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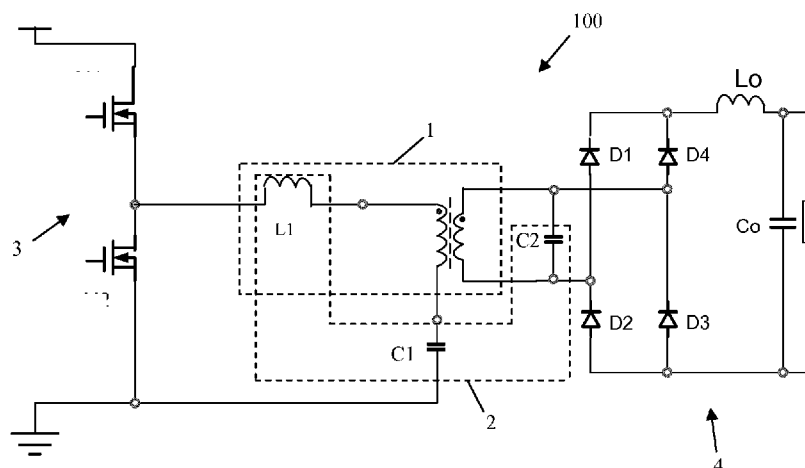


Fig. 1

(57) Abstract: The present invention relates to a driving device for a lighting apparatus and a lighting apparatus comprising the driving device, wherein the driving device comprises: a converter, wherein an input end of the converter is connected to a power supply unit and is provided with a series capacitor; an output end of the converter is connected to a load unit of the lighting apparatus and is provided with a parallel capacitor, the converter is internally integrated with a first inductor, wherein the series capacitor, the parallel capacitor, and the first inductor form a resonant tank.



DRIVING DEVICE AND LIGHTING APPARATUS COMPRISING THE DRIVING DEVICE

DESCRIPTION

5 The present invention relates to a driving device for a lighting apparatus and a light device comprising the driving device, and particularly to an LED lighting apparatus.

LED light sources, due to their advantages such as high lumen efficiency and energy saving, are widely used in lighting apparatus. Drives of such type of lighting apparatus will be generally designed to have a relatively wide range of output voltage or output current, in particular, the drivers use different topological structures so as to be capable of obtaining good electrical performances even at a relatively large range of output voltage or output current. Besides, existing drivers for the lighting apparatus will be generally designed to have a dimming function, and such type of drivers can provide additional sufficient energy-saving effect, which just means that a driving current of the driver of the lighting apparatus can be dimmed down depending on different scenarios or application environments. Thus, this enables a single type of driver devices to be capable of providing power to various different LED load types, which simplifies the types and categories of the product, increases the production and efficiency for single type, i.e. decreases production cost, while also reducing material and inventory cost for the products.

20 Nevertheless, the drivers of the lighting apparatus designed according to the existing topological structure will have the following problem, that is, during the startup period of the lighting apparatus, the driving circuit will work abnormally, which is due to the fact that a resonant tank in the driver is disturbed, and the normal running state of the driving circuit is destroyed, which leads to undesired changes of the output current waveform of the driver. In cases where the normal resonant tank of the driver is disturbed, this will cause the driver to consume more powers, resulting in additional power loss, therefore reducing the operation efficiency of the driver. In addition, the existing drivers will use a separate inductor as resonant inductance. However, this will result in high cost and low operation efficiency of the driver.

In order to address the above technical problems, two methods will be used in the conventional technologies, wherein in one method, the structure of a single section

bobbin transformer will be used, and a transformer according to this design will be separated by an insulation material between a primary winding and a secondary winding of for safety consideration. However, the manufacturing process of such design is complicated, and has a high cost and low safe reliability, incapable to meeting most scenarios, and in the other method, a three section bobbin will be used, while such bobbin is not commonly used and has a high cost, moreover, it cannot eliminate the above mentioned problems completely.

