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(54) LED driving apparatus and method of driving LED

(57) There are provided a light emitting device (LED) driving apparatus and a method of driving an LED. The LED driving apparatus includes a voltage detection unit detecting a driving voltage supplied from a driving unit for a light emitting unit having a plurality of light emitting devices; a current detection unit detecting a driving current flowing in the light emitting unit; and a control unit setting a reference current according to detected voltage from the voltage detection unit and controlling the driving unit according to the reference current and the detected current from the current detection unit.

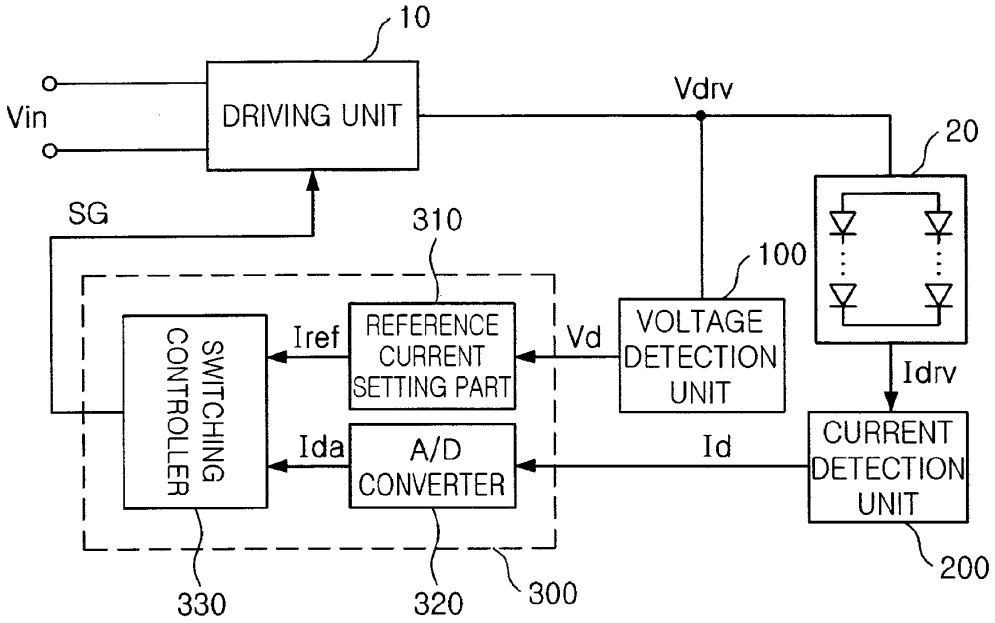

FIG. 1

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority of Korean Patent Application No. 10-2011-0136102 filed on December 16, 2011, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a light emitting device (LED) driving apparatus and a method of driving an LED, capable of being applied to a driving system driven by a PWM scheme and able to appropriately set a reference current according to a driving voltage varied at the time of changing the light emitting device when the reference current according to the driving voltage is previously set.

Description of the Related Art

[0003] Generally, applications for a light emitting diode (LED), a light emitting device, have been expanded, such as uses in a display, a lighting device, and the like.

[0004] An LED module including a plurality of LEDs generally has driving power applied thereto through a DC-DC converter that converts DC power from a power supply device (for example, SMPS) into driving power.

[0005] Meanwhile, in an LED lighting device using the LED module, a driver having voltage or current of the LED module fedback thereto performs a control operation to supply a constant voltage or constant current to the LED module.

[0006] However, the LED driver, according to an analog scheme of the related art, needs to use a separately designed reference circuit at the outside so as to control voltage or current and is set to a predefined reference value to meet LED lighting device output conditions.

[0007] However, in the LED driver of the related art, there may be a need to change a design of the reference circuit when the output conditions of the LED lighting device are different, such that it may be difficult to commonly use products.

[0008] For example, in developing an LED lighting device of 50 W, when there are (1) products having output specifications of a voltage of 50V and current 1A and (2) products having output conditions of a voltage of 25V and current 2A, different reference values are required, according to the specifications of the output current, such that a design of a circuit should be changed.

[0009] As such, types of LED lighting are gradually being increased as the LED lighting market is gradually expanded. Therefore, a need exists for a technology capable of appropriately controlling various types of LED lighting as well as a technology capable of being applied to various kinds of LED lighting devices while diversifying wattage and controlled voltage/current according to the usage of the LED lighting and an LED light source.

SUMMARY OF THE INVENTION

[0010] An aspect of the present invention provides a light emitting device (LED) driving apparatus and a method of driving an LED, capable of being applied to a driving system driven by a PWM scheme and appropriately setting a reference current according to driving voltage varied at the time of changing the light emitting device when the reference current according to the driving voltage is previously set, and being applied to various types of light emitting devices.

[0011] According to an aspect of the present invention, there is provided an LED driving apparatus including: a voltage detection unit detecting a driving voltage supplied from a driving unit for a light emitting unit having a plurality of light emitting devices; a current detection unit detecting a driving current flowing in the light emitting unit; and a control unit setting a reference current according to a detected voltage from the voltage detection unit and controlling the driving unit according to the reference current and the detected current from the current detection unit.

