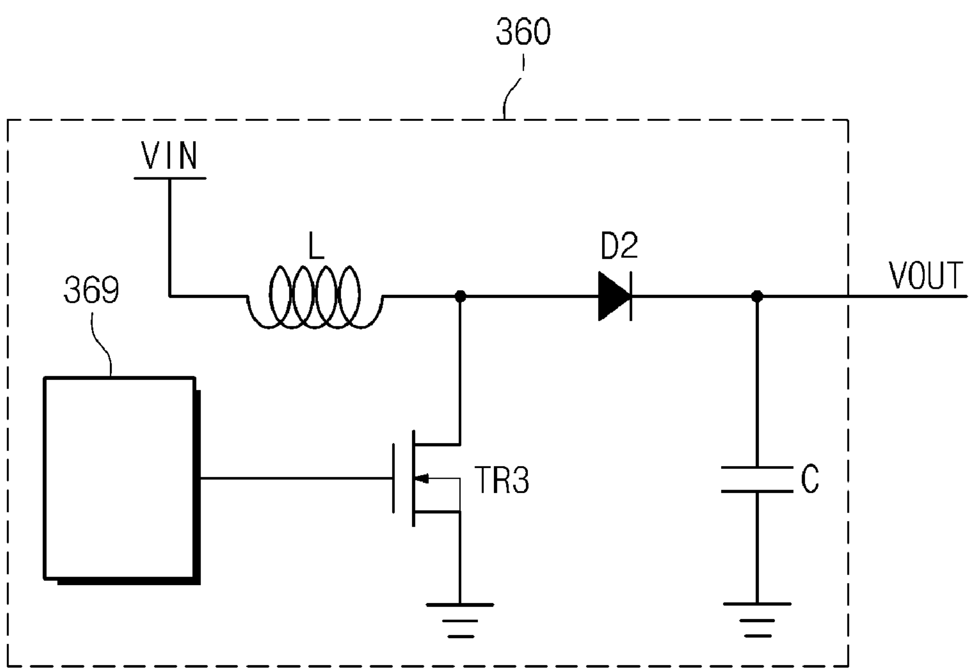


Fig. 1