In order to solve the above mentioned technical problems, the present invention provides a novel driving device for a lighting apparatus and a lighting apparatus comprising the driving device. The driving device according to the present invention not only can completely eliminate the problem of abnormal circuit output due to disturbance of the resonant tank in the driver, but also has a simple structure, capable of effectively decreasing the material consumption, reducing the manufacturing cost, and improving the operation efficiency of the circuit.

The object of the present invention is achieved by a driving device for a lighting apparatus. A driving device for a lighting apparatus is characterized by comprising: a convertor, wherein an input end of the convertor is connected to a power supply unit and is provided with a series capacitor; an output end of the convertor is connected to a load unit of the lighting apparatus and is provided with a parallel capacitor, the convertor is internally integrated with a first inductor, wherein the series capacitor, the parallel capacitor, and the first inductor form a resonant tank.

The driving device for a lighting apparatus according to the present invention can effectively address the problem that the resonant tank in the driving circuit is disturbed, which disturbance usually is caused by the high-frequency oscillation formed by the capacitor at the primary side of the convertor and the inductance integrated in the convertor, wherein the capacitor at the primary side and the inductance integrated in the convertor will form a resonant tank of a higher frequency. Therefore, the driving device according to the present invention can eliminate the undesirable high-frequency oscillation caused by the inductance integrated in the convertor, and specifically, the problem of abnormal output current caused by resonance occurring to the capacitance at the primary side of the convertor and the inductance integrated in the convertor is eliminated. Besides, the driving device also can sufficiently utilizes the inductance already integrated in the convertor so as to form the desired resonant tank, so that an additional inductor

which has to be provided at the outside of the convertor is omitted, that is, it is not required to arrange an independent inductor, which thus advantageously reduces the manufacturing cost, decreases the volume of the products, and improves the operation efficiency of the circuit.

- 5 The driving device according to a preferred example of the present invention further comprises: a second inductor, provided at the input end of the convertor, and forming the resonant tank with the first inductor, the series capacitor, and the parallel capacitor. Therefore, the driving device according to the present invention, on the basis of utilizing the inductance integrated to the convertor, can further utilize
10 the additional inductor provided at the primary side of the convertor, and the additional inductor together with the first inductor of the convertor forms the resonant inductance of the resonant tank. The driving device thus designed advantageously reduces the inductance value of the second inductor separately provided, thus reducing the cost of the inductor separately provided, and at the
15 same time considering the optimal design of the circuit performances.

- In the driving device according to a further example of the present invention, the first inductor is a leakage inductance of the convertor. The driving device according to the present invention not only can effectively avoid or eliminate the problem of abnormal circuit output caused by the leakage inductance of the
20 convertor, but also can sufficiently utilize the leakage inductance and use the same as the resonant inductance of the resonant tank, which therefore can advantageously avoid the additionally provided inductor. Besides, in cases where an inductor has been additionally provided, the leakage inductance of the convertor not only will not affect the normal operation of the driving circuit, but also will form
25 the resonant inductance with the additional inductor, which therefore advantageously improves the operation efficiency of the driving circuit.

- In the driving device according to a further example of the present invention, the power supply unit comprises a plurality of power transistors, wherein the plurality of power transistors is connected to the input end of the convertor. The power
30 transistors of the power supply unit can be used as switches, and further high or lower level signals are respectively input to the switches according to the scenarios.

In the driving device according to a further example of the present invention, the load unit comprises a rectifying circuit, a filtering circuit, and an output load, wherein

the rectifying circuit has one end connected to the parallel capacitor, and the other end connected to the output load through the filtering circuit. The filtering circuit of the load unit can smooth a unidirectional pulsating voltage or current after being rectified by the rectifying circuit, to reduce pulsating components of the output voltage or current, so that the output voltage or current is enabled to be closer to an ideal DC voltage or current.