[0012] The control unit may include: a reference current setting part setting a reference current corresponding to a level of the detected voltage from the voltage detection unit; an A/D converter converting the detected current from the current detection unit into a digital detected current; and a switching controller generating a gate signal according to an error between the reference current and the digital detected current and providing the generated gate signal to the driving unit.

[0013] The driving unit may be a DC-DC converter including a switch device operated in response to the gate signal.

[0014] The gate signal may be a PWM gate signal.

[0015] The reference current setting part may include: an A/D converter converting the detected voltage from the voltage detection unit into the digital detected voltage; and a V/I converter converting the digital detected voltage from the A/D converter into a corresponding current and providing the current as the reference current.

[0016] The reference current setting part may include: an A/D converter converting the detected voltage from the voltage detection unit into the digital detected voltage; a memory storing a V/I lookup table in which a current level corresponding to each voltage level is preset; and a V/I converter retrieving the current corresponding to the level of the digital detected voltage from the A/D converter from the memory to set the retrieved current as the reference current.

[0017] According to another aspect of the present invention, there is provided a method of driving a light emitting device, including: detecting a detected voltage corresponding to a driving voltage provided from a driving

unit for a light emitting unit having a plurality of light emitting devices; detecting a detected current corresponding to a driving current flowing in the light emitting unit; and setting a reference current according to the detected voltage and controlling the driving unit according to the reference current and the detected current.

[0018] The controlling of the driving unit may include: setting the reference current corresponding to a level of the detected voltage; converting the detected current into a digital detected current; and generating a gate signal according to an error between the reference current and the digital detected current and providing the generated gate signal to the driving unit.

[0019] The driving unit may be a DC-DC converter including a switch device operated in response to a PWM gate signal.

[0020] The gate signal may be the PWM gate signal.

[0021] The setting of the reference current may include: converting the detected voltage from the voltage detection unit into the digital detected voltage; and converting the digital detected voltage into a corresponding current and providing the converted current as the reference current.

[0022] The setting of the reference current may include: converting the detected voltage into the digital detected voltage; and converting the digital detected voltage into a corresponding current and setting the converted current as reference current, by using a previously provided V/I lookup table.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The above and other aspects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram of an LED driving apparatus according to an embodiment of the present invention;

FIG. 2 is a diagram showing a variation example of a reference current setting part according to an embodiment of the present invention;

FIG. 3 is a diagram showing another variation example of the reference current setting part according to the embodiment of the present invention;

FIG. 4 is a diagram showing a variation example of a V/I lookup table of a memory according to the embodiment of the present invention;

FIG. 5 is a flow chart of a method of driving a light emitting device according to another embodiment of the present invention;

FIG. 6 is a flow chart of a light emission drive controlling process according to another embodiment of the present invention;

FIG. 7 is a diagram showing a variation example of a reference current setting process according to another embodiment of the present invention; and

FIG. 8 is a diagram showing another variation example of a reference current setting process according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0024] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

[0025] The present invention should not be limited to the embodiments set forth herein and the embodiments may be used to assist in understanding the technical idea of the present invention. Like reference numerals designate like components having substantially the same constitution and function in the drawings of the present invention.

[0026] FIG. 1 is a block diagram of an LED driving apparatus according to an embodiment of the present invention.

[0027] Referring to FIG. 1, an LED driving apparatus according to an embodiment of the present invention may include a voltage detection unit 100 detecting a driving voltage Vdrv supplied from a driving unit 10 for a light emitting unit 20 having a plurality of light emitting devices, a current detection unit 200 detecting a driving current Idrv flowing in the light emitting unit 20, and a control unit 300 setting a reference current Iref according to detected voltage Vd from the voltage detection unit 100 and controlling the driving unit 10 according to the reference current Iref and the detected current Id from the current detection unit 200.

[0028] In this configuration, the driving unit 10 may convert an input voltage Vin into a predetermined voltage to provide the driving voltage Vdrv to the light emitting unit 20. In this case, the light emitting unit 20 may include at least one of channels in which the plurality of light emitting devices are connected with one another in series. Here, the light emitting device may be an LED.

[0029] In this case, the voltage detection unit 100 may detect the driving voltage Vdrv supplied from the driving unit 10 of the light emitting unit 20 having the plurality of light emitting devices and provide the detected driving voltage Vdrv to the control unit 300.

[0030] The current detection unit 200 may detect the driving current Idrv flowing in the light emitting unit 20 and provide the detected driving current Idrv to the control unit 300.

[0031] Further, the control unit 300 may set the reference current Iref according to the detected voltage Vd from the voltage detection unit 100 and may control the driving unit 10 according to the reference current Iref and the detected current Id from the current detection unit 200.

[0032] As one example, the control unit 300 may include a reference current setting part 310 setting the reference current Iref corresponding to a level of the detected voltage Vd from the voltage detection unit 100, an A/D

converter 320 converting the detected current Id from the current detection unit 200 into a digital detected current Ida, and a switching controller 330 generating a gate signal SG according to an error between the reference current Iref and the digital detected current Ida and providing the generated gate signal SG to the driving unit 10.

