

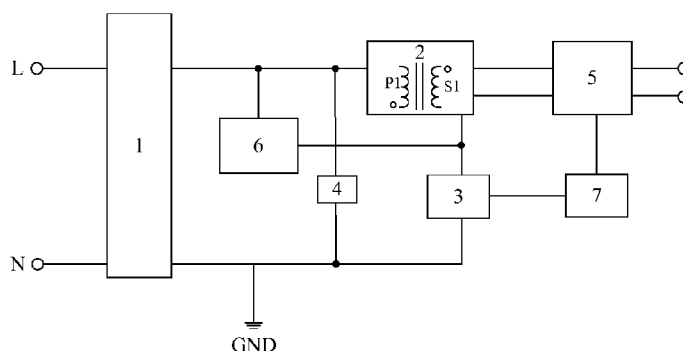
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(54) Title: SINGLE STAGE LED DRIVER AND ILLUMINATING DEVICE HAVING THE LED DRIVER, LOW RIPPLE BY
INPUT BOOST UNIT**Figure 3**(57) Abstract: The present invention relates to an LED driver for an illuminating device, comprising a rectifier bridge (1); a conver-
tor (2) connected to the rectifier bridge (1) and comprising a primary winding (P1) and a secondary winding (S1); a primary filter
unit (4) having first end connected between a first terminal of the primary winding (P1) and the rectifier bridge (1) and second end
connected to ground (GND); a switch unit (3) connected to a second terminal of the primary winding (P1) to control connection
between the primary winding (P1) and the ground (GND); and a secondary output unit (5) connected to the secondary winding (S1),
characterized in that the LED driver further comprises a boost input unit (6) that has first end connected between the rectifier bridge
(1) and the first terminal of the primary winding (P1) and second end connected to the second terminal of the primary winding (P1),
wherein when the switch unit (3) is enabled, the boost input unit (6) and the primary winding (P1) are charged, and the primary filter
unit (4) discharges via the primary winding (P1); and when the switch unit (3) is disabled, the boost input unit (6) discharges via
the primary winding (P1) so as to provide a charge current to the primary filter unit (4). In addition, the present invention also relates
to an illuminating device having the above type of the LED driver.

Description

SINGLE STAGE LED DRIVER AND ILLUMINATING DEVICE HAVING THE LED DRIVER, LOW RIPPLE BY INPUT BOOST UNIT

5 Technical Field

The present invention relates to an LED driver for an illuminating device. In addition, the present invention further relates to an illuminating device having such LED driver.

Background Art

10 An LED illuminating device as a cold light source has the advantages such as pure color of light, concentrated light beam, high color rendering index, good temperature properties, low electrical energy consumption, stable performance, long service lifetime, no pollution and simple utilization.

15 In order to drive an LED light source, a large number of various types of AC-DC LED drivers are available in the market, which include single-stage LED driver, two-stage LED driver. However, they have different advantages and disadvantages, for example, the single-stage LED driver has a simple

20 structure and low cost, and can provide a good power factor, but generates a big ripple current; otherwise some problems will appear in some applications. For instance, in indoor application, a big ripple current is easily caught by a camera because the ripple current is 100Hz/120Hz which is coupled

25 from a main input. The two-stage LED driver can provide a high power factor and a relatively low ripple current, but has a complex structure and a high cost.

A single-stage LED driver is disclosed in the prior art. As shown in Fig. 1, the primary terminal of the single-stage LED

30 driver has a quite simple structure and only has a bypass ca-

pacitor C3 connected downstream from the rectifier bridge for reducing the ripple current. However, the capacitance value of the bypass capacitor C3 is usually small and cannot effectively reduce the ripple current in the primary terminal. In order to reduce the ripple current in the current output from the secondary terminal, a plurality of capacitors C2, C4 and C5 having a big capacitance value should be connected in parallel at the output terminal, which obviously will increase the cost.

10 A two-stage LED driver is shown in Fig. 2. This two-stage LED driver is connected with a boost input unit and an additional filter capacitor C1 downstream from the rectifier bridge. This boost input unit is directly connected to the filter capacitor C1 for maintaining the voltage in the filter capacitor C1, but an additional control IC and control switch are needed. Though this solution well reduces the ripple current in the main output, it has a high cost.

Summary of the Invention

20 In order to solve the above technical problem, the present invention provides an LED driver that can well reduce the ripple current in the main output and has a relatively low cost and simple structure. In addition, the present invention also provides an illuminating device having such LED driver.

25 The first object of the present invention is accomplished via an LED driver. The LED driver comprises a rectifier bridge; a convertor connected to the rectifier bridge and comprising a primary winding and a secondary winding; a primary filter unit that has a first end connected between a first terminal of the primary winding and the rectifier bridge and a second end connected to ground; a switch unit connected to a second

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terminal of the primary winding to control connection between the primary winding and the ground; and a secondary output unit connected to the secondary winding, wherein the LED driver further comprises a boost input unit that has a first end connected between the rectifier bridge and the first terminal of the primary winding and a second end connected to the second terminal of the primary winding, wherein when the switch unit is enabled, the boost input unit and the primary winding are charged, and the primary filter unit discharges via the primary winding; and when the switch unit is disabled, the boost input unit discharges via the primary winding so as to provide a charge current to the primary filter unit. In the solution of the present invention, the ripple current on the primary rectifier unit can be well maintained by means of the boost input unit, so that the ripple current in the discharge current of the primary winding is relatively small, and the ripple current in the main output also can be well reduced without using capacitors having a big capacitance value. In addition, it completely does not need additional control IC for controlling the boost input unit to charge the primary filter unit, thus further reducing the cost.

