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(71) Applicant: **Koito Manufacturing Co., Ltd.**
Tokyo 108-8711 (JP)

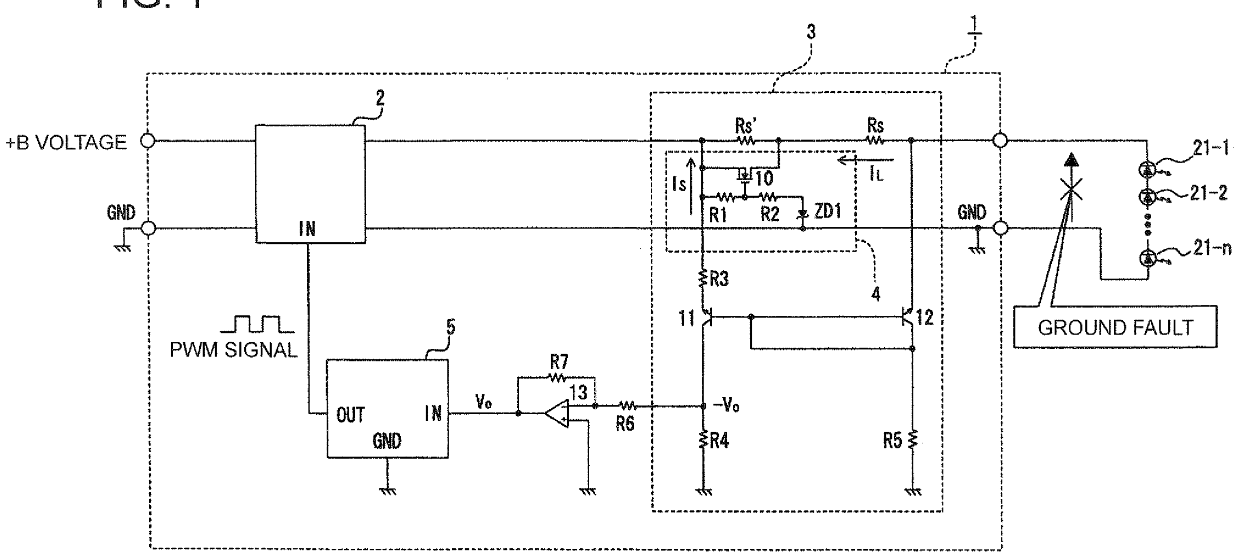
(72) Inventors:
- **Matsui, Kotaro**
  Shizuoka-shi
  Shizuoka (JP)
- **Sugiyama, Takao**
  Shizuoka-shi
  Shizuoka (JP)
- **Kitagawa, Takayoshi**
  Shizuoka-shi
  Shizuoka (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) **Controller for vehicular lamp**

(57) To reduce manufacturing costs by suppressing a ground fault current, a controller for a vehicular lamp includes an inverting converter 2 for supplying power to LEDs 21-1 to 21-n, and a current detection unit 3 that includes a shunt resistor Rs connected serially to the LEDs 21-1 to 21-n and detects an LED driving current flowing through the LEDs 21-1 to 21-n. The current detection unit 3 includes a shunt resistor Rs' connected serially to the LEDs 21-1 to 21-n via the shunt resistor Rs, and a bypass section 4. The bypass section 4 includes an NMOS transistor 10 connected parallel to the shunt resistor Rs' and a Zener diode ZD1 that causes the NMOS transistor 10 to turn off when a ground fault occurs at a positive polarity output side or a negative polarity output side of the inverting converter 2.

FIG. 1



EP 2 200 406 A2

Description

[Technical Field]

[0001] The present invention relates to a controller for a vehicular lamp, and to a controller for a vehicular lamp for controlling lighting of semiconductor light sources constituted by semiconductor light-emitting elements.

[Related Art]

[0002] Conventionally known vehicular lamps are those employing semiconductor light-emitting elements such as light emitting diodes (LEDs) as semiconductor light sources. Such vehicular lamps are equipped with a controller for controlling lighting of the LEDs.

[0003] A controller of one known type includes a power supply unit, a current detection unit detecting an LED driving current (light source driving current) IL flowing through LEDs, and a current control unit controlling the output of the power supply unit (for example, see Patent Document 1). Some power supply units provide positive polarity output, while the others provide negative polarity output. A typically known power supply unit that provides negative polarity output is an inverting power supply unit (inverting converter).

[0004] Hereafter, an exemplary controller employing an inverting converter as the power supply unit will be described.

