(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 April 2010 (15.04.2010)

PCT

(10) International Publication Number
WO 2010/041265 A2

(51) International Patent Classification:
H05B 33/08 (2006.01)

(21) International Application Number:
PCT/IN2009/000363

(22) International Filing Date:
25 June 2009 (25.06.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1339/MUM/2008 26 June 2008 (26.06.2008) IN

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: LED DRIVER AND LIGHTING SYSTEM USING THE SAME

(57) Abstract: An apparatus for driving at least one light-emitting diode (LED), comprising: a current switching unit enabled to switch an input current signal through current pulse width modulation, control peaks of the switched current signal and adjust duty cycle of the switched current signal to provide an intermediate current signal and amplify the intermediate current signal as per requirements of the at least one LED to provide an output current signal.

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LED DRIVER AND LIGHTING SYSTEM USING THE SAME

TECHNICAL FIELD OF INVENTION

The present invention relates to an LED driver and to lighting systems comprising the LED driver.

BACKGROUND AND PRIOR ART

Light emitting diode (LED) is a semiconductor diode. On application of electrical signal, LED converts electrical energy in to light energy and emits light. As a source of light, LED has applications in outdoor lighting, pilot lights (in circuits), backlights, tube lights, torches, toys, indicators, sensors and control apparatus, lanterns, tunnel and mine lights, decorative and landscaping lights, pathways and runway lights, light house lights etc. In electronic system, a LED driver is used to supply desired current and voltage to LED or an array of multiple LEDs.

In general, brightness of the LED increases with a current supplied to the LED, but increase in the supplied current increases temperature of the p-n junction and lowers the performance of the LED. Therefore, the LED driver is used to achieve optimum performance of the LED.

The patent application WO2007021935 discloses an LED driver which includes a switch current regulator connected to a current control signal input. The switch current regulator controls a current provided to an LED based upon the magnitude of a voltage on the current control signal input. The current supply is regulated by regulating the amount of voltage. Therefore, the current supplied to LED is constant and consumes more energy and gives varying shades of output light.

Patent application US20060170373 discloses an LED driver, including a current adjusting unit to adjust magnitude of a current flowing on the LED by supplying power from a power supply device to the LED and cutting off the power.

Patent application US20050088209 relates to a switching device for driving an LED array. The switching device drives the LED array by means of pulse shaped current. The value of the pulse shaped current is regulated by at least one of frequency modulation, pulse width modulation and amplitude modulation. The regulation of current is achieved through voltage regulation.

The LED drivers known in the art use techniques of pulse width modulated (PWM) voltage control to provide a constant current to drive LEDs. These drivers provide the constant current for driving the LEDs in an inefficient manner and thus consume large amount of power and have higher heat dissipation. The lumen output of the LED is low. Therefore, the known LED drivers increase the size and cost of the LED lighting system.

Hence there is a need for an LED driver which overcomes the drawbacks of the LED drivers of the prior art as well as the conventional LED drivers and improve the performance of the LED without increasing the power consumption and temperature.

SUMMARY

The present invention in an embodiment, is directed towards an apparatus for driving at least one light-emitting diode (LED). The apparatus for driving the at least one LED comprises a current switching unit enabled to switch an input current signal through current pulse width modulation, control peaks of the switched current signal and adjust duty cycle of the switched current signal to provide an intermediate current signal and amplify the intermediate current signal as per requirements of the at least one LED to provide an output current signal.

In another embodiment, the present invention is directed towards a lighting system comprising at least one light emitting diode (LED) and the apparatus for driving the at least one LED.

In a further embodiment, the present invention is directed towards a method for driving at least one light-emitting diode (LED). The method comprises receiving an input current signal, switching the input current signal through current pulse width modulation to obtain a switched current signal, controlling peaks of the switched current signal to obtain a switched current signal with controlled current peaks as per requirements of the at least one LED, adjusting duty cycle of the switched current signal with controlled current peaks signal to obtain an intermediate current signal as per requirements of the at least one LED and the controlled peaks of the switched current signal, amplifying the intermediate current signal to obtain an output current signal; and, providing the output current signal to the at least one LED.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the invention, reference is now be made to the embodiment illustrated in greater detail in the accompanying drawings and described below by way of an example of the invention.