In the driving device according to a further example of the present invention, the rectifying circuit comprises a plurality of rectifying bridges of diodes. The rectifying circuit can be advantageously constructed by for example a plurality of diodes, which particularly forms a bridge rectifying circuit. This rectifying circuit can change the alternating voltage or current, which is alternatively varied positively and negatively at the primary side of the convertor, into a unidirectional voltage or current.

In the driving device according to a further example of the present invention, the filtering circuit comprises an inductor and a capacitor. The inductor and the capacitor of the filtering circuit can form a resonant circuit so as to perform a smoothing treatment to a unidirectional pulsating voltage or current from the rectifying circuit.

The other object of the present invention is realized by such a lighting apparatus that comprises the driving device according to the above mentioned. The lighting apparatus according to the present invention has a more reliable and stable driving voltage or current, which particularly ensures the normal operation state of the lighting apparatus, and moreover, this lighting apparatus has a higher operation efficiency than the conventional lighting apparatus.

The lighting apparatus according to the example of the present invention is designed as an LED lighting apparatus. The lighting apparatus according to the present invention particularly has an LED light source, and the driving device can effectively and reliably provide a driving voltage or current to the LED load, so as to enable the LED lighting apparatus to be capable of normally operating and have higher operation efficiency.

The drawings constitute a portion of the description for further understanding of the present invention. These drawings illustrate the embodiments of the present

invention and explain the principle of the present invention together with the description. In the drawings, the same part is represented by the same reference sign. In the drawings,

5 Fig. 1 shows a circuit schematic diagram of a lighting apparatus according to a first embodiment of the present invention;

Fig. 2 shows a circuit schematic diagram of a lighting apparatus according to a second embodiment of the present invention;

Fig. 3a exemplarily shows a waveform of an output voltage of a driving device according to the prior art;

10 Fig. 3b exemplarily shows a waveform of an output voltage of a driving device according to the present invention;

Fig. 4a exemplarily shows a waveform of an output current of a driving device according to the prior art when being started up; and

15 Fig. 4b exemplarily shows a waveform of an output current of a driving device according to the present invention when being started up.

Fig. 1 shows a circuit schematic diagram of a lighting apparatus according to a first embodiment of the present invention. The lighting apparatus according to the present invention can comprise a power supply unit 3, a driving device 100 connected to an output end of the power supply unit 3, and a load unit 4 connected to an output end of the driving device 100. The driving device 100 comprises a convertor 1, a primary side of the convertor 1 is connected to the power supply unit 3, and a secondary side of the convertor 1 is connected to the load unit 4. The convertor 1 in the present invention can be preferably implemented as a transformer with a primary side and a secondary side. The primary side of the convertor 1 is provided with a series capacitor C1, and the secondary side of the convertor 1 is provided with a parallel capacitor C2.

In the driving device 100 of the lighting apparatus according to the first embodiment of the present invention, the primary side of the convertor 1 is not provided with an additional inductor, however, in order to form a resonant tank 2 or a resonant cavity for the driving device 100, the series capacitor C1 at the primary side of the convertor 1 and the parallel capacitor C2 at the secondary side of the convertor 1 take effect together with a leakage inductance of the convertor 1, wherein the leakage inductance of the convertor 1 acts as a first inductor L1 integrated in the convertor 1. Therefore, the resonant tank 2 or the resonant cavity of the driving device 100 can be favorably formed into an LCC resonant tank 2. Thus, the first

inductor L1 integrated in the convertor 1 acts as a resonant inductance in the formed resonant tank 2. The driving device 100 according to the first embodiment can advantageously prevent influences caused by high-frequency oscillation formed by the parallel capacitor C2 in the resonant tank 2 and the first inductor L1
5 integrated in the convertor 1, i.e. the leakage inductance in the convertor 1, wherein, for embodiment, the parallel capacitor C2 and the leakage inductance, when being in parallel, will disturb the LCC resonant tank 2 which should have been formed by the series capacitor C1, the parallel capacitor C2, and the resonant inductance.