[0005] The current detection unit is formed to include a shunt resistor Rs, an NPN transistor Tr1, an NPN transistor Tr2, a resistor Ra connected to the emitter of the NPN transistor Tr1, and a resistor Rb connected to the collector of the NPN transistor Tr1. The shunt resistor Rs has one end connected to the emitter of the NPN transistor Tr2, and has the other end connected to the emitter of the NPN transistor Tr1 via the resistor Ra.

[0006] The output of the current detection unit is supplied to the negative input of an inverting amplifier. Light source driving current information at the output side of the current detection unit is (-V0) It is to be noted that, while the light source driving current information (-V0) and the output voltage V0 of the inverting amplifier are the same in magnitude, they are opposite in polarity. The output of the inverting amplifier is connected to the input of the current control unit whose output is connected to the gate of a PMOS transistor of the inverting converter.

[0007] An LED driving current IL detected at the shunt resistor is converted into light source driving current information (-V0) by the current detection unit. The light source driving current information (-V0) has polarity inverted by the inverting amplifier to be output. The output voltage V0 of the inverting amplifier is provided to the current control unit. In order to allow the output voltage V0 to be constant, the current control unit sends a PWM (Pulse Width Modulation) signal to the gate of the PMOS transistor of the inverting converter.

[0008]

[Patent Document 1]
Japanese Patent Application Laid-Open (Kokai) No. JP-A-2004-126041

[Disclosure of the Invention]

[Problem to be Solved by the Invention]

[0009] Meanwhile, the relationship between the LED driving current IL and a current Is flowing through the resistor Ra in a normal operation is as follows:

$$Is=V0/Rb=Rs \cdot IL/Ra \ldots (1)$$

Here, it is assumed that the NPN transistor Tr1 and the NPN transistor Tr2 are equal in base voltage.

[0010] Accordingly, the LED driving current IL is as follows:

$$IL=Ra \cdot V0/Rs \cdot Rb \ldots (2)$$

[0011] On the other hand, when a ground fault occurs at the positive polarity output side or the negative polarity output side of the inverting converter (hereafter referred to as "when a ground fault occurs"), the emitter voltage of the NPN transistor Tr2 reaches ground (GND) potential, causing the NPN transistor Tr2 to turn off and the NPN transistor Tr1 to turn on. Accordingly, until the output voltage information V0 becomes constant, the LED driving current IL flows through the shunt resistor Rs. Denoting the LED driving current IL at this timing as an IL-Fault (ground fault current), the relationship between the ground fault current IL-Fault and the current Is flowing through the resistor Ra is expressed as follows;

$$V0+Is \cdot Ra=IL\text{-}Fault \cdot Rs...(3)$$

and the current Is is as follows:

$$Is=Rs \cdot IL\text{-}Fault/(Ra+Rb)...(4)$$

[0012] Accordingly, the ground fault current IL-Fault is: IL-Fault=(Ra+Rb) - V0/(Rs · Rb)

$$=Ra \cdot V0/(Rs \cdot Rb)+V0/Rs...(5)$$

[0013] Comparing the expressions (2) and (5) with each other, the ground fault current IL-Fault that passes when a ground fault occurs is greater by V0/Rs than the LED driving current IL that passes in a normal operation.

[0014] Accordingly, the power rating of the elements connected serially to the resistor element (shunt resistor) and the semiconductor light sources must be increased in accordance with the ground fault current. This would invite an increase in the manufacturing costs.

[0015] Therefore, it is an object of the present invention to suppress the ground fault current, thereby reducing the manufacturing costs.

[Means for Solving the Problem]

[0016] A controller for a vehicular lamp according to an aspect of the present invention includes: power supply means for supplying power to a semiconductor light source; and current detection means that includes a first resistor connected serially to the power supply means and detects a light source driving current flowing through the semiconductor light source. The current detection means includes a second resistor connected serially to the semiconductor light source via the first resistor, and a bypass section having a switch portion connected parallel to the second resistor and further having a ground fault detection portion for causing the switch portion to turn off when a ground fault occurs at a positive polarity output side or a negative polarity output side of the power supply means. The controller for a vehicular lamp further includes a changeover unit for carrying out changeover of the switch portion between on and off states, thereby executing lighting adjustment control over the semiconductor light source.

[0017] Accordingly, by causing the switch portion to turn off when a ground fault occurs, the light source driving current flows through the second resistor via the first resistor.