[0033] In this case, the reference current setting part 310 may set the reference current Iref corresponding to the level of the detected voltage Vd from the voltage detection unit 100.

[0034] The A/D converter 320 may convert the detected current Id from the current detection unit 200 into the digital detected current Ida.

[0035] Further, the switching controller 330 may generate a gate signal SG according to the error between the reference current Iref and the digital detected current Ida and provide the generated gate signal SG to the driving unit 10, thereby controlling the driving unit 10.

[0036] Meanwhile, the driving unit 10 may include a DC-DC converter including a switch device operated in response to the gate signal SG. In this case, the gate signal SG may be a PWM gate signal that undergoes pulse width modulation.

[0037] That is, the DC-DC converter may convert the input voltage Vin into a predetermined voltage according to the PWM gate signal from the control unit 300.

[0038] FIG. 2 is a diagram showing a variation example of a reference current setting part according to an embodiment of the present invention.

[0039] Referring to FIGS. 1 and 2, the reference current setting part 310 may include an A/D converter 311 converting the detected voltage Vd from the voltage detection unit 100 into the digital detected voltage Vda, and an V/I converter 313 converting the digital detected voltage Vda from the A/D converter 311 into a corresponding current and providing the converted current as the reference current Iref.

[0040] In this case, the A/D converter 311 may convert the detected voltage Vd from the voltage detection unit 100 into the digital detected voltage Vda and provide the converted detected voltage Vda to the V/I converter 313.

[0041] Further, the V/I converter 313 may convert the digital detected voltage Vda from the A/D converter 311 into a current corresponding to the level thereof and provide the converted current as the reference current Iref.

[0042] FIG. 3 is a diagram showing another variation example of the reference current setting part according to the embodiment of the present invention.

[0043] Referring to FIGS. 1 and 3, the reference current setting part 310 may include the A/D converter 311 converting the detected voltage Vd from the voltage detection unit 100 into the digital detected voltage Vda, a memory 312 storing a V/I lookup table of which a current level corresponding to each voltage level is preset, and a V/I converter 313 setting the digital detected voltage Vda from the A/D converter 311 as the reference current by retrieving the current corresponding to the level from the memory 312.

[0044] In this case, the A/D converter 311 may convert the detected voltage Vd from the voltage detection unit 100 into the digital detected voltage Vda and provide the converted detected voltage Vda to the V/I converter 313.

[0045] The memory 312 may store the V/I lookup table in which the current level corresponding to each voltage level is preset, thereby providing the current level corresponding to the voltage level.

[0046] Further, the V/I converter 313 may convert the digital detected voltage Vda from the A/D converter 311 as the reference current Iref by retrieving the current corresponding to the level from the memory 312.

[0047] FIG. 4 is a diagram showing a variation example of a V/I lookup table of a memory according to the embodiment of the present invention.

[0048] Referring to FIG. 4, the V/I lookup table stored in the memory 312 may include reference currents Vref stored therein which are respectively and differently preset according to the level of the digital detected voltage Vda.

[0049] For example, in a case in which desired required output is 25 W, when the digital detected voltage Vda is 25V, the reference current Vref may be set to be 1A, when the digital detected voltage is 50V, the reference current Vref may be set to be 500 mA, and when the digital detected voltage Vda is 100V, the reference current Vref may be set to be 250 mA.

[0050] FIG. 5 is a flow chart of a method of driving a light emitting device according to another embodiment of the present invention.

[0051] Referring to FIGS. 1 and 5, the method of driving a light emitting device according to another embodiment of the present invention may include detecting a detected voltage Vd corresponding to a driving voltage Vdrv supplied from the driving unit 10 for the light emitting unit 20 having a plurality of light emitting devices (S100), detecting a detected current Id corresponding to the driving current Idrv flowing in the light emitting unit 20 (S200), and setting a reference current Iref according to the detected voltage Vd and controlling the driving unit 10 according to the reference current Iref and the detected current Id (S300).

[0052] In this case, the detected voltage Vd corresponding to the driving voltage Vdrv supplied from the driving unit 10 of the light emitting unit 20 having the plurality of light emitting devices may be detected by the voltage detection unit 100 shown in FIG. 1 (S100).

[0053] In addition, the detected current Id corresponding to the driving current Idrv flowing in the light emitting unit 20 may be detected by the current detection unit 200 shown in FIG. 1 (S200).

[0054] Further, by the control unit 300 shown in FIG.1, the reference current Iref may be set according to the detected voltage Vd and the driving unit 10 may be controlled according to the reference current Iref and the detected current Id (S300).

[0055] Meanwhile, when the entire processing procedures have an end thereof during performing the process

described above, the process may end, or otherwise, the above-mentioned process may be repeatedly performed (S400).

[0056] FIG. 6 is a flow chart of a light emission drive controlling process according to another embodiment of the present invention.

[0057] Referring to FIGS. 1 and 6, the controlling of the driving unit 10 (S300) may include setting the reference current Iref corresponding to the level of the detected voltage Vd (S310), converting the detected current Id into the digital detected current Ida (S320), and generating a gate signal SG according to the errors between the reference current Iref and the digital detected current Ida and providing the generated gate signal SG to the driving unit 10 (S330).