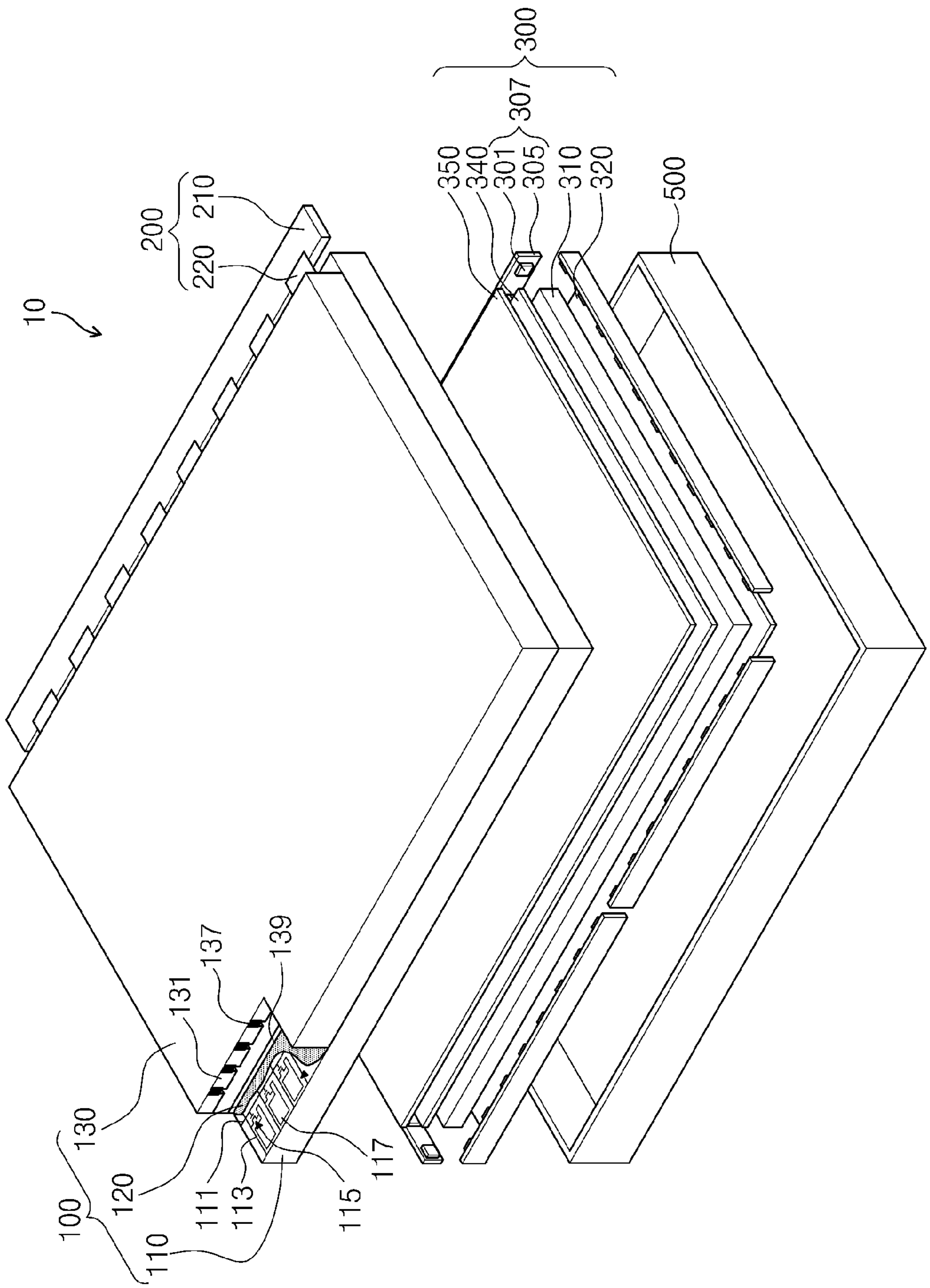
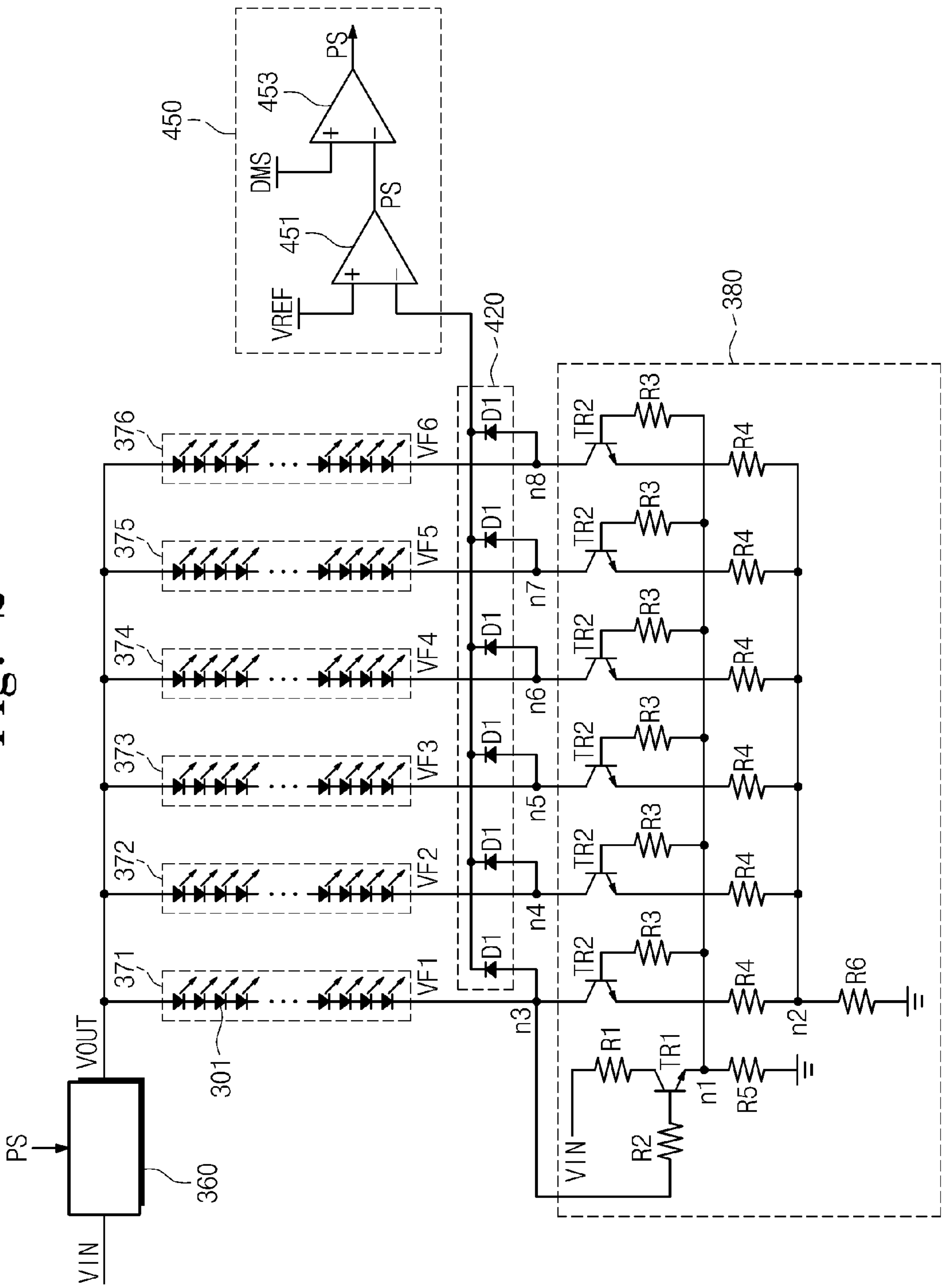