[Effects of the Invention]

[0018] The controller for a vehicular lamp according to the present invention includes: power supply means for supplying power to a semiconductor light source; and current detection means that includes a first resistor connected serially to the semiconductor light source and detects a light source driving current flowing through the semiconductor light source. The current detection means includes a second resistor connected serially to the semiconductor light source via the first resistor, and a bypass section having a switch portion connected parallel to the second resistor and further having a ground fault detection portion for causing the switch portion to turn off when a ground fault occurs at a positive polarity output side or a negative polarity output side of the power supply means. The controller for a vehicular lamp further includes a changeover unit for carrying out changeover of the switch portion between on and off states, thereby executing lighting adjustment control over the semiconductor light source. Therefore, by adjusting the value of the second resistor, the ground fault current can be adjusted.

[0019] Accordingly, depending on the value of the second resistor, the ground fault current is made smaller than the light source driving current in a normal operation so that the ground fault current can be suppressed. As a result, the manufacturing costs can be reduced.

[0020] Further, a single switch portion can achieve both the function of executing lighting adjustment control over the semiconductor light source and the function of suppressing the ground fault current.

[0021] In the invention according to claim 2, the ground fault detection portion is a Zener diode that turns off when the ground fault occurs. The switch portion is a switch element that turns off when the Zener diode turns off. The light source driving current flows through the switch element when the switch element turns on, and the light source driving current flows through the second resistor when the switch element turns off. Therefore, the switch element can surely be turned off so that the light source driving current flows through the second resistor when the ground fault occurs.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0022]

FIG. 1 shows the configuration of a controller for a vehicular lamp according to a first embodiment of the present invention.
FIG. 2 is a diagram for describing the setting range of the turn-on voltage of a Zener diode.
FIG. 3 shows the configuration of a controller for a vehicular lamp according to a second embodiment of the present invention.

[0023] In the invention according to claim 3, a turn-on voltage of the Zener diode is set to be greater than an output voltage of the power supply means when the ground fault occurs, and to be equal to or smaller than a forward direction voltage with which a current starts to flow through the semiconductor light source. Therefore, the Zener diode can surely be turned on in a normal operation, and the Zener diode can surely be turned off when a ground fault occurs.

[Best Modes for Carrying Out the Invention]

[0024] Hereafter, a controller for a vehicular lamp according to a first embodiment of the present invention will be described.

[0025] As shown in FIG. 1, a controller 1 is formed to include an inverting converter 2 serving as power supply means, a current detection unit 3, a current control unit 5, and an inverting amplifier 13.

[0026] The inverting converter 2 is formed to include a switching transistor to receive an ON/OFF signal (PWM signal) from the current control unit 5 and supply a negative polarity output to LEDs 21-1 to 21-n (where n is an integer equal to or greater than 1) as semiconductor light sources.

[0027] The current detection unit 3 is formed to include a shunt resistor Rs serving as a first resistor, a shunt resistor Rs' serving as a second resistor, a bypass section 4, and NPN transistors 11, 12. The current detection unit 3 detects a light source driving current (LED driving current IL) flowing through the LEDs 21-1 to 21-n. The LED driving current IL is converted into light source driving current information (-V0) by the current detection unit 3.

[0028] The bypass section 4 is formed to include an NMOS transistor 10 serving as a switch portion connected parallel to the shunt resistor Rs', and a Zener diode ZD1 serving as a ground fault detection portion. The NMOS transistor 10 has a gate connected to the anode of the Zener diode ZD1 via a resistor R2 and connected to the emitter of the NPN transistor 11 via resistors R1, R3. The Zener diode ZD1 has a cathode connected to ground (GND).

[0029] The inverting amplifier 13 inverts the polarity of the light source driving current information (-V0), thereby providing output voltage V0. The inverting amplifier 13 has its negative input connected to its output via a resistor R7, and also to the collector of the NPN transistor 11 of the current detection unit 3 via a resistor R6, and has its positive input grounded.

[0030] The current control unit 5 is formed to include an error amplifier (not shown) and a PWM comparator (not shown). In order for the output voltage information V0 to be constant, the current control unit 5 sends a PWM signal to the switching transistor, thereby controlling the negative polarity output of the inverting converter 2.