The power supply unit 3 of the lighting apparatus can comprise a plurality of power
10 transistors, for example, power MOSFETs, and high or low level signals are respectively input to these power MOSFETs as switches. The load unit 4 comprises a rectifying circuit, a filtering circuit, and an output load. The rectifying circuit comprises a plurality of diodes D1, D2, D3, and D4, and these diodes D1, D2, D3, and D4 form a bridge rectifying circuit, to change a voltage or a current, which
15 is alternatively varied positively and negatively at the primary side and the secondary side of the convertor 1, into a unidirectional voltage or current. The filtering circuit comprises an output inductor L_o and an output capacitor C_o, and the filtering circuit performs a smoothing treatment to a unidirectional pulsating voltage or current after being rectified by the rectifying circuit, which reduces pulsating
20 components of the output voltage or current, so that the output voltage or current is enabled to be close to an ideal DC voltage or current. The output load can for example be designed as an LED or a resistor which can emit light.

Fig. 2 shows a circuit schematic diagram of a lighting apparatus according to a second embodiment of the present invention. A driving device 100 of the second
25 embodiment not only comprises the convertor 1 and the series capacitor C1 connected to the primary side of the convertor 1 and the parallel capacitor C2 connected to the secondary side of the convertor 1 in the first embodiment, and the driving device 100 also comprises a second inductor L2 connected to the primary side of the convertor 1. In the second embodiment, the second inductor L2
30 provided at the primary side of the convertor 1, together with the leakage inductance of the convertor 1, can form a resonant inductance for the LCC resonant tank 2, that is, a summation of the second inductor L2 and the leakage inductance can be equivalent to the resonant inductor of the LCC resonant tank 2. Thus, the leakage inductance of the convertor 1 does not act as a whole resonant inductance
35 of the LCC resonant tank 2, but as a part of the resonant inductance. The driving

device 100 according to the second embodiment reduces the inductance value of the resonant inductor separately provided, i.e. reduces the inductance value of the second inductor L2, and sufficiently utilizes the leakage inductance of the convertor 1.

5 Fig. 3a and Fig. 3b exemplarily show waveforms of output voltages of driving devices according to the prior art and the present invention, respectively. Fig. 3a shows a voltage waveform at output diodes D2 and D3 of the driving device when using the prior art. It can be seen from the drawing that the output voltage apparently has problem of ringing voltage during turn-on and turn-off. According to
10 the output voltage waveform as shown in Fig. 3b, the driving device according to the present invention can completely eliminate the ringing voltage generated at the output diodes D2 and D3 when turned on and turned off.

Fig. 4a and Fig. 4b exemplarily show waveforms of output currents of driving devices according to the prior art and the present invention when being started up,
15 respectively. It can be seen obviously from Fig. 4a that when the driving device is started up, abnormality occurs to the output current due to influences of high-frequency oscillation of the leakage inductance of the transformer and the parallel capacitor. It can be seen obviously from Fig. 4b that the driving device according to the present invention provides a good output current waveform when
20 started up since the unfavorable influences brought by the leakage inductance of the transformer and the parallel capacitor in the prior art are eliminated.

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,
25 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	convertor
	2	resonant tank
	3	power supply unit
5	4	load unit
	C1	series capacitor
	C2	parallel capacitor
	D1, D2, D3, D4	diode
	L1	first inductor
10	L2	second inductor
	Lo	output inductor
	Co	output capacitor
	100	driving device.