Preferably, the boost input unit comprises an inductor and a first diode, the inductor has a first terminal connected between the rectifier bridge and the first terminal of the primary winding and the second terminal connected to an anode of the first diode, and a cathode of the first diode is connected to the second terminal of the primary winding. When the switch unit is turned on, the current from the rectifier bridge is charged the inductor, so that when the switch power supply is turned off, the inductor provides a charge current to the primary filter unit.

Advantageously, the LED driver according to the present invention further comprises a second diode that has an anode connected between the first terminal of the inductor and the rectifier bridge and a cathode connected to the first terminal of the primary winding. The second diode is used to provide a charge circuit to the primary filter unit when the LED driver is started, preventing an impulse current from flowing through the boost input unit.

Further preferably, the primary filter unit is a first capacitor, an anode of the first capacitor is connected between the cathode of the second diode and the first terminal of the primary winding, and a cathode of the first capacitor is connected to the ground. In one solution of the present invention, the first capacitor is designed to be an electrolytic capacitor.

According to one preferred solution of the present invention, the boost input unit further comprises an RCD snubber that comprises a first resistor, a second capacitor and a third diode, wherein the first resistor has a first end connected between the second terminal of the inductor and the anode of the first diode and a second end connected to a cathode of the third diode, an anode of the third diode is connected to the ground, and the second capacitor has a first terminal connected between the second terminal of the inductor and the anode of the first diode and a second terminal connected between the second end of the first resistor and the cathode of the third diode. When the switch unit is disabled, the first diode enters into reverse recovery, and a current will reversely flow into the inductor. After reverse biased of the first diode, the inductor needs a continuous current loop, otherwise, the first diode possibly will be reverse broken down. The RCD snubber provides this continuous current loop

Preferably, the LED driver further comprises a third capacitor that has a first end connected between the first terminal of the inductor and the rectifier bridge and a second end connected to the ground. The third capacitor has a relatively
5 small capacitance value and has a filtering function.

According to the present invention, the convertor is designed to be a flyback convertor. According to the principle of flyback convertor, the primary winding of the flyback convertor is charged when enabled, and discharges when disabled to
10 transfer energy to the secondary winding.

Further preferably, the switch unit comprises a controller and a transistor, wherein an output end of the controller is connected to a control Electrode of the transistor, a working Electrode of the transistor is connected to the second terminal of the primary winding, and a reference Electrode of the transistor is connected to the ground. The controller controls on or off state of the transistor, so that the primary winding and the ground are allowed to be turned on or turned off. In one solution of the present invention, the transistor
15 can be a MOS transistor.
20

According to the present invention, the secondary output unit comprises a fourth diode, a fourth capacitor and a second resistor, wherein a first terminal of the secondary winding is connected to an anode of the fourth diode, a cathode of the
25 fourth diode is connected to an anode of a LED, the second terminal of the second winding is connected to the cathode of the LED through the second resistor, an anode of the fourth capacitor is connected between the cathode of the fourth diode and the anode of the LED, and a cathode of the fourth capacitor is connected between a second terminal of the secondary winding and the second resistor. When the switch unit is
30

enabled, the primary winding and the inductor charge, and the fourth diode is reverse biased. When the switch unit is disabled, the primary winding discharges, the fourth diode is forward biased, so as to realize energy transfer. In one solution of the present invention, only one fourth capacitor having a small capacitance value is used in the secondary input unit, and this fourth capacitor is designed to be an electrolytic capacitor that is sufficient to reduce the ripple current in the main output.

10 According to the present invention, the LED driver further comprises a detecting unit that comprises a first detection input, a second detection input and a detection output, wherein the first detection input is connected between the cathode of the fourth diode and the anode of the LED for detecting a voltage in the main output, the second detection input is connected between the second resistor and the cathode of the LED, and the detection output is connected to an input of the controller. In one solution of the present invention, the detecting unit, on one hand, detects the voltage in the main output to provide overvoltage protection, and on the other hand, detects the current in the main output and generates a control signal for the switch unit. The controller in the switch unit controls frequency of on and off of the transistor according to this control signal so as to obtain expected output voltage.

The other object of the present invention is realized by an illuminating device having the LED driver of the above type. The frequency of light output from the illuminating device is higher, and flicker of the light will not be easily captured by the camera. Besides, the cost of the illuminating device of the present invention is lower.

It shall be understood that both the above general description and the following detailed description are for illustrative and explanative purposes in order to provide further description of the claimed present invention.

5 **Brief Description of the Drawings**

The accompanying drawings constitute a part of the present Description and are used to provide further understanding of the present invention. Such accompanying drawings illustrate the embodiments of the present invention and are used to describe the principles of the present invention together with the Description. In the accompanying drawings the same components are represented by the same reference numbers. As shown in the drawings:

Fig. 1 is a circuit diagram of a single-stage LED driver in the prior art;

Fig. 2 is a circuit diagram of a two-stage LED driver in the prior art;

Fig. 3 is a principle block diagram of an LED driver according to the present invention;

Fig. 4 is a circuit diagram of a first embodiment of the LED driver according to the present invention;

Fig. 5 is a circuit diagram of a second embodiment of the LED driver according to the present invention;

Fig. 6 is a waveform diagram of current of the LED driver of the present invention;

Fig. 7 is a waveform diagram of ripple current in a main output of an LED driver in the prior art; and

Fig. 8 is a waveform diagram of ripple current in a main output of an LED driver according to the present invention.