[0031] Hereafter, description will be given on the operation of the bypass section 4 as to respective cases in a normal operation and where a ground fault occurs at the negative polarity output side (hereafter referred to as "when a ground fault occurs"). FIG. 2 is for describing the setting range of the turn-on voltage of the Zener diode ZD1 (the region B in FIG. 2). The turn-on voltage of the Zener diode ZD1 is set to be greater than the output voltage (Va) of the inverting converter 2 when a ground fault occurs, and to be equal to or smaller than the output voltage (Vb) of the inverting converter 2 with which the LED driving current IL starts to flow in a normal operation. It is to be noted that Vc is the output voltage of the inverting converter 2 in a normal operation.

[0032] In a normal operation, the output voltage (Vc, the region C in FIG. 2) of the inverting converter 2 is higher than the turn-on voltage (>Va, ≤Vb) of the Zener diode ZD1. Therefore, the anode-cathode voltage (=Vc) of the Zener diode ZDl is higher than the turn-on voltage, whereby the Zener diode ZD1 turns on. As the Zener diode ZD1 turns on, the NMOS transistor 10 likewise turns on, and the LED driving current IL flows through the shunt resistor Rs and the NMOS transistor 10.

[0033] Accordingly, the LED driving current IL is as follows:

$$IL = R1 \cdot V0/Rs \cdot R2 \ldots (6)$$

It is to be noted that the ON resistance of the NMOS transistor 10 is far smaller as compared with the shunt resistor Rs.

[0034] On the other hand, when a ground fault occurs, the output voltage (≤Va, the region A in FIG. 2) of the inverting converter 2 is lower than the turn-on voltage of the Zener diode ZD1. Therefore, the anode-cathode voltage (≤Va) of the Zener diode ZD1 is lower than the turn-on voltage, whereby the Zener diode ZD1 turns off. As the Zener diode ZD1 turns off, the NMOS transistor 10 likewise turns off, and the LED driving current IL flows through the shunt resistor Rs and the shunt resistor Rs'.

[0035] Accordingly, denoting the LED driving current IL when a ground fault occurs as the ground fault current IL-Fault, it is expressed as follows:

$$\begin{aligned} IL\text{-}Fault &= (R1+R2) \cdot V0/(Rs+Rs') \cdot R2 \\ &= R1 \cdot V0/(Rs+Rs') \cdot R2+V0/(Rs+Rs') \ldots (7) \end{aligned}$$

[0036] As shown in the expression (7), the ground fault current IL-Fault becomes small as the value of the shunt resistor Rs' is increased.

[0037] For example, solving the expression (7) assuming that the LED driving current IL in a normal operation is 100 milliamperes (mA), the shunt resistor Rs is 1 ohm (Ω), the shunt resistor Rs' is 19 ohms (Ω), and the output voltage information V0 is 1 volt (V), the derived ground fault current IL-Fault is 55 mA. Here, applying the same conditions as above (IL = 100 (mA), Rs = 1 (Ω), V0 = 1 (V)) to the expression (5) of the related art described above to obtain the ground fault current IL-Fault, the derived ground fault current IL-Fault is 1.1 amperes (A).

[0038] Accordingly, by adjusting the value of the shunt resistor Rs', the ground fault current IL-Fault can be adjusted. Depending on the value of the shunt resistor Rs', the ground fault current IL-Fault can be made smaller than the LED driving current IL in a normal operation.

[0039] Additionally, since the turn-on voltage of the Zener diode ZD1 is set to be greater than the output voltage (Va) of the inverting converter 2 when a ground fault occurs and to be equal to or smaller than the output voltage (Vb) of the inverting converter 2 where the LED driving current IL starts to flow, it is ensured that the output voltage of the inverting converter 2 is smaller than the turn-on voltage of the Zener diode ZD1 when a ground fault occurs. Accordingly, the Zener diode ZD1 can surely be turned off and the NMOS transistor 10 can surely be turned on when a ground fault occurs.

[0040] As described in the foregoing, according to the first embodiment, the manufacturing costs can be reduced by suppressing the ground fault current.

[0041] While it has been described in the first embodiment about the controller that includes as power supply means the inverting converter 2 which is a negative polarity output converter, the same effects can be obtained employing a positive polarity output converter as the power supply means. Specifically, the controller is formed to include a positive polarity output converter serving as power supply means, and a current detection unit and a current control unit each having the circuit configuration similarly to that in the first embodiment. The output of the current detection unit is directly sent to the current control unit. It is to be noted that the positive polarity output converter provides a positive output, so that the current detection unit provides a positive output. Therefore, the inverting amplifier is not necessary.