10
200
210
220
300
307
350
340
301
305
310
320
500
100
110
111
113
115
117
120
130
131
137
139

Fig. 2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453
451
PS
DMS
VREF
420
380
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375
374
373
372
371
301
360
VOUT
VIN
VF1
VF2
VF3
VF4
VF5
VF6
D1
TR1
TR2
R1
R2
R3
R4
R5
R6
n1
n2
n3
n4
n5
n6
n7
n8

Fig. 3

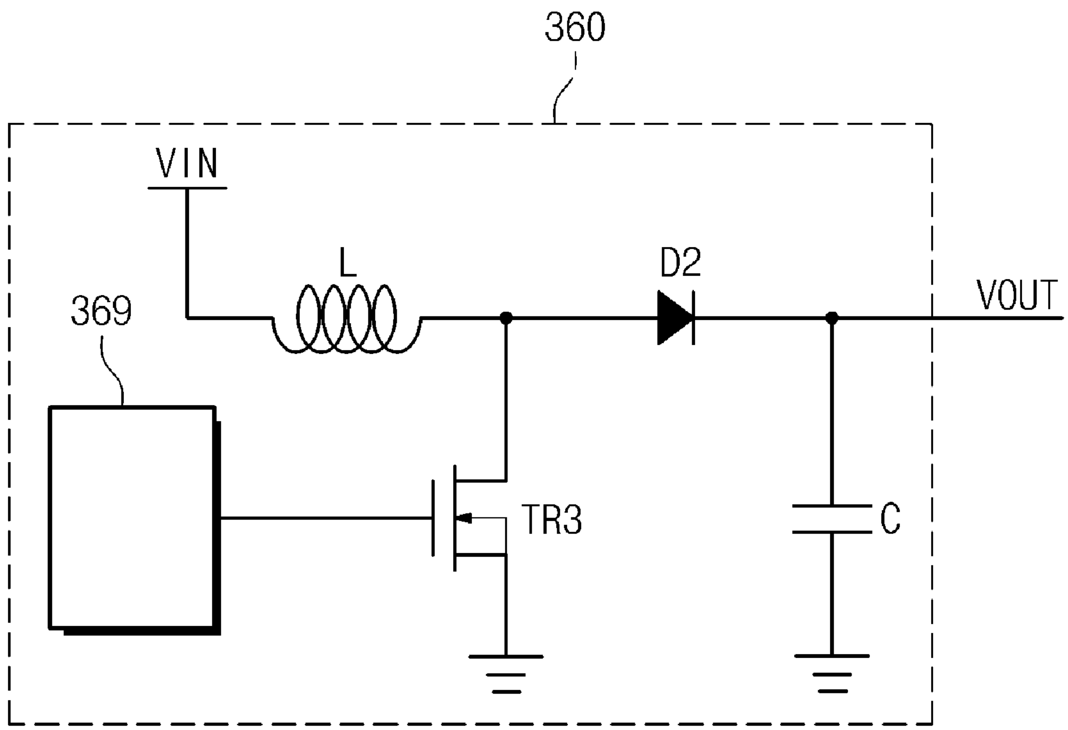
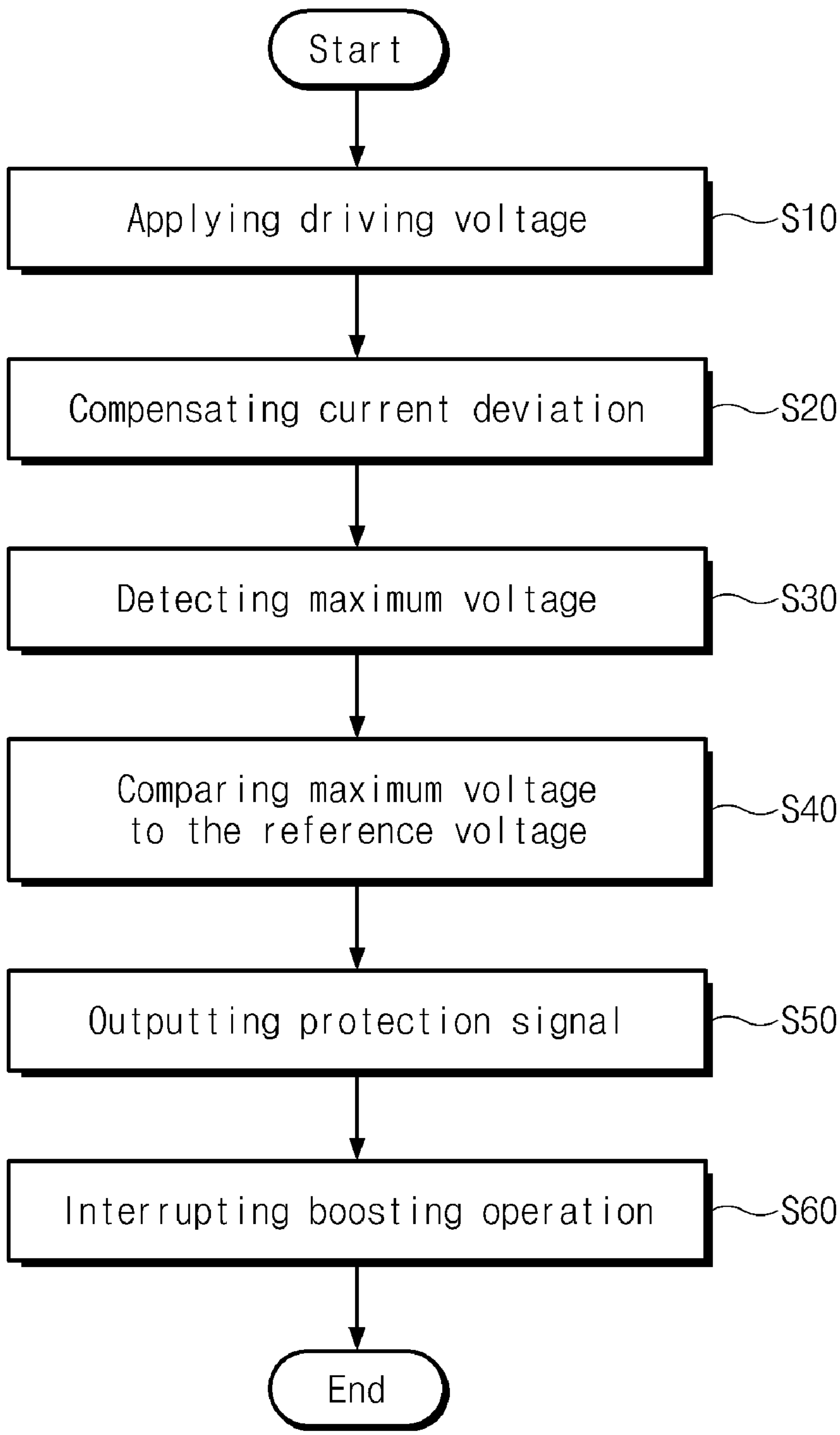


Fig. 4


Start
Applying driving voltage
S10
Compensating current deviation
S20
Detecting maximum voltage
S30
Comparing maximum voltage to the reference voltage
S40
Outputting protection signal
S50
Interrupting boosting operation
S60
End

BACKLIGHT UNIT, DISPLAY APPARATUS HAVING THE SAME AND METHOD OF INSPECTING THE SAME

This application claims priority to Korean Patent Application No. 10-2009-0072900, filed on Aug. 7, 2009, and all the benefits accruing therefrom under 35 U.S.C. §119, the content of which in its entirety is herein incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a backlight unit, a display apparatus having the same and a method of inspecting the backlight unit. More particularly, the present invention relates to a backlight unit which detects an abnormal condition of a light source included therein, a display apparatus having the backlight unit and a method of inspecting, e.g., testing, the backlight unit.

2. Description of the Related Art

A liquid crystal display ("LCD") typically includes a liquid crystal layer interposed between two display substrates. To display an image, the LCD controls a transmittance of a light passing through the liquid crystal layer. However, since the LCD is not a self-emissive device, the LCD requires a light source as a backlight unit.

The backlight unit may include a light emitting diode, for example, as a light source for generating the light. More particularly, the backlight unit typically includes a light emitting diode string having light emitting diodes connected to each other in electrical series. However, if any one of the light emitting diodes included in the light emitting diode string fails or malfunctions, the entire light emitting diode string becomes inoperable, and the light emitting diode string cannot operate effectively as the light source of the backlight unit.

BRIEF SUMMARY OF THE INVENTION

An exemplary embodiment of the present invention provides a backlight unit which detects an abnormal condition of a light source and controls an operation of the light source based on the same.

Another exemplary embodiment of the present invention provides a display apparatus having the backlight unit.

Still another exemplary embodiment of the present invention provides a method of inspecting, e.g., testing, the backlight unit, in which an abnormal condition of the light source is detected and identified during operation of the backlight unit.

According to one or more exemplary embodiments of the present invention, a backlight unit includes light source groups, a converter, a compensator, a detector and a protector. Each of the light source groups has a light source. The converter boosts an input voltage to a driving voltage and supplies the driving voltage to the light source groups. The compensator is connected to the light source groups and compensates a deviation between currents fed back to the compensator from the light source groups. The detector is connected between the compensator and the light source groups to detect a maximum voltage from among feedback voltages fed back to the compensator from the light source groups. The protector is connected to the detector, and receives the maximum voltage, compares the maximum voltage to a reference voltage and outputs a protection signal to the converter based on a compared result.