5 Detailed Description of the Embodiments

Fig. 3 is a principle block diagram of an LED driver according to the present invention. It can be seen from Fig. 3 that the LED driver comprises a rectifier bridge 1; a convertor 2 connected to the rectifier bridge 1 and comprising a primary winding P1 and a secondary winding S1; a primary filter unit 4 that has a first end connected between a first terminal of the primary winding P1 and the rectifier bridge 1 and a second end connected to GND; a switch unit 3 connected to a second terminal of the primary winding P1 to control connection between the primary winding P1 and the ground GND; and a secondary output unit 5 connected to the secondary winding S1. It also can be seen from Fig. 3 that the LED driver further comprises a boost input unit 6 that has a first end connected between the rectifier bridge 1 and the first terminal of the primary winding P1 and a second end connected to the second terminal of the primary winding P1. In one solution of the present invention, the convertor 2 is designed to be a fly-back convertor that is charged when the primary winding P1 is enabled and discharges when the primary winding P1 is disabled to transfer energy to the secondary winding S1.

Fig. 4 is a circuit diagram of a first embodiment of the LED driver according to the present invention. It can be seen from Fig. 4 that the boost input unit 6 comprises an inductor L1 and a first diode D1. The inductor L1 has first terminal connected between the rectifier bridge 1 and the first terminal of the primary winding P1 and a second terminal connected to the second terminal of the primary winding P1.

nal of the primary winding P1 and the second terminal connected to an anode of the first diode D1, and a cathode of the first diode D1 is connected to the second terminal of the primary winding P1. In addition, in order to provide a charge
5 circuit to the primary filter unit 4 and prevent an impulse current from flowing through the boost input unit 6 when the LED driver is started, the LED driver further comprises a second diode D2 that has an anode connected between the first terminal of the inductor L1 and the rectifier bridge 1 and a
10 cathode connected to the first terminal of the primary winding P1.

In the circuit diagram shown in Fig. 4, the first capacitor C1 constitutes the primary filter unit 4. An anode of the first capacitor C1 is connected between the cathode of the
15 second diode D2 and the first terminal of the primary winding P1, and a cathode of the first capacitor C1 is connected to the ground GND.

Besides, it can be seen from Fig. 4 that the LED driver also comprises a third capacitor C3 that has a first end connected
20 between the first terminal of the inductor L1 and the rectifier bridge 1 and a second end connected to the ground GND.

The switch unit 3 controlling the primary winding P1 comprises a controller 3a and a transistor Q1, wherein an output of the controller 3a is connected to a control Electrode of
25 the transistor Q1, a working Electrode of the transistor Q1 is connected to the second terminal of the primary winding P1, and a reference Electrode of the transistor Q1 is connected to the ground GND.

The secondary output unit 5 of the LED driver according to
30 the present invention is shown on the right of the secondary

winding S1, which comprises a fourth diode D4, a fourth capacitor C4 and a second resistor R2, wherein a first terminal of the secondary winding S1 is connected to an anode of the fourth diode D4, a cathode of the fourth diode D4 is connected to an anode of a LED, the second terminal of the second winding S1 is connected to the cathode of the LED through the second resistor R2, an anode of the fourth capacitor C4 is connected between the cathode of the fourth diode D4 and the anode of the LED, and a cathode of the fourth capacitor C4 is connected between a second terminal of the secondary winding S1 and the second resistor R2.

In order to detect a voltage of a main output for overvoltage protection, and for the sake of detecting a current in the main output to generate a control signal for the switch unit, the LED driver also comprises a detecting unit 7. The detecting unit 7 comprises a first detection input 7a, a second detection input 7b and a detection output 7c, wherein the first detection input 7a is connected between the cathode of the fourth diode D4 and the anode of the LED, the second detection input 7b is connected between the second resistor R2 and the cathode of the LED, and the detection output 7c is connected to an input of the controller 3a.

Fig. 5 is a circuit diagram of a second embodiment of the LED driver according to the present invention, which has the only difference from the first embodiment of the LED driver according to the present invention shown in Fig. 4 in that the boost input unit 6 further comprises an RCD snubber. The RCD snubber comprises a first resistor R1, a second capacitor C2 and the third diode D3. The first resistor R1 has a first end connected between the second terminal of the inductor L1 and the anode of the first diode D1 and a second end connected to a cathode of the third diode D3, an anode of the third diode

D3 is connected to the ground GND, and the second capacitor C2 has a first terminal connected between the second terminal of the inductor L1 and the anode of the first diode D1 and the second terminal connected between second end of the first resistor R1 and the cathode of the third diode D3. When the switch unit 3 is disabled, the first diode D1 enters into reverse recovery, and a current will reversely flow into the inductor L1. After reverse cut-off of the first diode D1, the inductor L1 needs a continuous current loop, otherwise, the first diode D1 possibly will be reverse broken down. The RCD snubber provides this continuous current loop.

Next, the actual working condition of the LED driver according to the present invention will be described according to the waveform diagram of current shown in Fig. 6. It can be seen from Fig. 6 that in t_0 - t_1 period of time, the transistor Q1 is enabled, the inductor L1 and the primary winding P1 store energy, at which time, the fourth diode D4 is reverse biased, and the primary winding P1 does not transfer energy to the secondary winding S1. In t_1 - t_2 period of time, the transistor Q1 is disabled, the inductor L1 releases stored energy, which energy flows through the primary winding P1 and enables the first capacitor C1, at which time, the fourth diode D4 is forward biased, and after release of the energy of the inductor L1 is completed, the circuit enters oscillation. Thereafter, the circuit again enters the t_0 - t_1 period of time. In this solution of the present invention, the controller 7 is a fixed on time type, thus, the current on the inductor L1 will follow up the input voltage, and the power factor also will be relatively high.