[0042] Hereafter, a controller for a vehicular lamp according to a second embodiment of the present invention will be described (see FIG. 3). Additionally to the operation in the first embodiment, a controller 30 according to the second embodiment carries out changeover of a Zener diode ZD10 between on and off states by a changeover unit 36 in a normal operation, thereby carrying out changeover of an NMOS transistor 40 between on and off states to execute lighting adjustment control over LEDs 51-1 to 51-n.

[0043] The controller 30 is formed to include an inverting converter 32, a current detection unit 33, a current control unit 35, the changeover unit 36, and an inverting amplifier 43. Since the constituents of the controller 30, i.e., the inverting converter 32, the current detection unit 33, the current control unit 35, and the inverting amplifier 43 are respectively structured similarly to the constituents of controller 1 shown in FIG. 1, i.e., the inverting converter 2, the current detection unit 3, the current control unit 5, and the inverting amplifier 13, descriptions therefor are omitted.

[0044] The changeover unit 36 is formed to include an NPN transistor 44, a PNP transistor 45, and resistors R18, R19, R20, R21. The NPN transistor 44 receives at its base a lighting adjustment signal via the resistor R18.

[0045] The NPN transistor 44 has a collector connected to the base of the PNP transistor 45 via the resistor R20. The PNP transistor 45 has an emitter connected to reference power supply Vcc, and has a collector connected to the cathode of the Zener diode ZD10.

[0046] Hereafter, the operation of the changeover unit 36 will be described as to respective cases where the lighting adjustment signal is a low level signal and where it is a high level signal, each in a normal operation and when a ground fault occurs. Furthermore, in the following, the description will be given on an example where the LEDs 51-1 to 51-n are used in a positioning lamp functioning as a clearance lamp and in a daytime running lamp effecting a marker function as being lit except during the nighttime. The following description is based on an assumption that a low level signal is transmitted as the lighting adjustment signal while the positioning lamp is lit, and a high level signal is transmitted as the lighting adjustment signal while the daytime running lamp is lit.

[0047] It is to be noted that the turn-on voltage of the Zener diode ZD10 is set to be greater than the reference power supply voltage of reference power supply Vcc and to be equal to or smaller than the output voltage of the inverting converter 32 with which the LED driving current IL starts to flow in a normal operation.

[0048] In a normal operation, when a lighting adjustment signal of low level is provided to the base of the NPN transistor 44, the NPN transistor 44 turns off and the PNP transistor 45 turns off. when the PNP transistor 45 turns off, the anode of the Zener diode ZD10 attains high impedance. Therefore, the anode-cathode voltage becomes lower than the turn-on voltage, so that the Zener diode ZD10 turns off and the NMOS transistor 40 turns off. Thus, the LED driving current IL (= R1 · V0/ (Rs+Rs') . R2+V0/(Rs+Rs')) flows. Setting the shunt resistor Rs' to be great, the LED driving current IL is reduced.

[0049] When a ground fault occurs and the lighting adjustment signal of low level is provided to the base of the NPN transistor 44, the operation as described above similarly takes place. The NMOS transistor 40 turns off, and by setting the shunt resistor Rs' as described above, the LED driving current IL is reduced.

[0050] Accordingly, while the positioning lamp which does not require a great LED driving current IL is lit, the LED driving current IL can be reduced by providing the lighting adjustment signal of low level to the base of the NPN transistor 44 and setting the shunt resistor Rs' to be great. Thus, lighting adjustment control can properly be executed over the positioning lamp, and the ground fault current can be suppressed.

[0051] In a normal operation, when a lighting adjustment signal of high level is provided to the base of the NPN transistor 44, the NPN transistor 44 turns on and the PNP transistor 45 turns on. As the PNP transistor 45 turns on, the anode-cathode voltage of the Zener diode ZD10 becomes higher than the turn-on voltage, so that the Zener diode ZD10 turns on and the NMOS transistor 40 turns on. Thus, the LED driving current IL (= R1 · V0/Rs · R2) flows. The LED driving current IL herein is greater than the above-described LED driving current IL associated with the Zener diode ZD10 turning off.

[0052] When a ground fault occurs and the lighting adjustment signal of high level is provided to the base of the NPN transistor 44, the PNP transistor 45 turns on similarly as in the foregoing description. In the case where the PNP transistor 45 turns on also, the anode-cathode voltage of the Zener diode ZD10 becomes lower than the turn-on voltage. Therefore, the Zener diode ZD10 turns off and the LED driving current IL (=R1 · V0/(Rs+Rs') · R2+V0/ (Rs+Rs')) flows. By setting the shunt resistor Rs' to be great, the LED driving current IL is reduced.