In one or more exemplary embodiments, the detector includes a plurality of first diodes connected to the light source groups, and each first diode of the plurality of first diodes has an anode connected to a corresponding light source group of the light source groups and a cathode connected to the protector.

In one or more exemplary embodiments, the protector includes a first comparator which receives the maximum voltage and the reference voltage and outputs the protection signal when the maximum voltage is greater than the reference voltage.

In one or more exemplary embodiments, the reference voltage is a maximum deviation value of deviation values of the feedback voltages fed back to the compensator from the light source groups.

In one or more exemplary embodiments, the protector further includes a second comparator which receives the protection signal from the first comparator and a dimming signal, which dims the light source groups, and outputs the protection signal when the dimming signal is at a high level.

In one or more exemplary embodiments, the compensator includes switching devices, each connected to one of the light source groups. At least one resistor is connected to each of the switching devices.

In one or more exemplary embodiments, each of the switching devices has a first terminal connected to a corresponding light source group of the light source groups, a second terminal connected to a ground terminal and a third terminal which controls an electrical connection between the first terminal and the second terminal.

In one or more exemplary embodiments, the backlight unit further includes a controller which receives the protection signal and controls a boosting operation of the converter.

In one or more exemplary embodiments, the converter includes an inductor which receives the input voltage, a second diode connected to the inductor to rectify a current based on the input voltage, a capacitor connected between the second diode and a ground terminal and which is charged by the input voltage, and a second switching device connected to the controller, the ground terminal and a node disposed between the inductor and the second diode. The controller turns off the second switching device in response to the protection signal when the maximum voltage is greater than the reference voltage.

According to additional exemplary embodiments of the present invention, a display apparatus includes a display panel, light source groups, a converter, a compensator, a detector and a protector. The display panel receives a light and displays an image using the light. Each of the light source groups has a light source and supplies the light to the display panel. The converter boosts an input voltage to a driving voltage and supplies the driving voltage to the light source groups. The compensator is connected to the light source groups and compensates a deviation between currents fed back to the compensator from the light source groups. The detector is connected between the compensator and the light source groups and detects a maximum voltage from among feedback voltages fed back to the compensator from each of the light source groups. The protector is connected to the detector, and receives the maximum voltage, compares the maximum voltage to a reference voltage and outputs a protection signal to the converter based on a compared result.

In one or more exemplary embodiments, the detector includes a plurality of first diodes connected to the light source groups, and each first diode of the plurality of first diodes has an anode connected to a corresponding light source group of the light source groups and a cathode connected to the protector.

In one or more exemplary embodiments, the protector includes a first comparator which receives the maximum voltage and the reference voltage and outputs the protection signal when the maximum voltage is greater than the reference voltage.

In one or more exemplary embodiments, the reference voltage is a maximum deviation value of deviation values of the feedback voltages fed back to the compensator from the light source groups.

In one or more exemplary embodiments, the protector further includes a second comparator which receives the protection signal from the first comparator and a dimming signal, which dims the light source groups, and outputs the protection signal when the dimming signal is at a high level.

In one or more exemplary embodiments, the compensator includes switching devices, each connected to one of the light source groups. At least one resistor is connected to each of the switching devices.

In one or more exemplary embodiments, each of the switching devices has a first terminal connected to a corresponding light source group of the light source groups, a second terminal connected to a ground terminal and a third terminal which controls an electrical connection between the first terminal and the second terminal.

In one or more exemplary embodiments, the backlight unit further includes a controller which receives the protection signal and controls a boosting operation of the converter.

In one or more exemplary embodiments, the converter includes an inductor which receives the input voltage, a second diode connected to the inductor to rectify a current based on the input voltage, a capacitor connected between the second diode and a ground terminal and which is charged by the input voltage, and a second switching device connected to the controller, the ground terminal and a node disposed between the inductor and the second diode. The controller turns off the second switching device in response to the protection signal when the maximum voltage is greater than the reference voltage.

According to additional exemplary embodiments of the present invention, a display apparatus includes a display panel, light source groups, a converter, a compensator, a detector and a protector. The display panel receives a light and displays an image using the light. Each of the light source groups has a light source and supplies the light to the display panel. The converter boosts an input voltage to a driving voltage and supplies the driving voltage to the light source groups. The compensator is connected to the light source groups and compensates a deviation between currents fed back to the compensator from the light source groups. The detector is connected between the compensator and the light source groups and detects a maximum voltage from among feedback voltages fed back to the compensator from each of the light source groups. The protector is connected to the detector, and receives the maximum voltage, compares the maximum voltage to a reference voltage and outputs a protection signal to the converter based on a compared result.

According to other additional exemplary embodiments of the present invention, a method of inspecting a backlight unit includes: boosting an input voltage to generate a driving voltage; applying the driving voltage to light source groups, each having a light source; compensating currents fed back from each of the light source groups to generate compensated currents; detecting a maximum voltage from among feedback voltages of each of the light source groups, the feedback voltages adjusted based on the compensated currents; comparing the maximum voltage to a reference voltage to generate a compared result and output a protection signal based on the compared result; and controlling the boosting the input voltage based on the protection signal.

In one or more exemplary embodiments, the compensating the currents maintains the feedback voltages at a constant level.

In one or more exemplary embodiments, the reference voltage is a maximum deviation value of deviation values of the feedback voltages that are fed back from the light source groups.

In one or more exemplary embodiments, when the maximum voltage is greater than the reference voltage, the protection signal interrupts the boosting the input voltage.

Thus, according to the exemplary embodiments described herein, a backlight unit and a display apparatus having the same detect an abnormal operation of light sources, and thereby interrupt an operation of light source groups using a self-detection function.

In addition, in an inspection method of the backlight unit according to one or more additional exemplary embodiments, the backlight unit has the self-detection function and thus detects defects of the light sources, thereby easily fixing the defects and substantially reducing inspection costs of the backlight unit.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects and features of the present invention will become more readily apparent by describing in further detail exemplary embodiments thereof with reference to the accompanying drawings, in which:

FIG. **1** is an exploded perspective view of an exemplary embodiment of a display apparatus according to the present invention;

FIG. **2** is a schematic circuit diagram of an exemplary embodiment of a backlight unit according to the present invention;

FIG. **3** is a schematic circuit diagram of a converter of the backlight unit shown in FIG. **2**; and

FIG. **4** is a flow chart illustrating an exemplary embodiment of a method of inspecting a backlight unit according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention now will be described more fully hereinafter with reference to the accompanying drawings, in which various embodiments are shown. This invention may, however, be embodied in many different forms, and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like reference numerals refer to like elements throughout.