Fig. 7 is a waveform diagram of ripple current in a main output of an LED driver in the prior art; and Fig. 8 is a waveform diagram of ripple current in a main output of an LED

driver according to the present invention. Upon comparison of the two waveform diagrams, it can be seen that the ripple current in the main output of the LED driver according to the present invention is obviously smaller than the ripple current in the main output of the LED driver in the prior art.

The above is merely preferred embodiments of the present invention but not to limit the present invention. For the person skilled in the art, the present invention may have various alterations and changes. Any alterations, equivalent substitutions, improvements, within the spirit and principle of the present invention, should be covered in the protection scope of the present invention.

List of reference signs

1	rectifier bridge
2	convertor
5 3	switch unit
3a	controller
4	primary filter unit
5	secondary output unit
6	boost input unit
10 7	detecting unit
7a	first detection input
7b	second detection input
7c	detection output
P1	primary winding
15 S1	secondary winding
GND	ground
D1	first diode
D2	second diode

	D3	third diode
	D4	fourth diode
	L1	inductor
	C1	first capacitor
5	C2	second capacitor
	C3	third capacitor
	C4	fourth capacitor
	R1	first resistor
	R2	second resistor
10	Q1	transistor

Claims

1. An LED driver for an illuminating device, comprising a rectifier bridge (1); a convertor (2) connected to the rectifier bridge (1) and comprising a primary winding (P1) and a secondary winding (S1); a primary filter unit (4) having a first end connected between a first terminal of the primary winding (P1) and the rectifier bridge (1) and a second end connected to ground (GND); a switch unit (3) connected to a second terminal of the primary winding (P1) to control connection between the primary winding (P1) and the ground (GND); and a secondary output unit (5) connected to the secondary winding (S1), characterized in that the LED driver further comprises a boost input unit (6) that has a first end connected between the rectifier bridge (1) and the first terminal of the primary winding (P1) and a second end connected to the second terminal of the primary winding (P1), wherein when the switch unit (3) is enabled, the boost input unit (6) and the primary winding (P1) are charged, and the primary filter unit (4) discharges via the primary winding (P1); and when the switch unit (3) is disabled, the boost input unit (6) discharges via the primary winding (P1) so as to provide a charge current to the primary filter unit (4).

2. The LED driver according to Claim 1, characterized in that the boost input unit (6) comprises an inductor (L1) and a first diode (D1), a first terminal of the inductor (L1) is connected between the rectifier bridge (1) and the first terminal of the primary winding (P1) and a second terminal of the inductor (L1) is connected to an anode of the first diode (D1), and a cathode of the first diode (D1) is connected to the second terminal of the primary winding (P1).

3. The LED driver according to Claim 1, characterized in

that the LED driver further comprises a second diode (D2) that has an anode connected between the first terminal of the inductor (L1) and the rectifier bridge (1) and a cathode connected to the first terminal of the primary winding (P1).

5 4. The LED driver according to Claim 3, characterized in that the primary filter unit (4) is a first capacitor (C1), an anode of the first capacitor (C1) is connected between the cathode of the second diode (D2) and the first terminal of the primary winding (P1), and a cathode of the first capacitor
10 tor (C1) is connected to the ground (GND).

5. The LED driver according to Claim 3, characterized in that the boost input unit (6) further comprises an RCD snubber that comprises a first resistor (R1), a second capacitor (C2) and a third diode (D3), wherein a first end of the first
15 resistor (R1) is connected between the second terminal of the inductor (L1) and the anode of the first diode (D1) and a second end of the first resistor (R1) is connected to a cathode of the third diode (D3), an anode of the third diode (D3) is connected to the ground (GND), and the second capacitor
20 (C2) has a first terminal connected between the second terminal of the inductor (L1) and the anode of the first diode (D1) and the second terminal connected between the second end of the first resistor (R1) and the cathode of the third diode (D3).

25 6. The LED driver according to Claim 2, characterized in that the LED driver further comprises a third capacitor (C3) that has a first terminal connected between the first terminal of the inductor (L1) and the rectifier bridge (1) and a second terminal connected to the ground (GND).

30 7. The LED driver according to any one of Claims 1-6, char-

acterized in that the convertor (2) is a flyback convertor.

8. The LED driver according to any one of Claims 1-6, characterized in that the switch unit (3) comprises a controller (3a) and a transistor (Q1), wherein an output end of the controller (3a) is connected to a control Electrode of the transistor (Q1), a working Electrode of the transistor (Q1) is connected to the second terminal of the primary winding (P1), and a reference Electrode of the transistor (Q1) is connected to the ground (GND).

9. The LED driver according to Claim 8, characterized in that the secondary output unit (5) comprises a fourth diode (D4), a fourth capacitor (C4) and a second resistor (R2), wherein the first terminal of the secondary winding (S1) is connected to an anode of the fourth diode (D4), a cathode of the fourth diode (D4) is connected to an anode of LED, the second terminal of the second winding (S1) is connected to the cathode of the LED through the second resistor (R2), an anode of the fourth capacitor (C4) is connected between the cathode of the fourth diode (D4) and the anode of the LED, and a cathode of the fourth capacitor (C4) is connected between the second terminal of the secondary winding (S1) and the second resistor (R2).

10. The LED driver according to Claim 9, characterized in that the LED driver further comprises a detecting unit (7) that comprises a first detection input (7a), a second detection input (7b) and a detection output (7c), wherein the first detection input (7a) is connected between the cathode of the fourth diode (D4) and the anode of the LED, the second detection input (7b) is connected between the second resistor (R2) and the cathode of the LED, and the detection output (7c) is connected to an input of the controller (3a).

11. An illuminating device, characterized in that the illuminating device comprises the LED driver according to any one of Claims 1-10.