[0053] Accordingly, while the daytime running lamp which requires a great LED driving current IL (=R1 · V0/Rs · R2) is lit, by providing the lighting adjustment signal of high level to the base of the NPN transistor 44, lighting adjustment control can properly be executed over the daytime running lamp and the ground fault current can be suppressed without reducing the LED driving current IL.

[0054] The embodiments so far described are merely examples of preferred embodiments of the present invention. The present invention can be practiced in various modifications insofar as they do not depart from the gist of the invention.

[Description of the Reference Numerals]

[0055]

1, 30	CONTROLLER
2, 32	INVERTING CONVERTER (POWER SUPPLY MEANS)
3, 33	CURRENT DETECTION UNIT
4, 34	BYPASS SECTION
5, 35	CURRENT CONTROL UNIT
10, 40	NMOS TRANSISTOR (SWITCH PORTION)
21-1 to 21-N, 51-1 to 51-N	LED

36 CHANGEOVER UNIT

Claims

1. A controller for a vehicular lamp, comprising:

power supply means for supplying power to a semiconductor light source; and
current detection means that includes a first resistor connected serially to the power supply means and detects a light source driving current flowing through the semiconductor light source, **characterized in that**
the current detection means includes a second resistor connected serially to the semiconductor light source via the first resistor, and a bypass section having a switch portion connected parallel to the second resistor and further having a ground fault detection portion for causing the switch portion to turn off when a ground fault occurs at a positive polarity output side or a negative polarity output side of the power supply means, and
the controller for a vehicular lamp further comprises a changeover unit for carrying out changeover of the switch portion between on and off states, thereby executing lighting adjustment control over the semiconductor light source.

2. The controller for a vehicular lamp according to claim 1, **characterized in that**
the ground fault detection portion is a Zener diode that turns off when the ground fault occurs,
the switch portion is a switch element that turns off when the Zener diode turns off, and
the light source driving current flows through the switch element when the switch element turns on, and the light source driving current flows through the second resistor when the switch element turns off.

3. The controller for a vehicular lamp according to claim 1 or 2, **characterized in that**
a turn-on voltage of the Zener diode is set to be greater than an output voltage of the power supply means when the ground fault occurs, and to be equal to or smaller than a forward direction voltage with which a current starts to flow through the semiconductor light source.