FIG. 1 illustrates a schematic diagram of an LED driver for driving at least one LED, in accordance with an embodiment of the present invention.

FIG. 2 illustrates a schematic diagram for a lighting system, in accordance with an embodiment of the present invention.

FIG. 3 illustrates a schematic diagram for a method of driving at least one LED, in accordance with an embodiment of the present invention.

It is to be understood that the drawing is not to scale and is schematic in nature. In certain instances details, which are not necessary for an understanding of the present invention or which renders other details difficult to perceive may be omitted. It is to be understood, of course, that the invention is not necessarily limited to the particular embodiments illustrated herein.

DETAILED DESCRIPTION

In describing the embodiment of the invention which is illustrated in the drawings, specific terminology is resorted to for the sake of clarity. However, it is not intended that the invention be limited to the specific terms so selected and it is to be understood that each specific term includes all technical equivalents that operate in a similar manner to accomplish a similar purpose.

The present invention relates to a Light Emitting Diode (LED) driver apparatus and a lighting system comprising the LED driver. The LED driver is be used to drive a single LED or an array of multiple LEDs in a range of milliWatts to 100 Watts or more.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the

components set forth in the following description or illustrated in the drawings. The invention is applicable to other embodiments or of being practiced or carried out in various ways.

FIG. 1 depicts an LED driver (100) for driving at least one LED, in accordance with one embodiment of the present invention. The LED driver comprises a current switching unit (110) enabled to switch an input current signal through current pulse width modulation, control peaks of the switched current signal and adjust a duty cycle of the switched current signal to provide an intermediate current signal and amplify the intermediate current signal as per the requirements of the LED to provide an output current signal.

In an embodiment, the current switching unit 110 includes a first integrated circuit 112, and a second integrated circuit 114.

The second integrated circuit 114 receives an input current signal through the first integrated circuit 112. The first integrated circuit 112 triggers the second integrated circuit after receiving an external signal in the form of a relay or a switch. The first integrated circuit 112 receives an output voltage supply from the voltage converter unit 130 or directly from a power source.

In an embodiment, the current switching unit includes a first inductor 116, in communication with the second integrated circuit 114. The first inductor 116 provides oscillations for current pulse width modulation of the input current signal. The first inductor 116 is a coil or a solenoid.

In another embodiment, the current switching unit includes a first variable resistor 118 in communication with the second integrated circuit 114. The pulse width modulated switched current signal is regulated through the first variable resistor 118. The first variable resistor 118 controls peaks of the pulse width modulated switched current signal depending on requirements of the at least one LED. Thus, the first variable resistor 118 is configured accordingly. In one embodiment, for example, the current peaks are adjusted to 2 - 10 times of the rated current required by the at least one LED, using the first variable resistor 118. The first variable resistor 118 is controlled externally and in one embodiment the value of the first variable resistor 118 is programmed. In another embodiment, the first variable resistor 118 is a potentiometer, rheostat or a preset.

In another embodiment, the current switching unit 110 includes a second variable resistor 120 in communication with the second integrated circuit 114. The second variable resistor 120 regulates a duty cycle of the pulse width modulated switched current signal with controlled current peaks to provide an intermediate current signal. The regulation of duty cycle is based on requirements of the at least one LED and configuration of the first variable resistor 118. Thus, the second variable resistor 120 is configured accordingly. The second variable resistor 120 is controlled externally and in one embodiment the value of the second variable resistor 120 is programmed. In another embodiment the second variable resistor is a potentiometer, rheostat or a preset.