It will be understood that when an element is referred to as being "on" another element, it can be directly on the other element or intervening elements may be present therebetween. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements present. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

It will be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," or "includes" and/or "including" when used in this specification, specify the presence of stated features, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components, and/or groups thereof.

Furthermore, relative terms, such as "lower" or "bottom" and "upper" or "top," may be used herein to describe one element's relationship to another element as illustrated in the Figures. It will be understood that relative terms are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures. For example, if the device in one of the figures is turned over, elements described as being on the "lower" side of other elements would then be oriented on "upper" sides of the other elements. The exemplary term "lower," can therefore, encompasses both an orientation of "lower" and "upper," depending on the particular orientation of the figure. Similarly, if the device in one of the figures is turned over, elements described as "below" or "beneath" other elements would then be oriented "above" the other elements. The exemplary terms "below" or "beneath" can, therefore, encompass both an orientation of above and below.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

Exemplary embodiments are described herein with reference to cross section illustrations that are schematic illustrations of idealized embodiments. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments described herein should not be construed as limited to the particular shapes of regions as illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. For example, a region illustrated or described as flat may, typically, have rough and/or nonlinear features. Moreover, sharp angles that are illustrated may be rounded. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the precise shape of a region and are not intended to limit the scope of the present claims.

Hereinafter, exemplary embodiments of the present invention will be described in further detail with reference to the accompanying drawings.

FIG. **1** is an exploded perspective view of an exemplary embodiment of a display apparatus according to the present invention.

Referring to FIG. **1**, a display apparatus **10** includes a display panel **100**, a driving circuit **200**, a backlight unit **300** and a chassis **500**.

The display panel **100** receives a light to display an image using the light. The display panel **100** includes a lower substrate **110**, and an upper substrate **130** facing, e.g., disposed opposite to, the lower substrate **110**, and a liquid crystal layer **120** interposed between the lower substrate **110** and the upper substrate **130**. To display the image, a transmittance of the light passing through the liquid crystal layer is controlled.

The lower substrate **110** includes a first base substrate including a glass or a plastic material, for example. The lower substrate **110** includes gate lines **111** disposed on the first base substrate and which extend along a first direction, e.g., a longitudinal direction (as viewed in FIG. **1**), and are alternately arranged along a second direction substantially perpendicular to the first direction. In addition, the gate lines **111** are spaced apart from each other on the first base substrate, and data lines **113** extend along the second direction on the first base substrate to cross the gate lines **111**, as shown in FIG. **1**. Thin film transistors ("TFTs") **115** are connected to a corresponding gate line **111** of the gate lines **111** and a corresponding data line **113** of the data lines **113**, and a pixel electrode **117** is connected to each of the thin film transistors **115**. For purposes of illustration in FIG. **1**, only one gate line **111** has been shown, but it will be understood that exemplary embodiments are not limited thereto (nor are exemplary embodiments limited by numbers of other components, such as data lines **113**, TFTs **115** or pixel electrodes **117** shown in FIG. **1**).

The upper substrate **130** includes a second base substrate including glass or plastic, for example. The upper substrate **130** includes a plurality of color filters **131** arranged in predetermined patterns on the second base substrate and corresponding to the pixel electrodes **117** of the lower substrate **110**. In addition, the upper substrate **130** includes a black matrix **137**, portions of which are arranged between two adjacent color filters **131**, and a common electrode **139** that forms an electric field with the pixel electrodes **117** to drive, e.g., control an alignment of, the liquid crystal layer **120** to display the image.

The driving circuit **200** according to one or more exemplary embodiments includes a gate driver (not shown), a data driver (not shown), a controller (not shown) and a circuit substrate **210** to supply various driving signals to the display panel **100** and/or to the abovementioned components of the driving circuit **200**. The controller is disposed on, e.g., mounted on, the circuit substrate **210** and is electrically connected to the lower substrate **110** by signal transmission films **220**.

The gate driver may be directly formed on the lower substrate **110** or, alternatively, may be mounted on the lower substrate **110** and/or the signal transmission films **220** in a form of a chip. Likewise, the data driver may be mounted on the lower substrate **110** or, alternatively, on the signal transmission films **220** in a form of a chip, for example.

The backlight unit **300** includes at least one light source group **307**, a light guide plate **310**, a reflection sheet **320**, a diffusion sheet **340** and a prism sheet **350** to supply the light to the display panel **100**.

The light source group **307** includes at least one light source **301**, e.g., a light emitting diode ("LED") **301**, and an LED bar **305** on which the LED **301** or, alternatively, a plurality of the LEDs **301**, are disposed, e.g., are mounted. The

LEDs **301** receive a driving voltage, described in greater detail below, via the LED bar **305**. The LED bar **305** on which the LEDs **301** are mounted is arranged adjacent to a side surface of the display panel **100**.

The light guide plate **310** includes a transparent material which refracts light. The light guide plate **310** receives the light through an incident surface thereof, adjacent to the light source group **307**, and changes a traveling direction of the light. The light guide plate **310** refracts the light incident through the incident surface, and supplies the refracted light to the display panel **100**.

The reflection sheet **320** includes a base sheet and a light reflection layer disposed, e.g., arranged, on the base sheet and disposed under the light guide plate **310**, as shown in FIG. **1**. The reflection sheet **320** reflects light which leaks from a lower surface of the light guide plate **310**, and a loss of the light traveling through the light guide plate **310** is thereby substantially reduced.

The diffusion sheet **340** is arranged on the light guide plate **310** and receives the light exiting from the light guide plate **310**. The diffusion sheet **340** diffuses the received light from the light guide plate **310** such that the light is uniformly supplied to the display panel **100**.

The prism sheet **350** is arranged on the diffusion sheet **340** and receives the diffused light from the diffusion sheet **340**. The prism sheet **350** collects the received light exiting from the diffusion sheet **340** such that the light is supplied vertically incident to the display panel **100**. In one or more exemplary embodiments, the diffusion sheet **340** and the prism sheet **350** may be a combination of two or three sheets, but alternative exemplary embodiments are not limited thereto.

The chassis **500** receives the display panel **100** and the backlight unit **300** therein and protects the display panel **100** and the backlight unit **300** from damage from external impact, for example.