FIG. 1

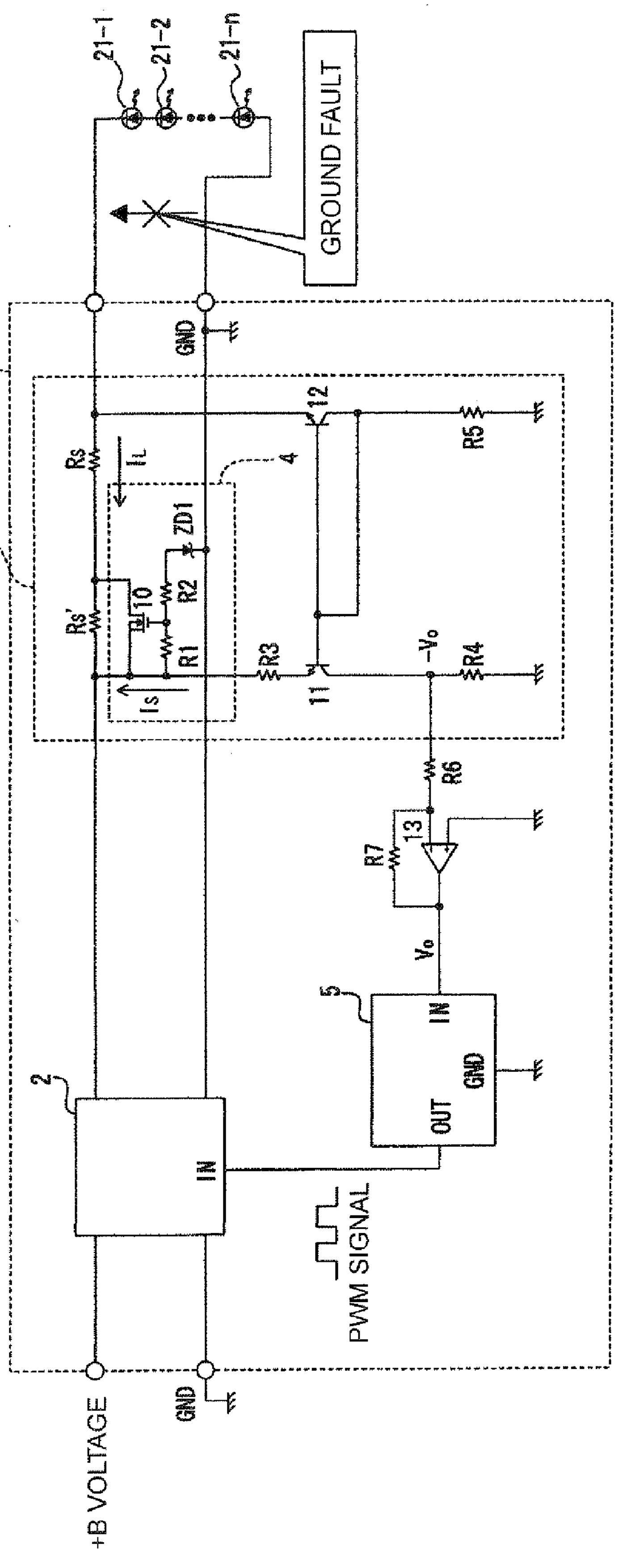

21-1
21-2
21-n
GROUND FAULT
1
GND
3
4
Rs
Rs'
IL
Is
ZD1
10
R1
R2
R3
R4
R5
R6
R7
11
12
13
-Vo
Vo
2
IN
5
IN
GND
OUT
PWM SIGNAL
+B VOLTAGE
GND