The current switching unit also includes a transistor 122, in communication with the second integrated circuit 114. The transistor 122 receives the intermediate current signal from the second integrated circuit 114 and amplifies the intermediate current signal to give an output current signal. This output current signal is an amplified pulse width modulated switched current signal with controlled current peaks and adjusted duty cycle. The output signal is provided to the at least one LED. The at least one LED provides high lumen output and reduces power consumption because of high current peaks and adjusted duty cycle respectively. Further, lower power consumption leads to negligible heat dissipation.

A feedback resistor 124 senses the output current signal provided to the at least one LED and provides the measured signal information to the second integrated circuit 114. The output of the second integrated circuit 114 is thus regulated.

The LED driver apparatus 100 optionally includes a voltage converter unit 130. The voltage converter unit 130 is enabled to provide an output voltage supply based on the requirements of the current switching unit. The voltage converter unit 130 further includes a third integrated circuit 132, a second inductor 134, a second feedback resistor 136, and a third variable resistor 138.

The third integrated circuit 132 receives an input voltage supply from a power supply and provides an output current signal.

The second inductor 134 provides oscillations for pulse width modulation of the input current signal. The second inductor 134 is a coil or a solenoid.

The third variable resistor 138 regulates upper limit of the output current signal based on requirements of the current switching unit 110. Thus, the third variable resistor 138 is configured accordingly.

The second feedback resistor 136 measures the output voltage supply and provides the measured information to the third integrated circuit 132. Thus, the output voltage supply from the third integrated circuit 132 is regulated.

The voltage converter unit 130 optionally comprises a transformer to boost the voltage of the output voltage supply. The voltage converter unit 130 is an optional component. The voltage converter unit is alternately called SMPS.

In a further embodiment, the present invention is directed towards a lighting system comprising an LED or an array of multiple LEDs and an LED driver. The system optionally comprises at least one power source. The system also optionally comprises a heat dissipation apparatus.

FIG. 2 depicts a lighting system 200 in accordance with an embodiment of the present invention. The lighting system 200 comprises an LED driver 220 and an LED or an array of multiple LEDs 230. The lighting system also further comprises at least one power supply 210.

The power supply 210 supplies AC or DC power. Power supply is an electrical power supply, a solar power supply or a battery supply. Further, the power supply is 24 - 48 volts DC supply, or 220 - 240 volts AC supply. The AC supply is converted to DC before feeding to the voltage converter unit 222.

The LED driver 220 further comprises the voltage converter unit 222 and a current switching unit 224. The voltage converter unit 222 is an optional component.

The voltage converter unit 222 changes the voltage level of supplied power. The voltage converter unit 222 either boosts or drops the voltage level depending on type of power supply used and requirements of the current switching unit 224. The power supply such as a lithium-ion battery, having a normal operating voltage of about 3.6 volts either cannot power the circuit because of low

supply voltage or gives deteriorated performance when the battery runs down. In such cases the voltage converter unit is used to step-up the voltage to a desired voltage level.

The current switching unit 224 receives an output voltage supply from the voltage converter unit 222 or directly from the power supply 210. The current switching unit 224 provides an output current signal to drive the LED or the array of multiple LEDs 230. The output current signal is a pulse width modulated switched current signal with controlled current peaks and adjusted duty cycle. The LED or array of multiple LEDs is driven on this output current signal and hence provides high lumen output with lower power consumption and minimal heat dissipation.

FIG. 3 depicts a method for driving at least one LED or an array of multiple LEDs in accordance with an embodiment of the present invention. The method comprises receiving an input current signal 310 and switching the input current signal through current pulse width modulation to obtain a switched current signal 320. Oscillations for current pulse width modulation are provided by a first inductor. The method further comprises controlling the peaks of the switched current signal to obtain a switched current signal with controlled current peaks 330. The peaks of the switched current signal are controlled as per requirements of an LED or an array of multiple LEDs through a first variable resistor. The method further comprises adjusting duty cycle of the switched current signal with controlled current peaks to obtain an intermediate current signal 340. The intermediate current signal is a pulse width modulated switched current signal with controlled current peaks and adjusted duty cycle. The duty cycle adjustment is carried out through a second variable resistor based on the requirements of the LED or array of multiple LEDs and configuration of the first variable resistor. The method further comprises amplifying the intermediate current signal to obtain an output current signal 350. The output current signal is a pulse width modulated switched current signal with controlled current peaks and adjusted duty cycle. The amplification is carried out through a transistor. The method further comprises providing the output current signal to the LED or the array of multiple LEDs 360.