FIG. **2** is a schematic circuit diagram of an exemplary embodiment of a backlight unit according to the present invention.

Referring to FIG. **2**, in one or more exemplary embodiments, a backlight unit **300** of the display apparatus **10** (FIG. **1**) includes a converter **360**, a plurality light source groups, e.g., a first light source group **371**, a second light source group **372**, a third light source group **373**, a fourth light source group **374**, a fifth light source group **375** and a sixth light source group **376** (hereinafter collectively referred to as "light source groups **371** through **376**" or "first through sixth light source groups **371** through **376**"), a compensator **380**, a detector **420** and a protector **450**.

The converter **360** receives an input voltage VIN, supplied from an exterior source (not shown) and converts the input voltage VIN to a driving voltage VOUT to output the driving voltage VOUT to the light source groups **371** through **376**.

Each of the light source groups **371** through **376** includes a plurality of the LEDs **301**, which, within a given light source group, are connected to each other in electrical series, as shown in FIG. **2**. The light source groups **371** through **376** are connected to each other in electrical parallel, and input terminals of the light source groups **371** through **376** are connected to an output terminal of the converter **360**. Each light source group of the first through sixth light source groups **371** through **376** receives the driving voltage VOUT from the converter **360** and generates light based on, e.g., in response to, the driving voltage VOUT.

The compensator **380** according to one or more exemplary embodiments includes a current mirror circuit (not shown) and compensates a deviation between currents that are fed back from each of the first through sixth light source groups **371** through **376**. To compensate the deviations of the currents, the compensator **380** includes a first switching device TR**1**, a plurality of second switching devices TR**2**, a first resistor R**1**, a second resistor R**2**, a plurality of third resistors R**3**, a plurality of fourth resistors R**4**, a fifth resistor R**5** and a sixth resistor R**6**.

The first switching device TR**1** includes a collector to which the input voltage VIN is applied via the first resistor R**1**, a base to which a first feedback voltage VF**1**, fed back from the first light source group **371**, is applied via the second resistor R**2**, and an emitter connected to the fifth resistor R**5**. The first switching device TR**1** is turned on in response to the first feedback voltage VF**1**.

Each of the second switching devices TR**2** includes a base connected to the emitter of the first switching device TR**1** via a corresponding third resistor R**3** of the plurality of third resistors R**3**, a collector connected to a corresponding light source group of the first through sixth light source groups **371** through **376**, and an emitter connected to a corresponding fourth resistor R**4** of the plurality of fourth resistors R**4**. The base of each second switching device TR**2** is connected to the emitter of the first switching device TR**1** at a first node n**1**, e.g., a first connection node n**1**. Respective collectors of the second switching devices TR**2** receive the first feedback voltage VF**1**, a second feedback voltage VF**2**, a third feedback voltage VF**3**, a fourth feedback voltage VF**4**, a fifth feedback voltage VF**5** and a sixth feedback voltage VF**6**, which are fed back from the first through sixth light source groups **371** through **376**, respectively. Each of the second switching devices TR**2** is turned on in response to an emitter voltage of the switching device TR**1**.

The fourth resistors R**4** are commonly connected to a second node n**2**. The fifth resistor R**5** is connected between the emitter of the first switching device TR**1** and a ground terminal, and the sixth resistor R**6** is connected between the second node n**2** and the ground terminal.

In the compensator **380**, currents flowing through the bases of the switching devices TR**2** have a same level, since the bases of the second switching devices TR**2** are commonly connected at the first node n**1**. A collector current of each second switching devices TR**2** is determined by a current gain thereof, the first through sixth feedback voltages VF**1** through VF**6**, and resistance components of the first through sixth light source groups **371** through **376**. In one or more exemplary embodiments, a voltage between the base and the emitter of each of the second switching devices TR**2** is constant. In addition, in an exemplary embodiment, the current gain is greater than one (1), and the collector current of each of the second switching devices TR**2** is determined by the first through sixth feedback voltages VF**1** through VF**6** and the resistance components of to the first through sixth light source groups **371** through **376**, and the collector current of each of the second switching devices TR**2** has a constant value. It will be noted that, while the current gain may vary, the collector current of each of the second switching devices TR**2** has an effectively constant value, since any variation of the current gain is relatively small compared to the other factors described above. Accordingly, the compensator **380** according to an exemplary embodiment maintains the currents fed back from the first through sixth light source groups **371** through **376** at a substantially constant level.

The detector **420** receives feedback voltages fed back from the first through sixth light source groups **371** through **376** and supplies a maximum voltage from among the feedback voltages to the protector **450**. In one or more exemplary embodiments of the present invention, the detector **420** includes a plurality of first diodes D**1**, and first diodes D**1** of the plurality of first diodes D1 are connected to each other in electrical parallel, as shown in FIG. 2.

Specifically, each of the first diodes D1 includes an anode connected to the collector of a corresponding second switching device TR2 of the plurality of second switching devices TR2, and a cathode connected to the protector 450. More specifically, connecting nodes between the first diodes D1 and corresponding second switching devices TR2 are referred to as a third node n3, a fourth node n4, a fifth node n5, a sixth node n6, a seventh node n7 and an eighth node n8, as shown in FIG. 2. The protector 450 includes a first comparator 451 which receives the maximum voltage from the detector 420.

The first comparator 451 includes a first input terminal commonly connected to the cathodes of the first diodes D1 and a second input terminal which receives a reference voltage VREF, which in an exemplary embodiment is a predetermined reference voltage VREF. In one or more exemplary embodiments, the reference voltage VREF is a maximum deviation value of deviation values of the first through sixth feedback voltages VF1 through VF6. Alternatively (or additionally), the reference voltage VREF may be a maximum deviation value of deviation values of the driving voltage VOUT applied to each light source group 371 through 376. More particularly, the driving voltage VOUT applied to each of the first through sixth light source groups 371 through 376 may have a voltage level ranging from a first critical value to a second critical value, which are determined based on a number of the LEDs 301 included of each light source group 371 through 376 and/or characteristics of the LEDs 301, for example. In an exemplary embodiment, the first critical value is a minimum value of the driving voltage VOUT, and the second critical value is a maximum value of the driving voltage VOUT. Thus, since the driving voltage VOUT has the voltage level between the first and second critical values, a maximum deviation value of the driving voltage VOUT corresponds to a difference value between the first critical value and the second critical value.