FIG. 2

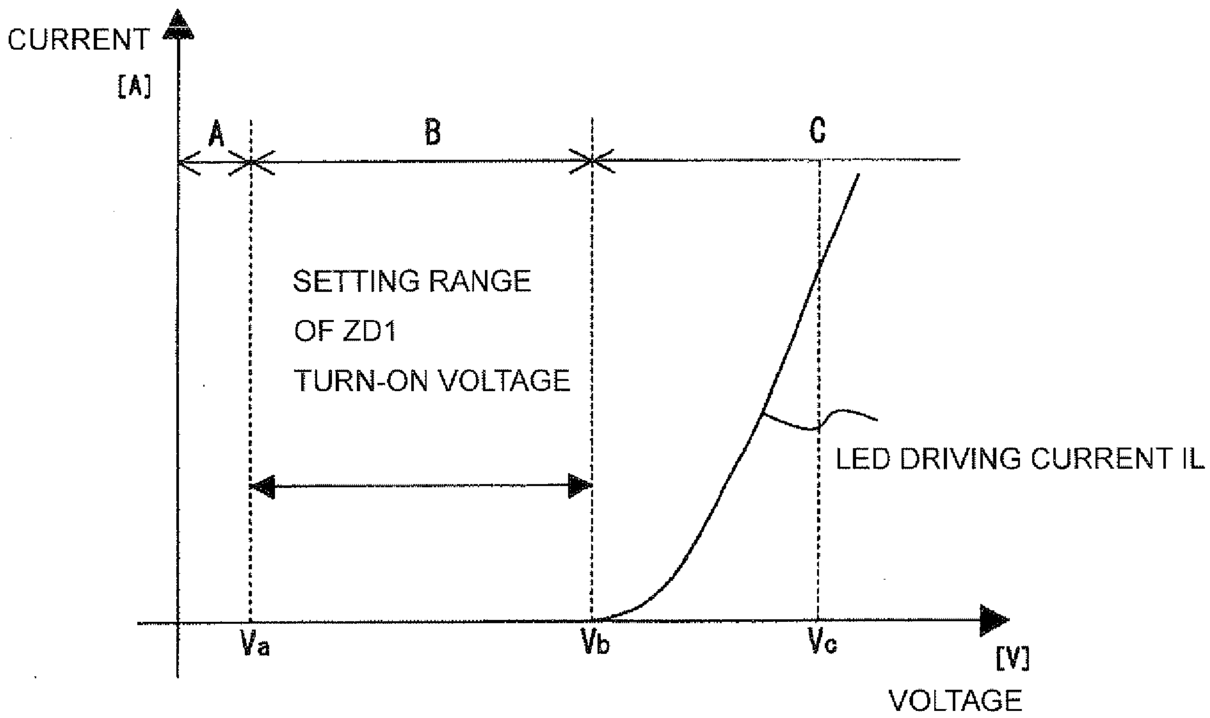
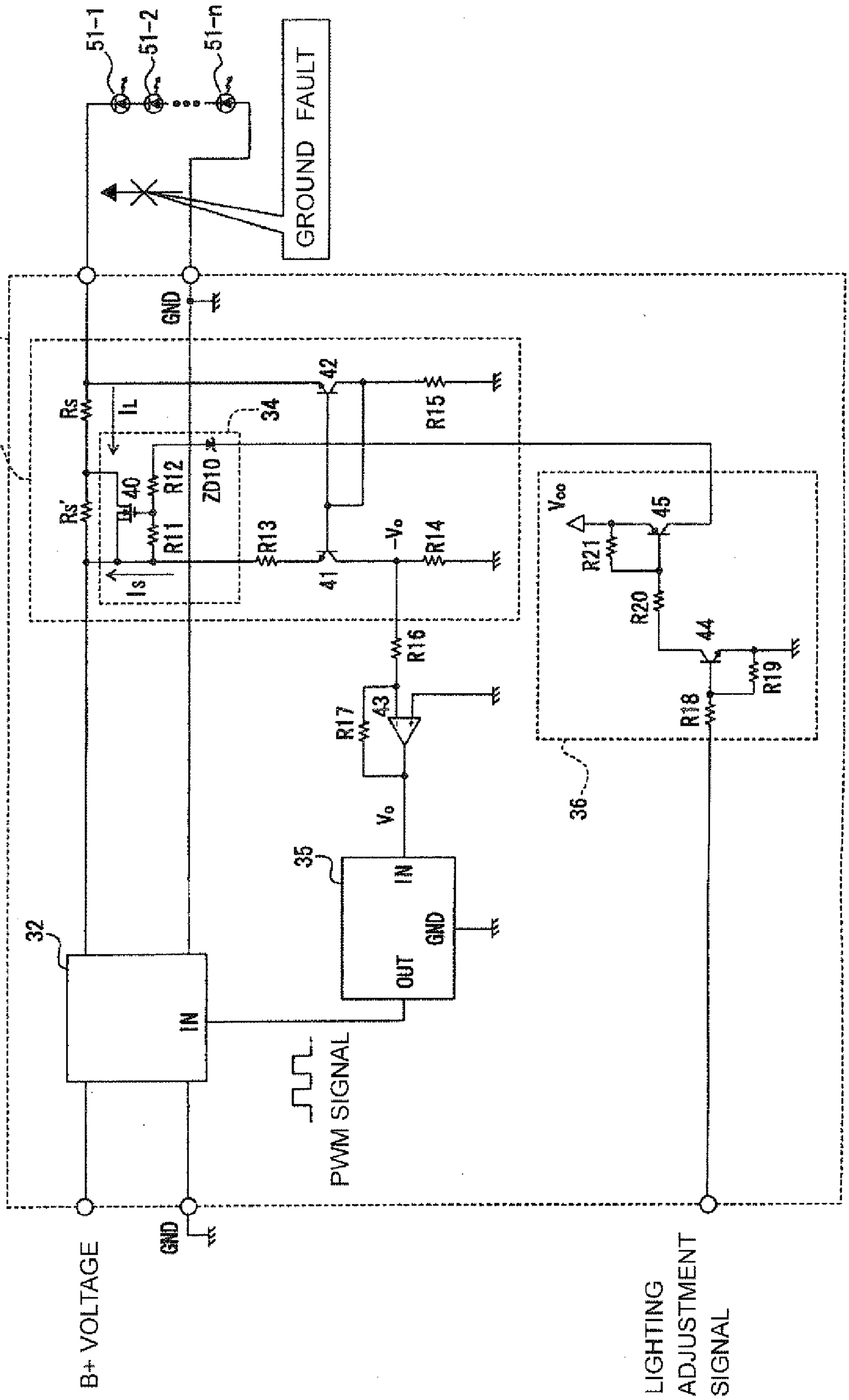

CURRENT
[A]
A
B
C
SETTING RANGE
OF ZD1
TURN-ON VOLTAGE
LED DRIVING CURRENT IL
Va
Vb
Vc
[V]
VOLTAGE

FIG. 3


51-1
51-2
51-n
GROUND FAULT
30
33
34
Rs
IL
Rs'
40
R12
ZD10
R11
R13
Is
42
R15
41
-Vo
R14
Vcc
45
R21
R20
44
R19
R18
36
R16
R17
43
Vo
35
IN
GND
OUT
32
IN
PWM SIGNAL
B+ VOLTAGE
GND
LIGHTING
ADJUSTMENT
SIGNAL

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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