The output current signal which is provided to the LED or the array of multiple LEDs is adjusted to 2 – 10 times the rated current required by the LED or the array of multiple LEDs.

The LED driver apparatus of the present invention drives LEDs to provide high lumen output with lower power consumption and minimal heat dissipation.

To illustrate the working of the LED driver apparatus of the present invention, the LED driver apparatus was operated at 45% duty cycle and current peaks of 500% and provided an output current signal, which provided maximum driving power to the LED. The LED provided 100% lumen output without dimming and the average power consumption was lowered by 35% - 40%.

Table 1 represents the comparison of the LED driver apparatus present invention over conventional LED drivers.

	LED drivers known in the art	**Present Invention**
Lumen Output	**65 %**	**100 %**
Junction Temperature of LED	**150° C**	**60° C – 70° C**
Power consumed	**145 %**	**55 %**

CLAIMS

We claim:

1. An apparatus for driving at least one light-emitting diode (LED), comprising:

a current switching unit enabled to switch an input current signal through current pulse width modulation, control peaks of the switched current signal and adjust duty cycle of the switched current signal to provide an intermediate current signal and amplify the intermediate current signal as per requirements of the at least one LED to provide an output current signal.

2. The apparatus of claim 1, wherein the current switching unit comprises a first integrated circuit and a second integrated circuit, wherein the second integrated circuit is enabled to receive an input current signal provided by the first integrated circuit, and provide the output current signal.

3. The apparatus of claim 2, wherein the current switching unit further comprises a first variable resistor in communication with the second integrated circuit, wherein the first variable resistor is configured to control peaks of the switched current signal based on the requirements of the at least one LED.

4. The apparatus of claim 3, wherein the current switching unit further comprises a second variable resistor in communication with the second integrated circuit, wherein the second variable resistor is configured to adjust the duty cycle of the switched current signal with controlled current peaks based on the requirements of the at least one LED and the configuration of the first variable resistor.

5. The apparatus of claim 4, wherein the current switching unit further comprises a first inductor enabled to provide oscillations for current pulse width modulation of the input current signal.

6. The apparatus of claim 5, wherein the current switching unit further comprises a transistor for amplifying the intermediate current signal as per requirements of the at least one LED.

7. The apparatus of claim 6, wherein the current switching unit further comprises a feedback resistor enabled to measure the output current signal and provide the measured current information to the first integrated circuit.

8. The apparatus of claim 1, optionally comprising at least one voltage converter unit, wherein the voltage converter unit is enabled to receive an input voltage supply and provide an output voltage supply as per requirements of the current switching unit.

9. The voltage converter unit of claim 8, wherein the voltage converter unit comprises:
a third integrated circuit enabled to switch the input voltage supply through pulse width modulation and provide the output voltage supply;
a third variable resistor in communication with the third integrated circuit and configured to control the output voltage supply as per the requirements of the current switching unit;
a second inductor in communication with the third integrated circuit and enabled to provide oscillations for pulse width modulation of the input voltage supply; and,
a second feedback resistor enabled to measure the output voltage supply and provide the measured information to the third integrated circuit.

10. A lighting system comprising:
at least one light emitting diode (LED) and
the apparatus for driving the at least one LED of claim 1.

11. The lighting system of claim 10, optionally comprising at least one power source.

12. A method for driving at least one light-emitting diode (LED), the method comprising:
receiving an input current signal,
switching the input current signal through current pulse width modulation to obtain a switched current signal,
controlling peaks of the switched current signal to obtain a switched current signal with controlled current peaks as per requirements of the at least one LED,
adjusting duty cycle of the switched current signal with controlled current peaks signal to obtain an intermediate current signal as per requirements of the at least one LED and the controlled peaks of the switched current signal,
amplifying the intermediate current signal to obtain an output current signal; and,
providing the output current signal to the at least one LED.