[0058] In this case, the reference current Iref corresponding to the level of the detected voltage Vd may be set by the control unit 300 shown in FIG. 1 (S310). The detected current Id may be converted into the digital detected current Ida (S320).

[0059] Further, the gate signal SG according to the error between the reference current Iref and the digital detected current Ida may be generated and may be provided to the driving unit 10 (S330).

[0060] Meanwhile, as described above, the driving unit 10 may include a DC-DC converter including a switch device operated in response to the gate signal SG. In this case, the gate signal SG may be the PWM gate signal.

[0061] That is, the DC-DC converter may convert the input voltage Vin into the predetermined voltage according to the PWM gate signal from the control unit 300.

[0062] FIG. 7 is a diagram showing a variation example of a reference current setting process according to another embodiment of the present invention.

[0063] Referring to FIGS. 1 and 7, the setting of the reference current (S310) may include converting the detected voltage Vd from the voltage detection unit 100 into the digital detected voltage Vda and converting the digital detected voltage Vda into the corresponding current and providing the current as the reference current Iref (S312).

[0064] In this case, the detected voltage Vd from the voltage detection unit 100 may be converted into the digital detected voltage Vda by the control unit 300 shown in FIG. 1 (S311). Further, the digital detected voltage Vda may be converted into a corresponding current, which may be in turn provided as the reference current Iref (S312).

[0065] FIG. 8 is a diagram showing another variation example of a reference current setting process according to another embodiment of the present invention.

[0066] Referring to FIGS. 1 and 8, the setting of the reference current (S310) may include converting the detected voltage Vd into the digital detected voltage Vda (S311) and converting the digital detected voltage Vda into a corresponding current and setting the converted current as the reference current by using a previously provided V/I lookup table (S313).

[0067] In this case, the detected voltage Vd may be converted into the digital detected voltage Vda by the control unit 300 shown in FIG. 1 (S311). Further, the digital detected voltage Vda may be converted into a corresponding current, and then may be set as the reference current, by using the previously provided V/I lookup table (S313).

[0068] As set forth above, the embodiments of the present invention may be applied to the driving system driven by the PWM scheme, may appropriately set the reference current according to the driving voltage varied at the time of changing the light emitting device when the reference current according to the driving voltage is previously set, and may be applied to various types of light emitting devices.

[0069] Further, according to the embodiments of the present invention, the circuits may be simplified by embedding the external circuits in the microcontroller and may be applied to several models without modifying the circuits by allowing the microcontroller to internally vary the reference current and to store several time constant values in the memory and to selectively use the time constant values, or the like.

[0070] While the present invention has been shown and described in connection with the embodiments, it will be apparent to those skilled in the art that modifications and variations may be made without departing from the spirit and scope of the invention as defined by the appended claims.

Claims

1. A light emitting device (LED) driving apparatus, comprising:

   a voltage detection unit detecting a driving voltage supplied from a driving unit for a light emitting unit having a plurality of light emitting devices;
   a current detection unit detecting a driving current flowing in the light emitting unit; and
   a control unit setting a reference current according to detected voltage from the voltage detection unit and controlling the driving unit according to the reference current and the detected current from the current detection unit.

2. The apparatus of claim 1, wherein the control unit includes:

   a reference current setting part setting a reference current corresponding to a level of the detected voltage from the voltage detection unit;
   an A/D converter converting the detected current from the current detection unit into a digital detected current; and
   a switching controller generating a gate signal

according to an error between the reference current and the digital detected current and providing the generated gate signal to the driving unit.

3. The apparatus of claim 2, wherein the driving unit is a DC-DC converter including a switch device operated in response to the gate signal.

4. The apparatus of claim 3, wherein the gate signal is a PWM gate signal.

5. The apparatus of claim 2, wherein the reference current setting part includes:

an A/D converter converting the detected voltage from the voltage detection unit into the digital detected voltage; and
a V/I converter converting the digital detected voltage from the A/D converter into a corresponding current and providing the current as the reference current.

6. The apparatus of claim 2, wherein the reference current setting part includes:

an A/D converter converting the detected voltage from the voltage detection unit into the digital detected voltage;
a memory storing a V/I lookup table in which a current level corresponding to each voltage level is preset; and
a V/I converter retrieving the current corresponding to the level of the digital detected voltage from the A/D converter, from the memory, to set the retrieved current as the reference current.

7. A method of driving a light emitting device, comprising:

detecting a detected voltage corresponding to a driving voltage provided from a driving unit for a light emitting unit having a plurality of light emitting devices;
detecting a detected current corresponding to a driving current flowing in the light emitting unit; and
setting a reference current according to the detected voltage and controlling the driving unit according to the reference current and the detected current.

8. The method of claim 7, wherein the controlling of the driving unit includes:

setting the reference current corresponding to a level of the detected voltage;
converting the detected current into a digital detected current; and
generating a gate signal according to an error between the reference current and the digital detected current and providing the generated gate signal to the driving unit.