CLAIMS:

1. A driving device (100) for a lighting apparatus, characterized by comprising:
a convertor (1), wherein an input end of the convertor (1) is connected to a power supply unit (3) and is provided with a series capacitor (C1); an
5 output end of the convertor (1) is connected to a load unit (4) of the lighting apparatus and is provided with a parallel capacitor (C2), the convertor (1) is internally integrated with a first inductor (L1), wherein the series capacitor (C1), the parallel capacitor (C2), and the first inductor (L1) form a resonant tank (2).
- 10 2. The driving device (100) according to claim 1, characterized in that the driving device (100) further comprises:
a second inductor (L2), provided at the input end of the convertor (1), and forming the resonant tank (2) with the first inductor (L1), the series capacitor (C1), and the parallel capacitor (C2).
- 15 3. The driving device (100) according to claim 1 or 2, characterized in that the first inductor (L1) is a leakage inductance of the convertor (1).
4. The driving device (100) according to claim 1 or 2, characterized in that the power supply unit (3) comprises a plurality of power transistors, wherein the plurality of power transistors are connected to the input end of the convertor (1).
- 20 5. The driving device (100) according to claim 4, characterized in that the load unit (4) comprises a rectifying circuit, a filtering circuit, and an output load, wherein the rectifying circuit has one end connected to the parallel capacitor (C2), and the other end connected to the output load through the filtering circuit.
- 25 6. The driving device (100) according to claim 5, characterized in that the rectifying circuit comprises a rectifying bridge having a plurality of diodes.
7. The driving device (100) according to claim 5, characterized in that the filtering circuit comprises an output inductor and an output capacitor.

- 10 -

8. A lighting apparatus, comprising the driving device (100) according to any one of claims 1-7.
9. The lighting apparatus according to claim 8, characterized in that the lighting apparatus is designed as an LED lighting apparatus.