13. The method of claim 12, wherein the method further comprises measuring the output current signal and providing measured signal information to a first integrated circuit through a feedback resistor.

14. The method of claim 12, wherein the method further comprises switching the input current signal through current pulse width modulation mode through oscillations provided by an inductor.

15. The method of claim 12, wherein the method further comprises controlling peaks of the switched current signal based on requirements of the at least one LED through configuring a first variable resistor.

16. The method of claim 12, wherein the method further comprises adjusting the duty cycle of the switched current signal with controlled current peaks through a second variable resistor, based on requirements of the at least one LED and configuration of the first variable resistor.

Dated, this 24th day of June, 2009

Signature:-

Name: Ms. Komal Shah
IN/PA-1162
(Authorized Registered Patent Agent)

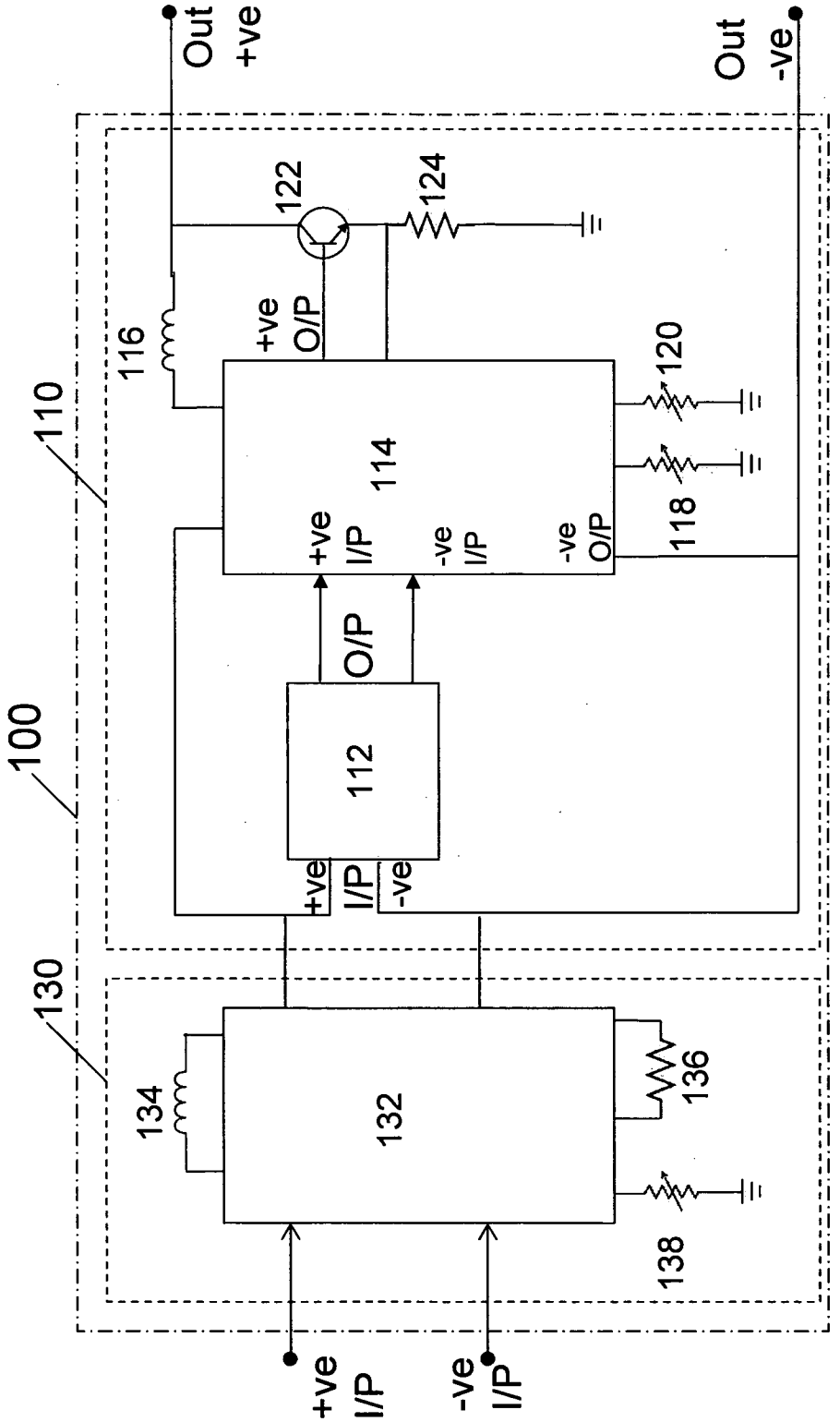
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Fig. 1