9. The method of claim 8, wherein the driving unit is a DC-DC converter including a switch device operated in response to a PWM gate signal.

10. The method of claim 9, wherein the gate signal is the PWM gate signal.

11. The method of claim 8, wherein the setting of the reference current includes:

converting the detected voltage from the voltage detection unit into the digital detected voltage; and
converting the digital detected voltage into a corresponding current and providing the converted current as the reference current.

12. The method of claim 8, wherein the setting of the reference current includes:

converting the detected voltage into the digital detected voltage; and
converting the digital detected voltage into a corresponding current and setting the converted current as the reference current, by using a previously provided V/I lookup table.

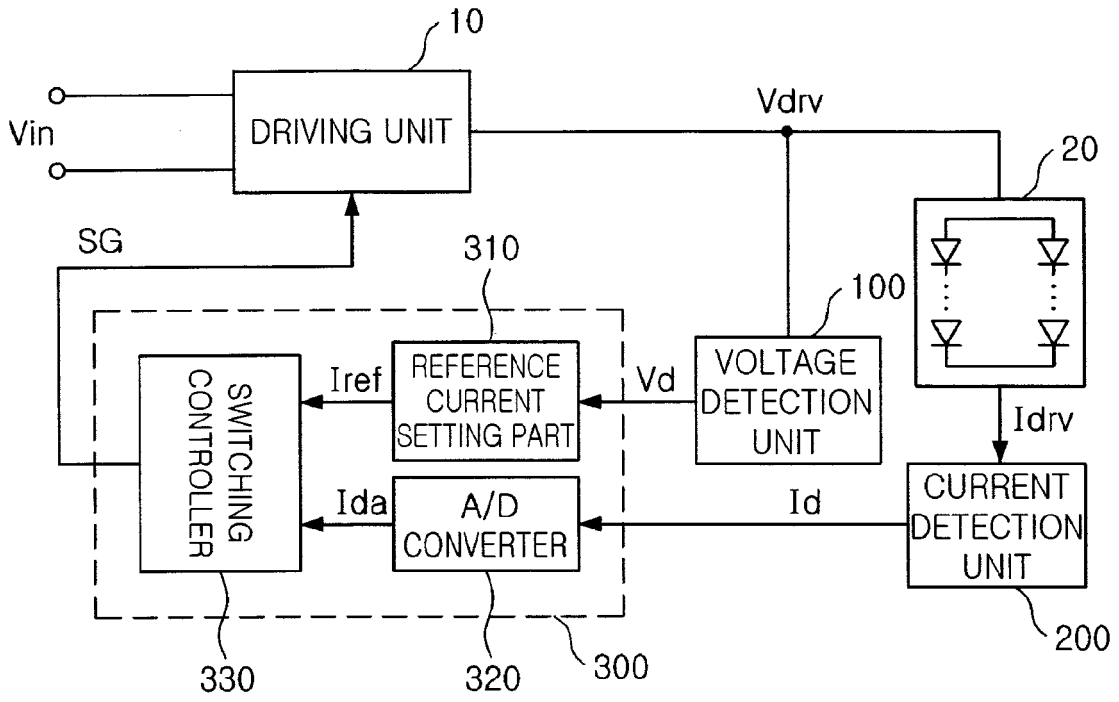
10
Vin
DRIVING UNIT
Vdrv
20
SG
310
100
SWITCHING CONTROLLER
Iref
REFERENCE CURRENT SETTING PART
Vd
VOLTAGE DETECTION UNIT
Idrv
Ida
A/D CONVERTER
Id
CURRENT DETECTION UNIT
330
320
300
200

FIG. 1

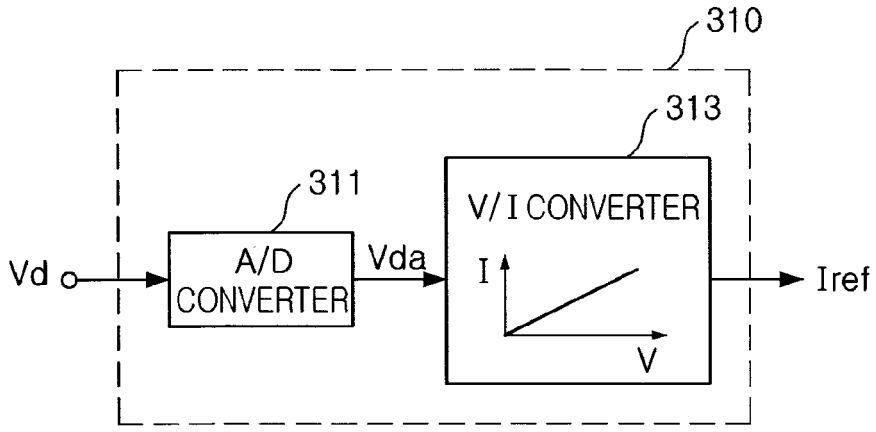
310
313
311
V/I CONVERTER
Vd
A/D CONVERTER
Vda
I
V
Iref