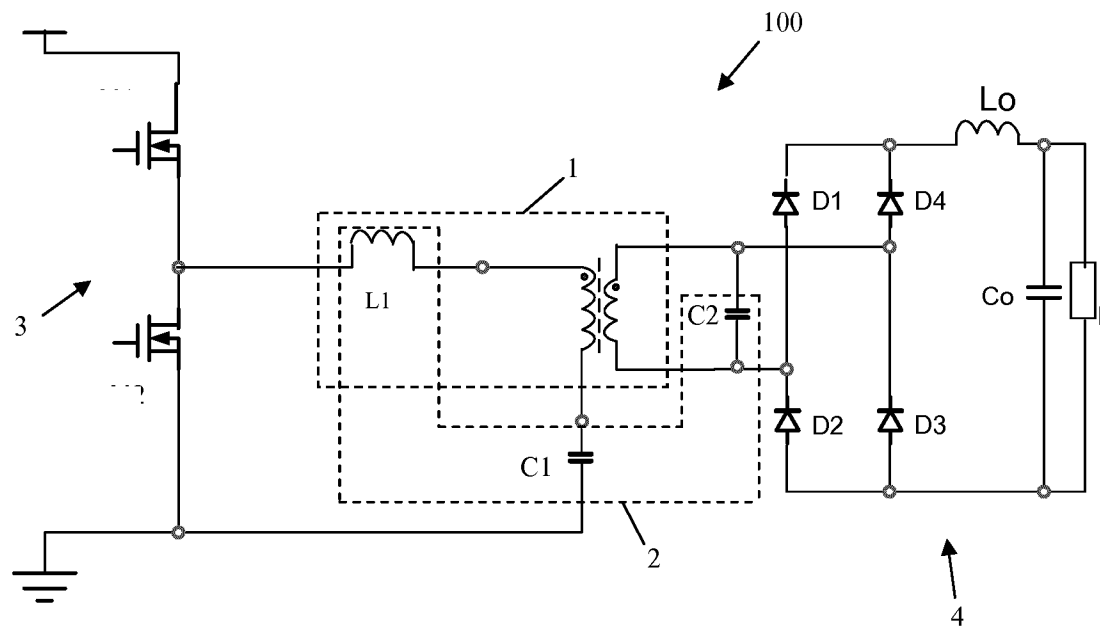


Fig. 1

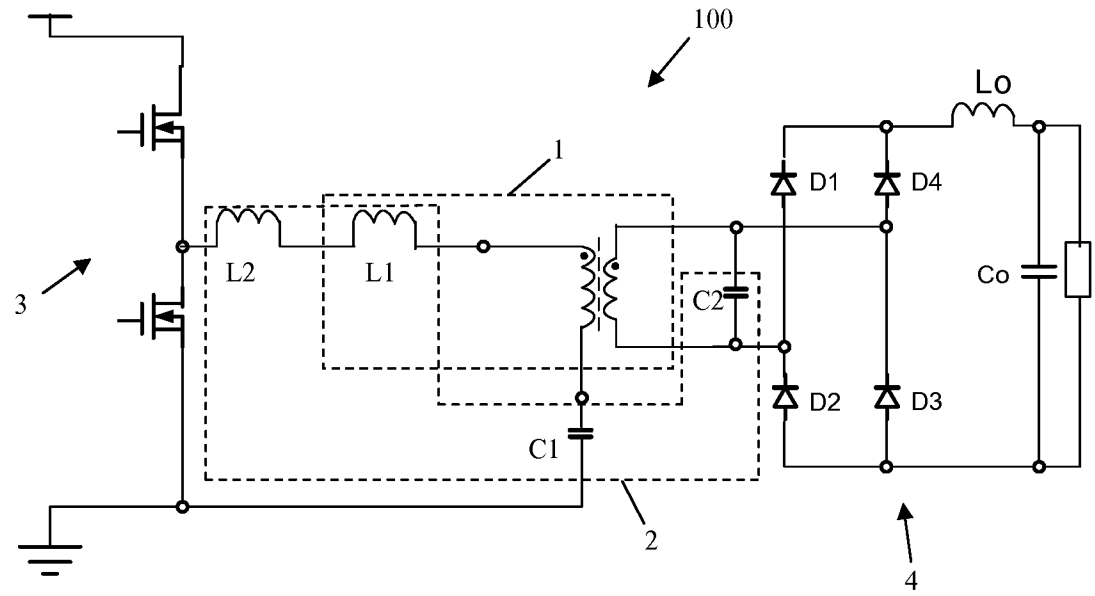
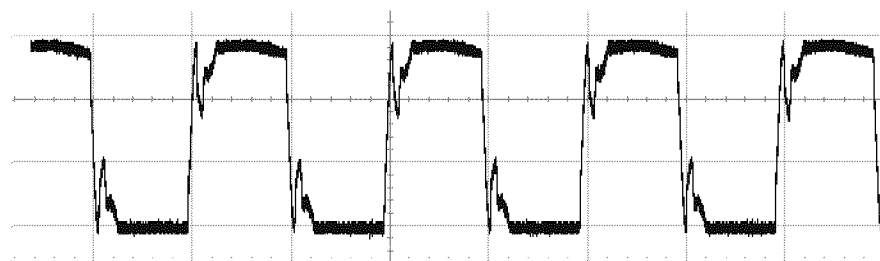
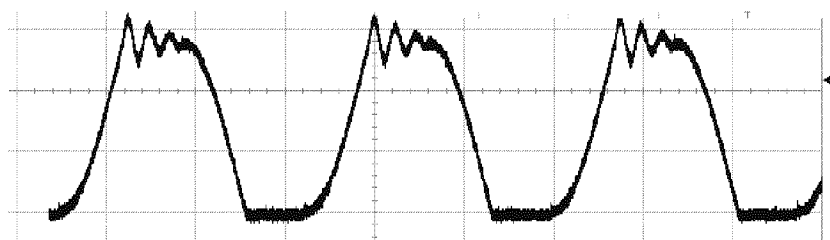