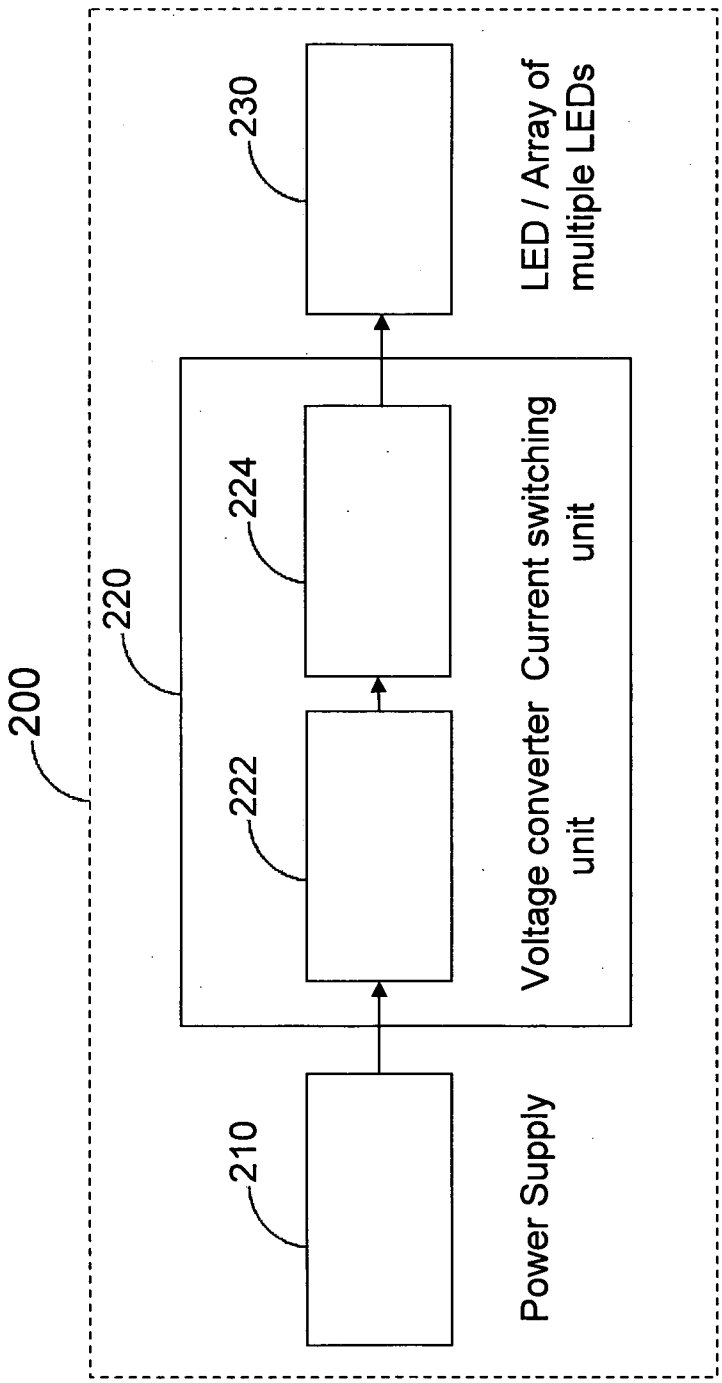
200
220
210
Power Supply
222
Voltage converter unit
224
Current switching unit
230
LED / Array of multiple LEDs