FIG. 2

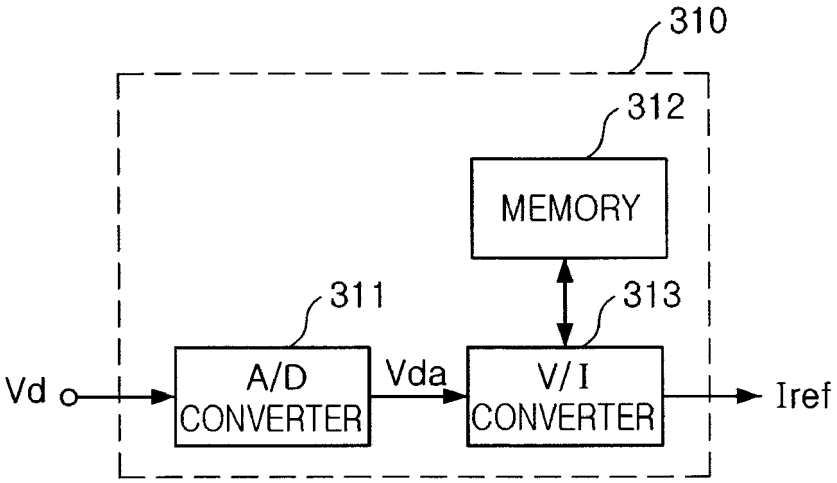

FIG. 3

OUTPUT	25W		
Vda	1(25V)	2(50V)	3(100V)
Iref	1(1A)	2(500mA)	3(250mA)

FIG. 4

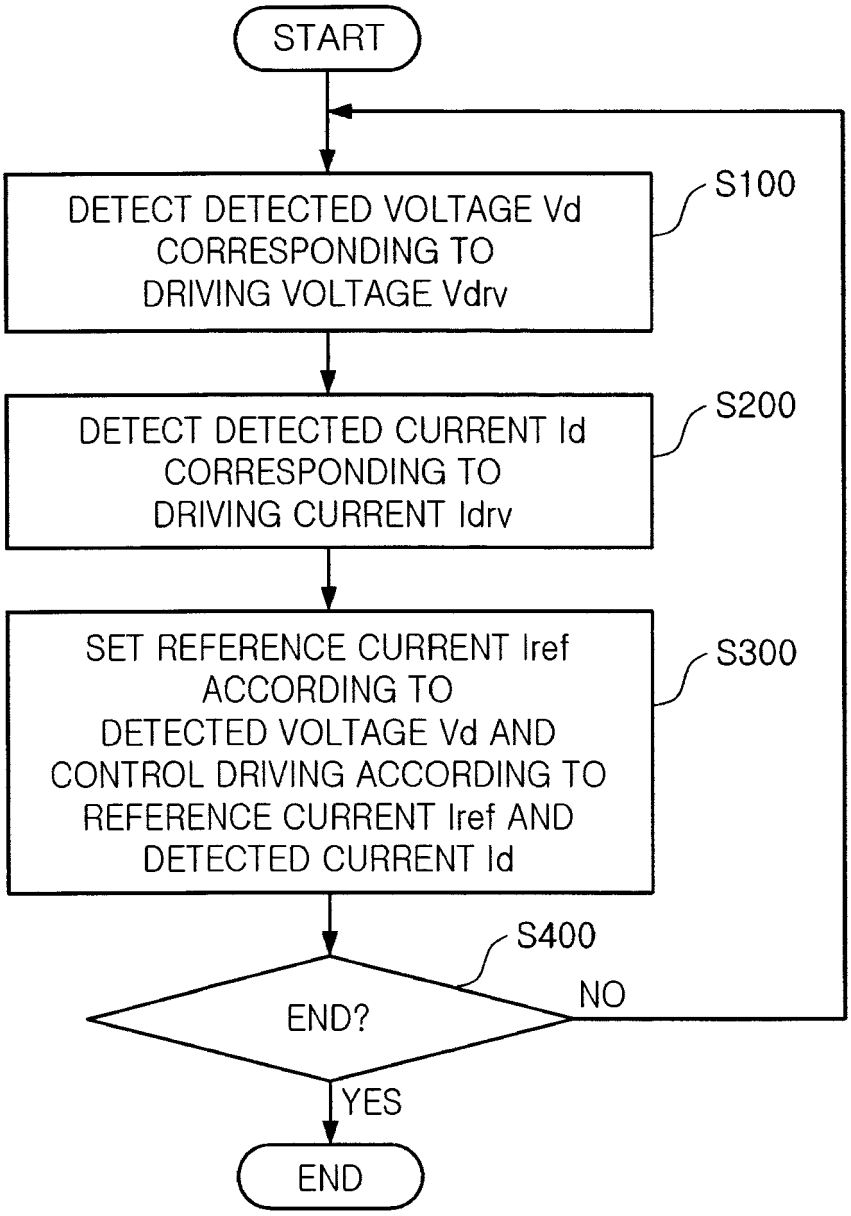
START
DETECT DETECTED VOLTAGE Vd CORRESPONDING TO DRIVING VOLTAGE Vdrv
S100
DETECT DETECTED CURRENT Id CORRESPONDING TO DRIVING CURRENT Idrv
S200
SET REFERENCE CURRENT Iref ACCORDING TO DETECTED VOLTAGE Vd AND CONTROL DRIVING ACCORDING TO REFERENCE CURRENT Iref AND DETECTED CURRENT Id
S300
S400
END?
NO
YES
END