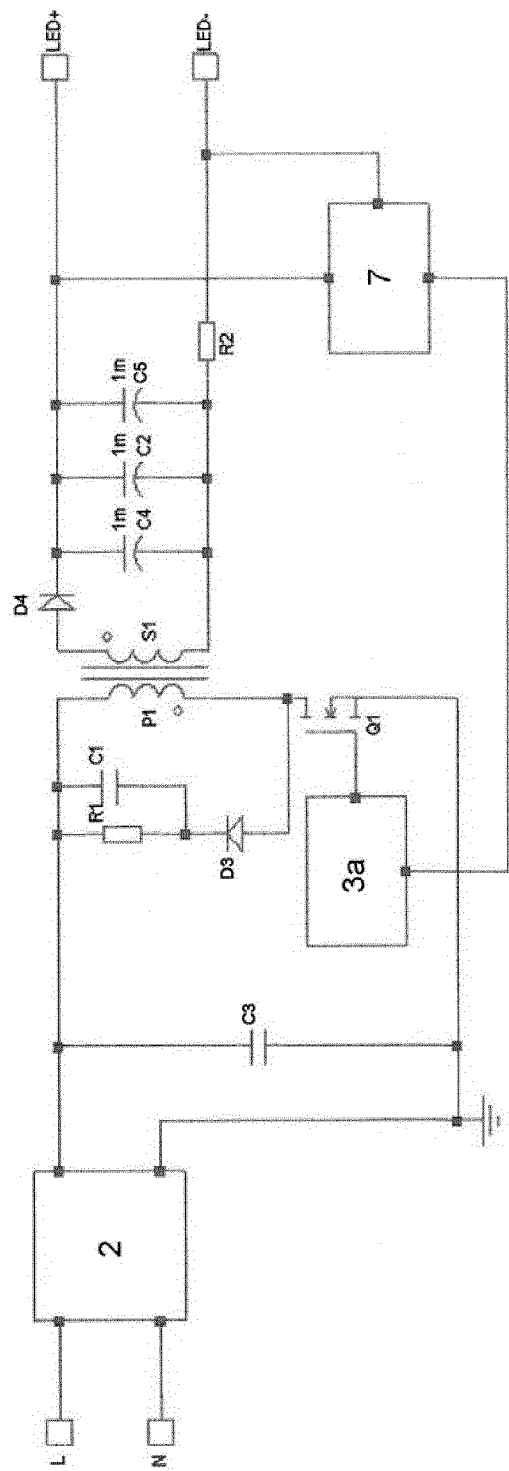


Figure 1

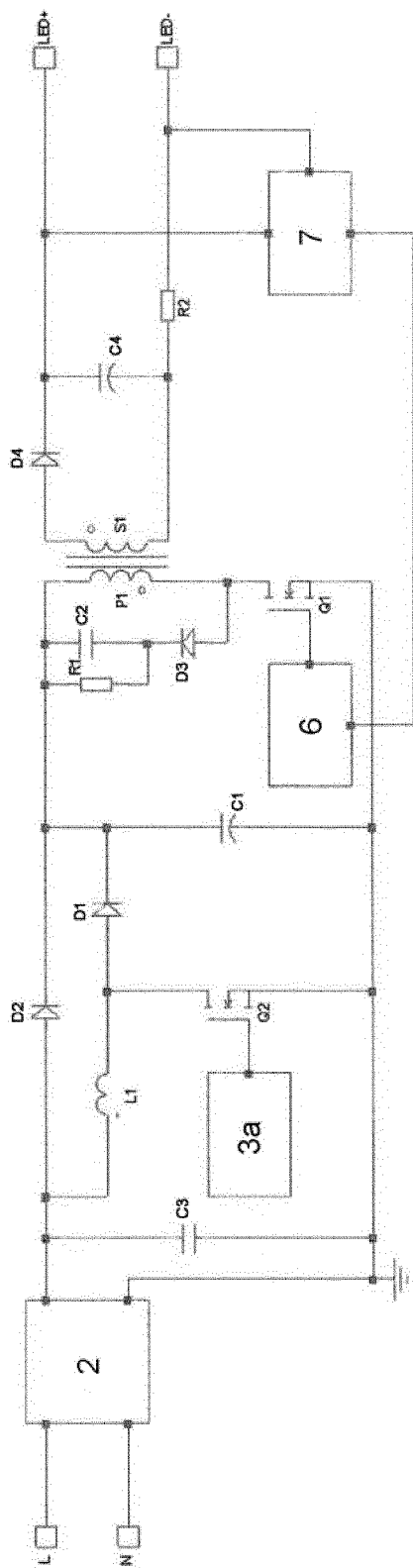


Figure 2

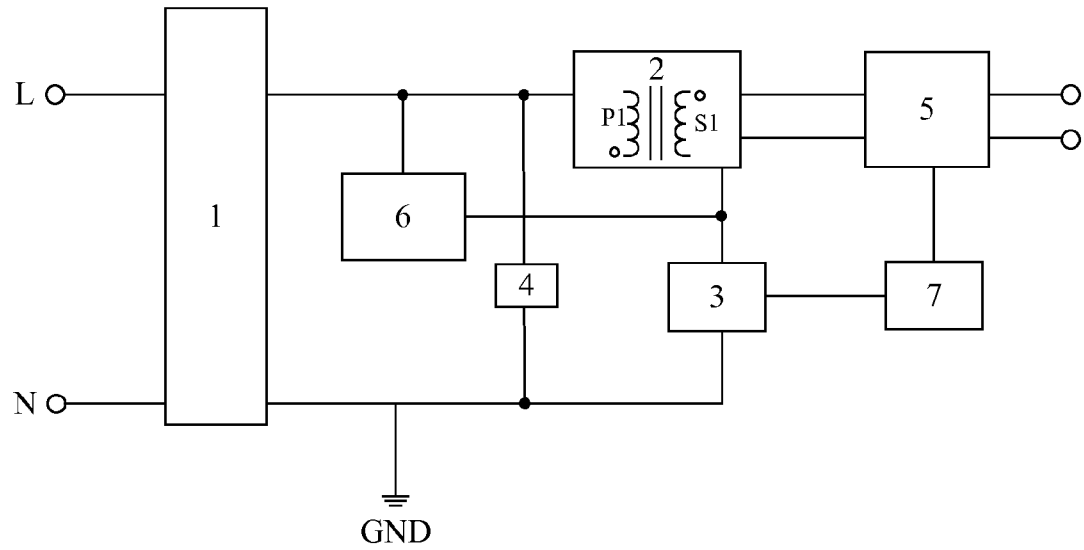


Figure 3

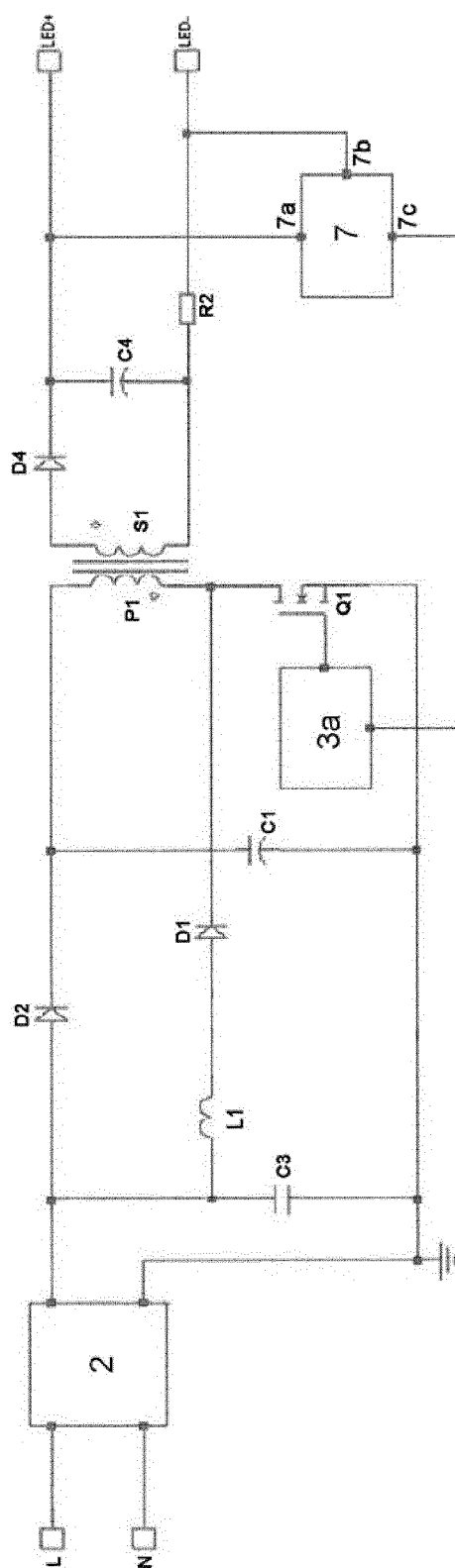


Figure 4

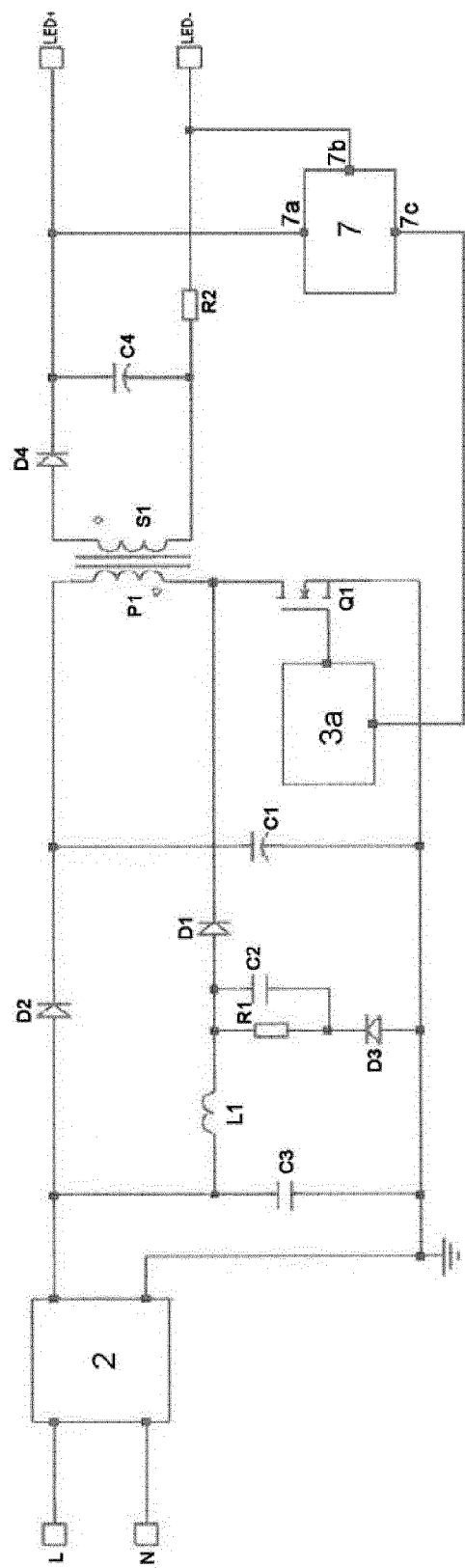


Figure 5

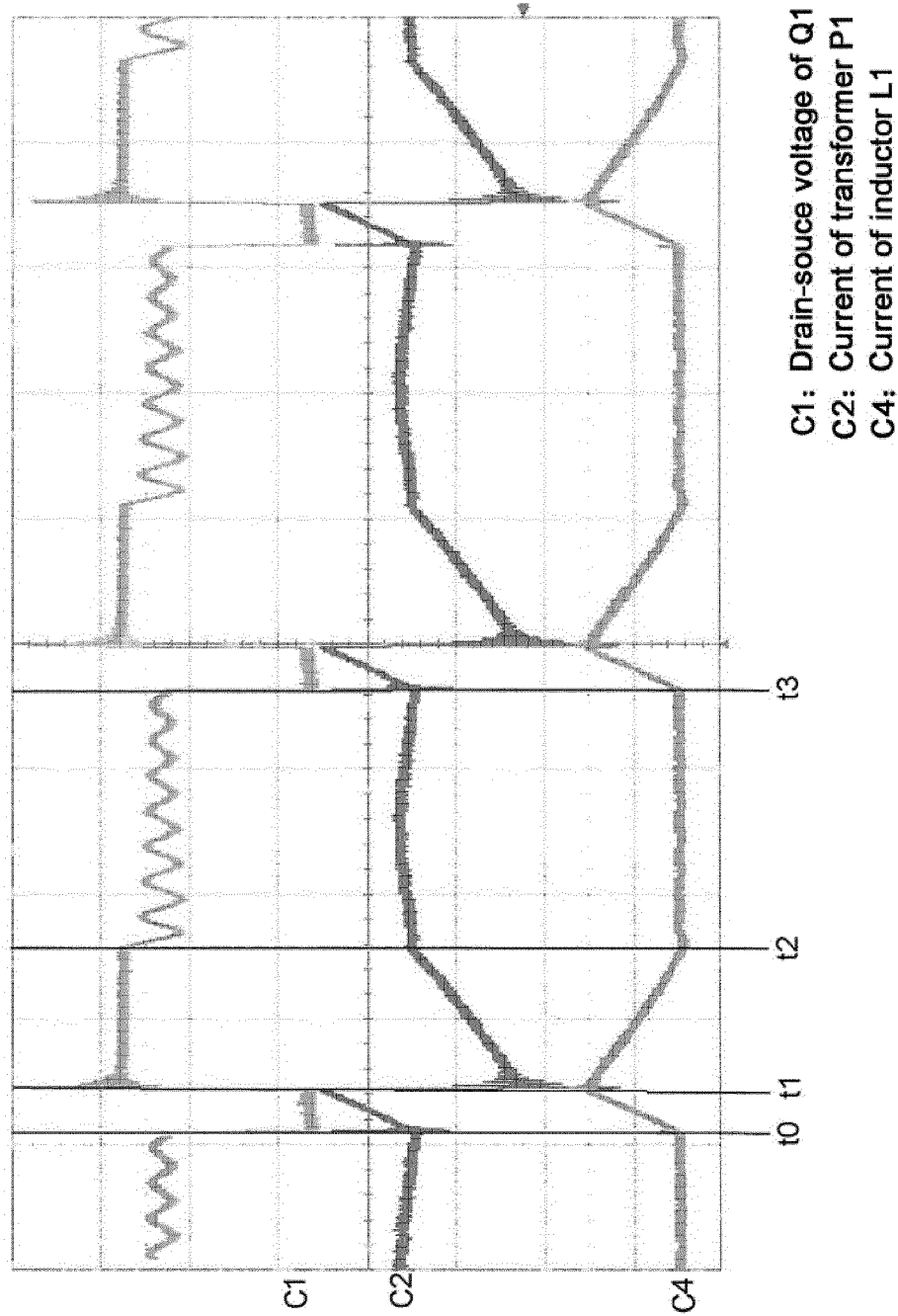