Fig. 2

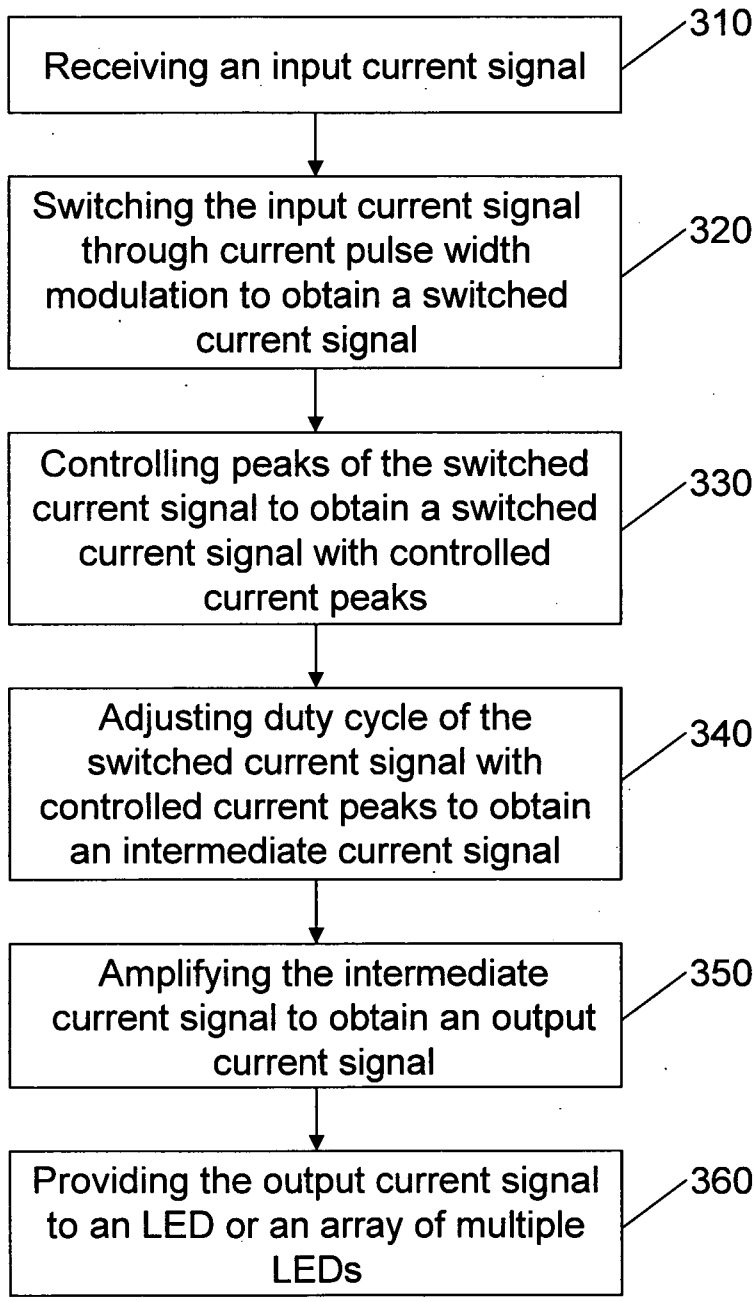
Receiving an input current signal
310
Switching the input current signal through current pulse width modulation to obtain a switched current signal
320
Controlling peaks of the switched current signal to obtain a switched current signal with controlled current peaks
330
Adjusting duty cycle of the switched current signal with controlled current peaks to obtain an intermediate current signal
340
Amplifying the intermediate current signal to obtain an output current signal
350
Providing the output current signal to an LED or an array of multiple LEDs
360

Fig. 3