In addition, the reference voltage VREF, which may be defined as the maximum deviation value of the driving voltage VOUT, has a value less than a driving voltage VOUT of one of the LEDs. Put another way, the reference voltage VREF is less than a feedback voltage fed back from a corresponding light source group when at least one of the LEDs 301 therein has a fault, e.g., is shorted. Therefore, when the maximum voltage supplied from the detector 420 is greater than the reference voltage VREF, the first comparator 451 outputs a protection signal PS.

Cathodes of the first diodes D1 included in the detector 420 are connected to the third through eighth nodes n3 through n8, and anodes of the first diodes D1 are commonly connected to the first input terminal of the first comparator 451. Thus, the first diodes D1 receive the first through sixth feedback voltages VF1 through VF6 via the third through eighth nodes n3 through n8, respectively, and supply the first through sixth feedback voltages VF1 through VF6 to the first input terminal of the first comparator 451. Since the anodes of the first diodes D1 are connected in electrical parallel to the first input terminal, an input voltage applied to the first input terminal of the first comparator 451 is based on an average value of the first through sixth feedback voltages VF1 through VF6. Specifically, when one of the LEDs 301 included in the sixth light source group 376, for example, is shorted, the sixth feedback voltage VF6 increases to become greater than each of the first through fifth feedback voltages VF1 through VF5. Accordingly, the input voltage applied to the first input terminal changes based on the increased sixth feedback voltage VF6. Since the increased sixth feedback voltage VF6 is larger than the first through fifth feedback voltages VF1 through VF5, the input voltage of the first input terminal has a voltage level substantially the same as the sixth feedback voltage VF6.

In an exemplary embodiment, the first diodes D1 of the detector 420 prevents a reverse current from the first comparator 451 to the first through sixth light source groups 371 through 376.

As described above, when at least one of the LEDs 301 has a fault, e.g., is shorted, in one or more of the first through sixth light source groups 371 through 376, the detector 420 detects an abnormal condition due to the shorted LED 301 (or plurality thereof). Thus, when at least one of the LEDs 301 included in each of the first through sixth light source groups 371 through 376 is shorted, the detector 420 outputs a feedback voltage that is increased greater than the reference voltage VREF. As a result, the input voltage applied to the first comparator 451 increases by the increased feedback voltage.

When one LED 301 of the LEDs 301 is shorted, an overall brightness of the light source group including the shorted LED 301 decreases by the brightness of the shorted LED 301, but it is difficult, during an inspection, for example, to perceive this relatively small change of the brightness with a human eye. However, the detector 420 according to the exemplary embodiments described herein easily detect the defect or defects of one or more of the LEDs 301 using the voltages fed back from the first through sixth light source groups 371 through 376, as described above. As a result, the defect of the LEDs 301 is easily detected thereby substantially improving an efficiency of an inspection of the display apparatus 10 according to one or more exemplary embodiments.

In exemplary embodiments of the present invention, the protector 450 further includes a second comparator 453 which receives the protection signal PS from the first comparator 451 and a dimming signal DMS for dimming of the first through sixth light source groups 371 through 376. The dimming signal DMS may control a brightness of the first through sixth light source groups 371 through 376 based on a duty ratio, e.g., according to a ratio of a low level period with respect to a high level period of the dimming signal DMS. The dimming signal DMS is supplied to the second comparator 453 using a pulse width modulation ("PWM") method, for example. In an exemplary embodiment, the second comparator 453 receives the protection signal PS and outputs the protection signal PS to the converter 360 during the high level period of the dimming signal DMS.

FIG. 3 is a schematic circuit diagram of a converter 360 of the backlight unit 300 shown in FIG. 2.

Referring to FIG. 3, the converter 360 converts the input voltage VIN supplied from an external source (not shown) to the driving voltage VOUT to supply the driving voltage VOUT to the light source groups 371 through 376. As shown in FIG. 3, the converter 360 includes an inductor L, a second diode D2, a capacitor C, a third switching device TR3 and a controller 369.

The inductor L is connected to the input terminal of the converter 360 and receives the input voltage VIN. The second diode D2 is connected to the inductor L and rectifies a current which is generated depending on the input voltage VIN. The capacitor C is connected between the second diode D2 and a ground terminal and is charged by the input voltage VIN applied thereto via the second diode D2. The third switching device TR3 is connected to the controller 369, the ground terminal and a connection node between the inductor L and the second diode D2. The controller 369 is connected to the third switching device TR3 and controls an operation of the third switching device TR**3**. Thus, the converter **360** boosts the input voltage VIN based on a switching operation of the third switching device TR**3**.

The controller **369** receives the protection signal PS from the protector **450** and controls the switching operation of the third switching device TR**3** based on the protection signal PS. More particularly, when the controller **369** receives the protection signal PS, the controller **369** turns off the third switching device TR**3**. When the third switching device TR**3** is turned off, the converter **360** does not boost the input voltage VIN to the driving voltage VOUT.

FIG. **4** is a flow chart illustrating an exemplary embodiment of a method of inspecting, e.g., testing, a backlight unit according to the present invention.

Referring to FIGS. **1** through **4**, the converter **360** boosts the input voltage supplied from an external source (no shown) to the driving voltage VOUT to drive the light source groups (step S**10**). Next, the driving voltage VOUT is applied to the light source groups **371** through **376**, each having the light sources **301**, e.g., the LEDs **301**, connected to each other in electrical series (step S**20**). The compensator **380** compensates the currents fed back from the light source groups **371** through **376** (step S**30**). The compensator **380** includes the current mirror circuit (not shown) to maintain the currents fed back from the light source groups **371** through **376** at a constant level, as described in greater detail above.

The detector **420** detects the maximum voltage among the feedback voltages VF**1** through VF**6** adjusted by the compensated currents (step S**40**). The protector **450** receives the reference voltage VREF and compares the maximum voltage to the reference voltage VREF to output a protection signal PS that controls the boosting operation of the converter **360** based on a compared result (step S**50**). The protector **450** includes the first comparator **451** and outputs the protection signal PS when the maximum voltage is greater than the reference voltage VREF, which is defined as the maximum deviation value of deviation values of the feedback voltages VF**1** through VF**6** fed back from the light source groups **371** through **376**. If the maximum voltage is less than the reference voltage VREF, the protector **450** again receives the maximum voltage from the detector **420** and compares the maximum voltage to the reference voltage VREF.

In one or more exemplary embodiments of the present invention, the protector **450** further includes the second comparator **453** which receives the protection signal PS and the dimming signal DMS (for dimming of the light source groups **371** through **376**) and outputs the protection signal PS during the high level period of the dimming signal DMS through the second comparator **453**, as described in greater detail above with reference to FIG. **2**.