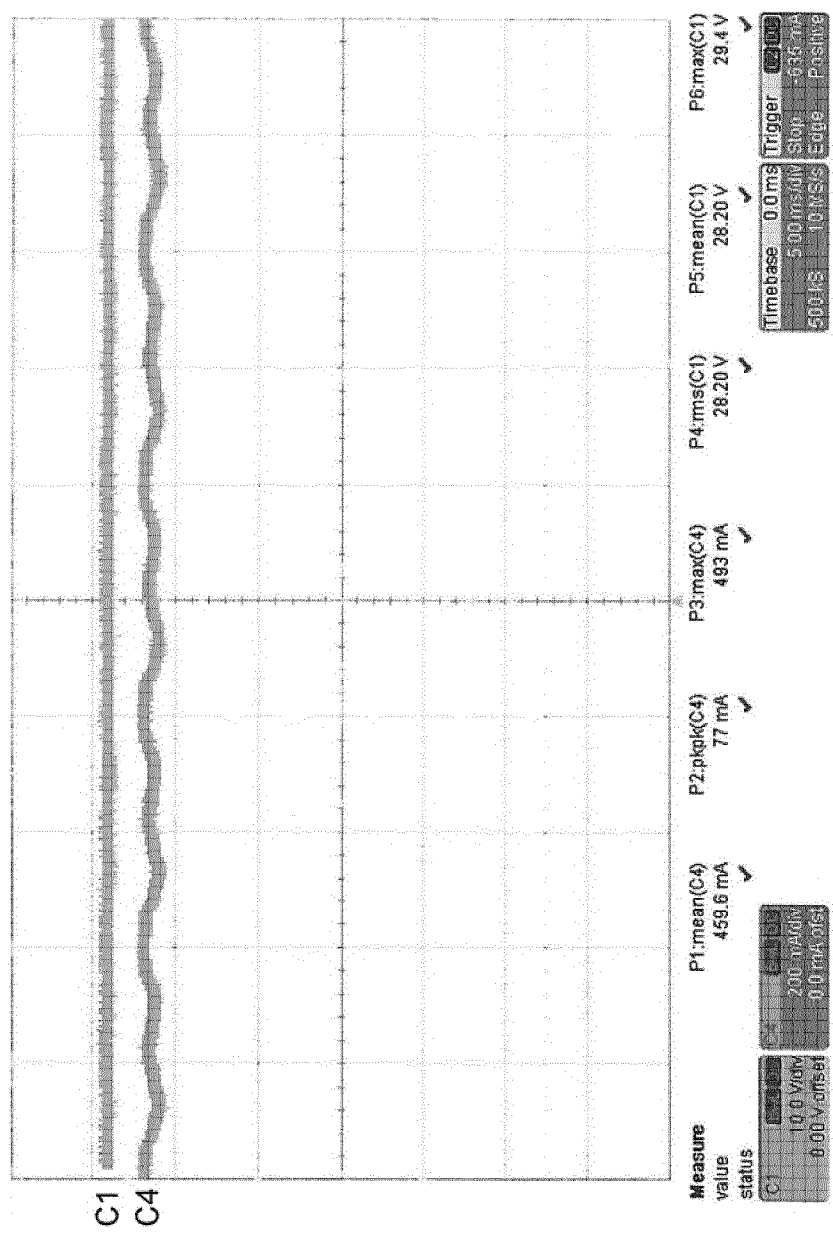
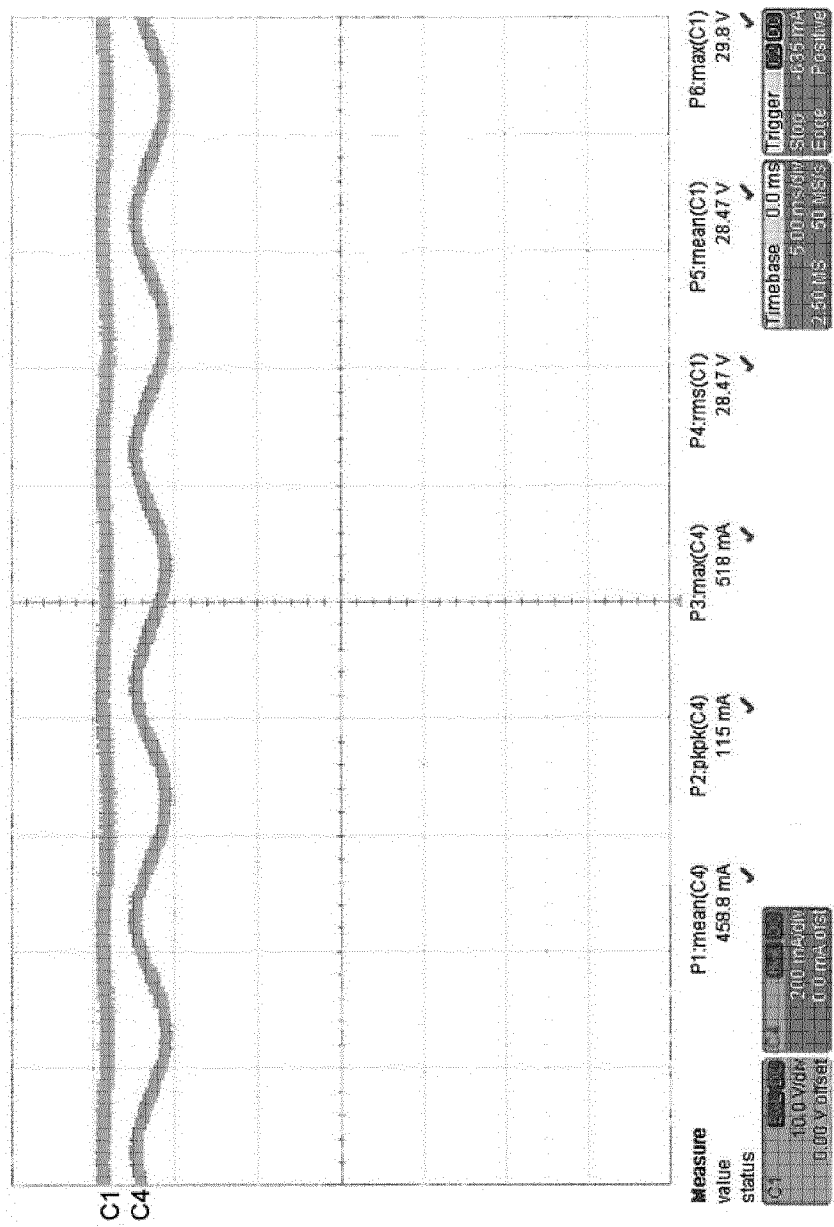


Figure 6



C1:Output voltage;
C4:Output current.

Figure 7



C1:Output voltage;
C4:Output current.

Figure 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/051457

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B33/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B H02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 790 389 A (HUA GUICHAO [US]) 4 August 1998 (1998-08-04) column 6, line 30 - column 6, line 68 figures 7, 8	1-11
A	----- EP 1 560 323 A1 (SANKEN ELECTRIC CO LTD [JP]) 3 August 2005 (2005-08-03) paragraph [0002] - paragraph [0002] paragraph [0010] - paragraph [0010] figure 1 -----	5



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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Information on patent family members

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