FIG. 5

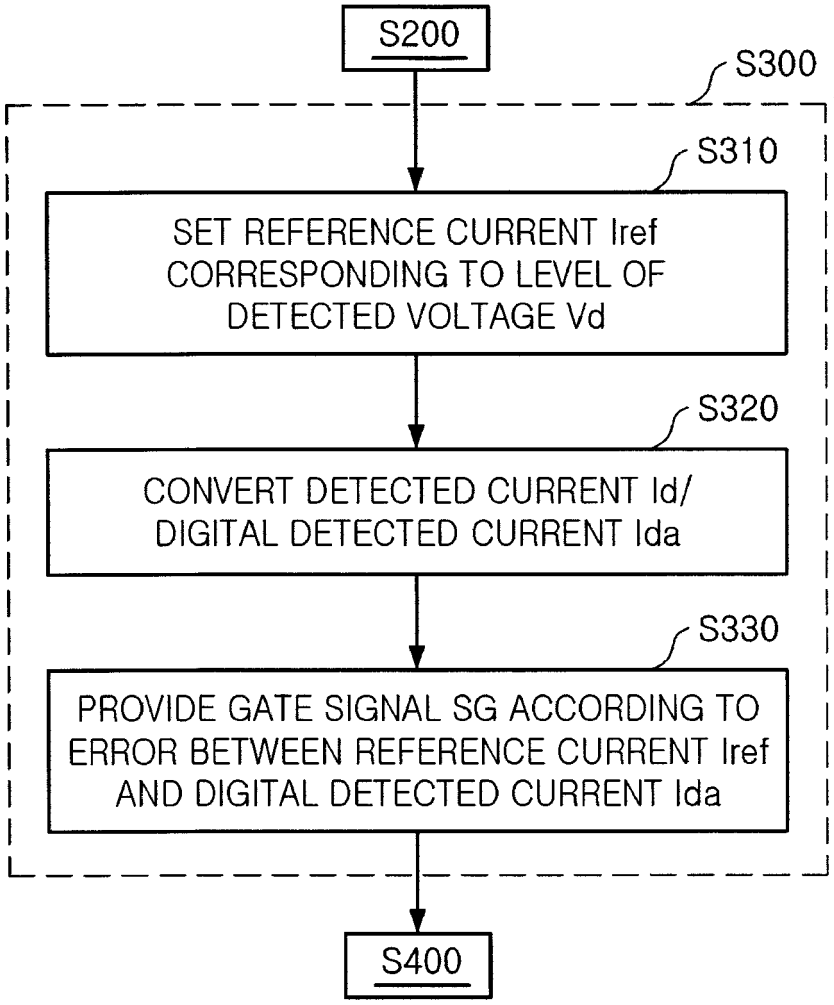
S200
S300
S310
SET REFERENCE CURRENT Iref CORRESPONDING TO LEVEL OF DETECTED VOLTAGE Vd
S320
CONVERT DETECTED CURRENT Id/ DIGITAL DETECTED CURRENT Ida
S330
PROVIDE GATE SIGNAL SG ACCORDING TO ERROR BETWEEN REFERENCE CURRENT Iref AND DIGITAL DETECTED CURRENT Ida
S400

FIG. 6

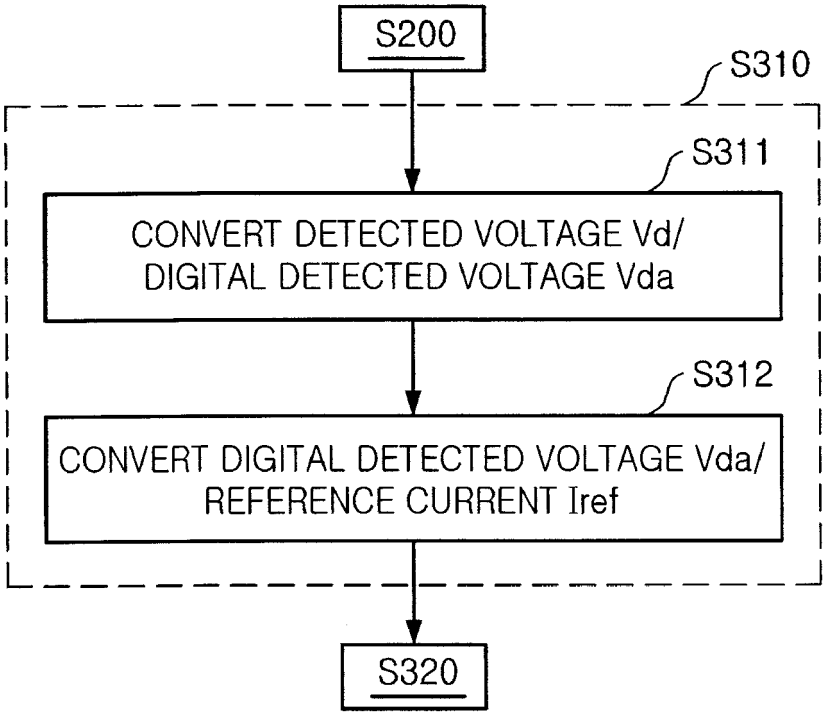
S200
S310
S311
CONVERT DETECTED VOLTAGE Vd/
DIGITAL DETECTED VOLTAGE Vda
S312
CONVERT DIGITAL DETECTED VOLTAGE Vda/
REFERENCE CURRENT Iref
S320