Fig. 2

**Fig. 3a****Fig. 3b**

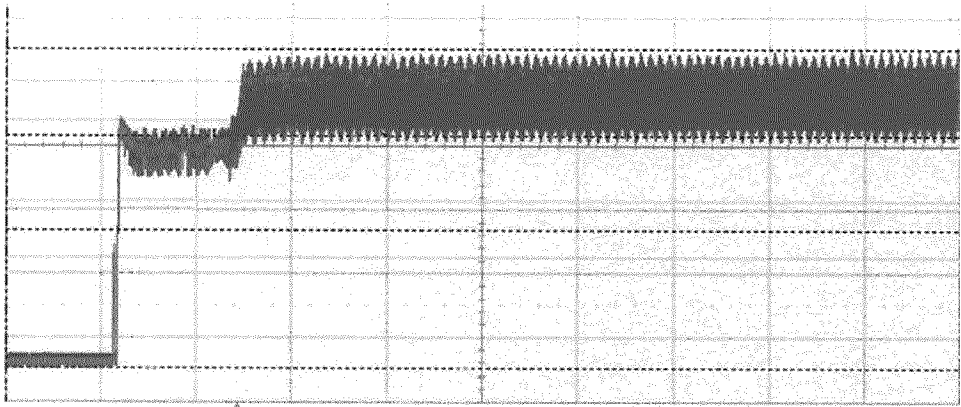


Fig. 4a

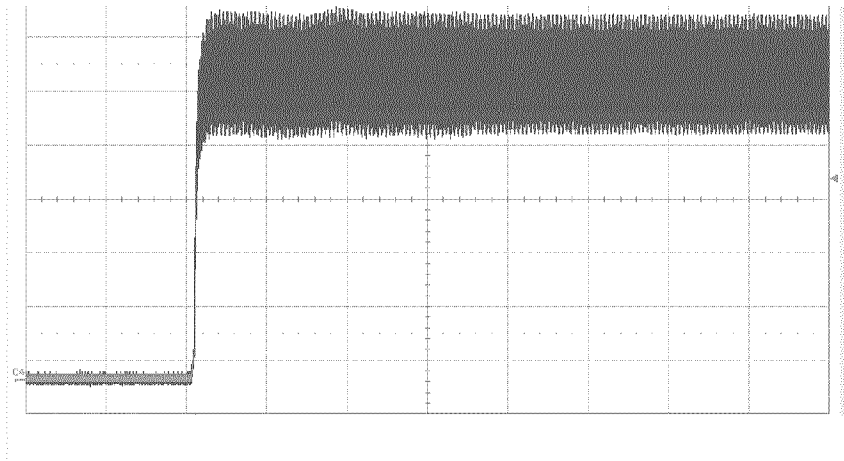


Fig. 4b

INTERNATIONAL SEARCH REPORT

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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

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)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	YUESHI GUAN ET AL: "A novel DC/DC converter based on series-parallel resonant network for LED driver", 2016 IEEE 8TH INTERNATIONAL POWER ELECTRONICS AND MOTION CONTROL CONFERENCE (IPEMC-ECCE ASIA), IEEE, 22 May 2016 (2016-05-22), pages 3301-3305, XP032924811, DOI: 10.1109/IPEMC.2016.7512824 [retrieved on 2016-07-13] abstract chapter II, item A.; figure 1 ----- -/--	1-4,8,9



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/061578

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BHAT A K S: "ANALYSIS AND DESIGN OF SERIES-PARALLEL RESONANT POWER SUPPLY", IEEE TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 28, no. 1, 1 January 1992 (1992-01-01), pages 249-258, XP000290790, ISSN: 0018-9251, DOI: 10.1109/7.135450 chapter I., fig.1, chapter II -----	1,4-7
A	LIU KWANG-HWA ET AL: "Secondary-side resonance for high-frequency power conversion", 1987 IEEE APPLIED POWER ELECTRONICS CONFERENCE AND EXPOSITION, IEEE, 28 April 1986 (1986-04-28), pages 83-89, XP032769384, ISSN: 1048-2334, DOI: 10.1109/APEC.1986.7073317 [retrieved on 2015-03-30] chapter 2.2; fig.17 -----	1-7