The converter **360** stops the boosting operation in response to the protection signal PS (step S**60**). Accordingly, the light source groups **371** through **376**, which each receive the driving voltage VOUT from the converter **360**, stop generating the light, thereby allowing an inspector to easily and efficiently detect an abnormal condition of the light source (or a plurality thereof).

According to exemplary embodiments described herein, a backlight unit and a display apparatus having the same detect an abnormal operation of light sources therein and interrupt operation of light source groups using a self-detection function, thereby allowing for efficient detection and fixing of defects, substantially reducing an inspection cost due to the defect.

The present invention should not be construed as being limited to the exemplary embodiments set forth herein. Rather, these exemplary embodiments are provided so that this disclosure will be thorough and complete and will fully convey the concept of the present invention to those skilled in the art.

While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit or scope of the present invention as defined by the following claims.

What is claimed is:

1. A backlight unit comprising:

light source groups, each including a light source;

a converter which boosts an input voltage to a driving voltage which is supplied to the light source groups;

a compensator connected to the light source groups and which compensates a deviation between currents fed back to the compensator from each of the light source groups;

a detector connected between the light source groups and the compensator and which detects a maximum voltage from among feedback voltages fed back to the compensator from each of the light source groups; and

a protector connected to the detector,

wherein the protector receives the maximum voltage, compares the maximum voltage to a reference voltage to generate a compared result and outputs a protection signal to the converter based on the compared result.

2. The backlight unit of claim **1**, wherein the detector comprises a plurality of first diodes, each first diode of the plurality of first diodes having an anode connected to a corresponding light source group of the light source groups and a cathode connected to the protector.

3. The backlight unit of claim **1**, wherein

the protector comprises a first comparator which receives the maximum voltage and the reference voltage, and

the first comparator outputs the protection signal when the maximum voltage is greater than the reference voltage.

4. The backlight unit of claim **3**, wherein the reference voltage is a maximum deviation value of deviation values of the feedback voltages fed back to the compensator from each of the light source groups.

5. The backlight unit of claim **3**, wherein

the protector further comprises a second comparator which receives the protection signal from the first comparator and a dimming signal which dims the light source groups, and

the second comparator outputs the protection signal when the dimming signal is at a high level.

6. The backlight unit of claim **1**, wherein

the compensator comprises switching devices, each connected to one of the light source groups, and

at least one resistor is connected to each of the switching devices.

7. The backlight unit of claim **6**, wherein each of the switching devices comprises:

a first terminal connected to a corresponding light source group of the light source groups;

a second terminal connected to a ground terminal; and

a third terminal which controls an electrical connection between the first terminal and the second terminal.

8. The backlight unit of claim **1**, further comprising a controller which receives the protection signal and controls a boosting operation of the converter.

9. The backlight unit of claim 2, wherein the converter comprises:

a controller which receives the protection signal and controls a boosting operation of the converter;

an inductor which receives the input voltage;

a second diode which is connected to the inductor and rectifies a current which is based on the input voltage;

a capacitor connected between the second diode and a ground terminal and which is charged by the input voltage; and

a switching device connected to the controller, the ground terminal and a node disposed between the inductor and the second diode,

wherein the controller turns off the switching device in response to the protection signal when the maximum voltage is greater than the reference voltage.

10. A display apparatus comprising:

a display panel which receives a light and displays an image;

light source groups which supply the light to the display panel, each of the light source groups including a light source;

a converter which boosts an input voltage to a driving voltage and supplies the driving voltage to the light source groups;

a compensator connected to the light source groups and which compensates a deviation between currents fed back to the compensator from the light source groups;

a detector connected between the light source groups and the compensator and which detects a maximum voltage from among feedback voltages fed back to the compensator from the light source groups; and

a protector connected to the detector, wherein the protector receives the maximum voltage, compares the maximum voltage to a reference voltage to generate a compared result and outputs a protection signal to the converter based on the compared result.

11. The display apparatus of claim 10, wherein the detector comprises a plurality of first diodes each first diode of the plurality of first diodes having an anode connected to a corresponding light source group of the light source groups and a cathode connected to the protector.

12. The display apparatus of claim 10, wherein the protector comprises:

a first comparator which receives the maximum voltage and the reference voltage; and

a second comparator which receives the protection signal from the first comparator and a dimming signal, which dims the light source groups, wherein

the first comparator outputs the protection signal when the maximum voltage is greater than the reference voltage, and

the second comparator outputs the protection signal when the dimming signal is at a high level.

13. The display apparatus of claim 12, wherein the reference voltage is a maximum deviation value of deviation values of the feedback voltages fed back to the compensator from each of the light source groups.

14. The display apparatus of claim 10, wherein the compensator comprises:

switching devices, each comprising:

a first terminal connected to a corresponding light source group of the light source groups;

a second terminal connected to a ground terminal; and

a third terminal which controls an electrical connection between the first terminal and the second terminal, wherein

at least one resistor is connected to each of the switching devices.

15. The display apparatus of claim 10, further comprising a controller which receives the protection signal and controls a boosting operation of the converter.

16. The display apparatus of claim 11, wherein the converter comprises:

an inductor which receives the input voltage;

a second diode which is connected to the inductor and rectifies a current which is based on the input voltage;

a capacitor connected between the second diode and a ground terminal and which is charged by the input voltage; and

a switching device connected to the controller, the ground terminal and a node disposed between the inductor and the second diode,

wherein the controller turns off the switching device in response to the protection signal when the maximum voltage is greater than the reference voltage.

17. A method of inspecting a backlight unit, the method comprising:

boosting an input voltage to generate a driving voltage;

applying the driving voltage to light source groups, each having a light source;

compensating currents fed back from each of the light source groups to generate compensated currents;

detecting a maximum voltage from among feedback voltages of each of the light source groups, the feedback voltages adjusted based on the compensated currents;

comparing the maximum voltage to a reference voltage to generate a compared result and output a protection signal based on the compared result; and

controlling the boosting the input voltage based on the protection signal.

18. The method of claim 17, wherein the compensating the currents maintains the feedback voltages at a constant level.

19. The method of claim 17, wherein the reference voltage is a maximum deviation value of deviation values of the feedback voltages fed back from the light source groups.

20. The method of claim 17, wherein the protection signal interrupts the boosting the input voltage when the maximum voltage is greater than the reference voltage.

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