FIG. 7

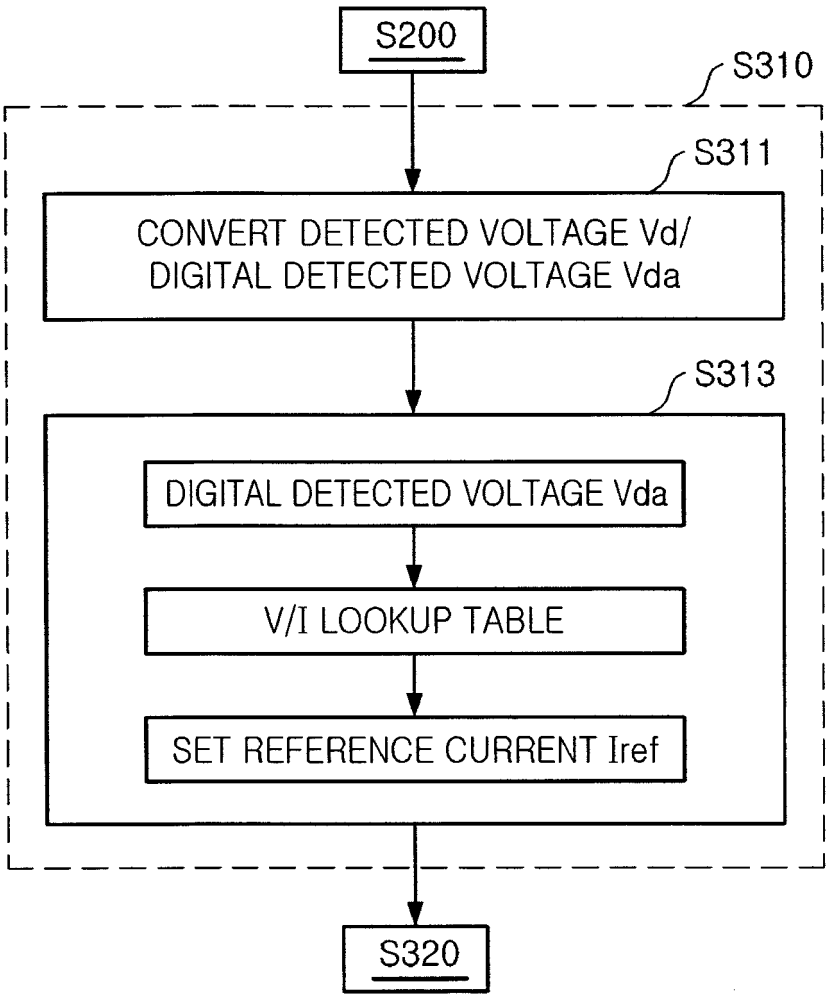
S200
S310
S311
CONVERT DETECTED VOLTAGE Vd/
DIGITAL DETECTED VOLTAGE Vda
S313
DIGITAL DETECTED VOLTAGE Vda
V/I LOOKUP TABLE
SET REFERENCE CURRENT Iref
S320

FIG. 8

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 12 27 5020

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 204 856 A1 (PANASONIC ELEC WORKS CO LTD [JP]) 7 July 2010 (2010-07-07) * paragraph [0021] - paragraph [0025]; figure 3 *	1-12	INV. H05B33/08
X	WO 2010/118944 A1 (TRIDONIC GMBH & CO KG [AT]; TRIDONIC AG [CH]; PEREIRA EDUARDO [CH]; ZI) 21 October 2010 (2010-10-21) * page 17, line 9 - page 18, line 20; figure 4 *	1-12	
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A	D. MAKSIMOVIC, R. ZANE, R.ERICKSON: "Impact of digital control in power electronics", PROCEEDINGS OF 2004 INTERNATIONAL SYMPOSIUM ON POWER SEMICONDUCTOR DEVICES & ICS, 31 December 2004 (2004-12-31), pages 13-22, XP002694419, Boulder,Co,USA * the whole document *	2,5,6,8, 11,12	TECHNICAL FIELDS SEARCHED (IPC) H05B
A	PRODIC A ET AL: "Design of a digital PID regulator based on look-up tables for control of high-frequency DC-DC converters", IEEE WORKSHOP ON COMPUTERS IN POWER ELECTRONICS, XX, XX, 3 June 2002 (2002-06-03), pages 18-22, XP002444875, * the whole document *	6,12	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	25 March 2013	Benedetti, Gabriele

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 27 5020

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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25-03-2013

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