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(54) Title: DRIVER WITH CHARGE PUMP CIRCUIT

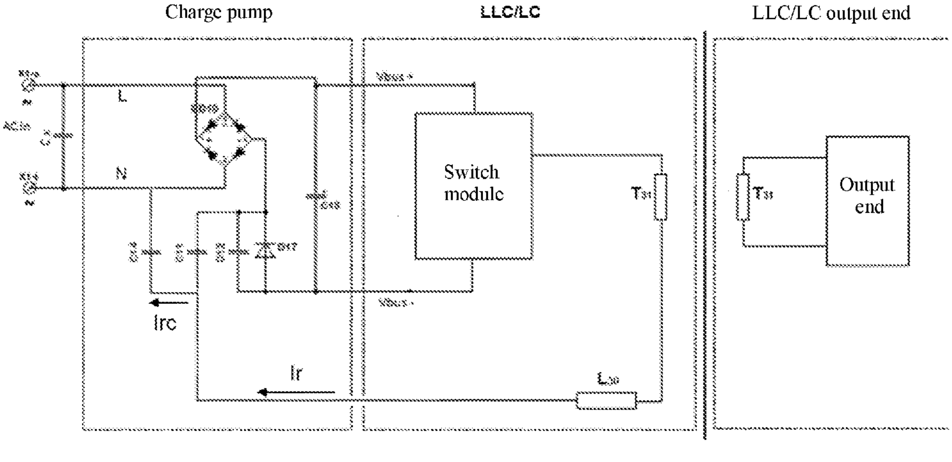

Fig. 3

(57) Abstract: Disclosed in the present application is a driver for lighting means, preferably light emitting diodes, comprising a charge pump circuit, which is improved based on a common first-stage charge pump circuit. A fifth capacitor is added to connect a power source input end of the charge pump circuit to an LLC or LC circuit, a compensation current is provided for the power source input end using a resonant current generated by a resonant inductance in the LLC or LC circuit, an input angle of a power input current is widened and the input current is smoothed, so as to improve the problems, that a total harmonic distortion is larger and the harmonic does not satisfy the IEC standard, of a single-stage charge pump circuit where the output range is larger. Moreover, compared with a second-stage charge pump circuit that can achieve the equivalent PFC effect, the charge pump circuit disclosed in the present application omits three diode devices and the corresponding connecting wires thereof, and thus has the advantages of a lower cost and smaller circuit volume.

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Description

Driver with charge pump circuit

Technical Field

The present invention relates to the technical field of circuits for lighting means, and in particular to a driver comprising a charge pump circuit for PFC.

Background Art

In the field of light emitting diode (LED) drivers with a switched converter like a half-bridge circuit structure, ballasts and other power source circuits with similar functions, the charge pump circuit is a commonly used PFC (Power Factor Correction) solution, and has the advantages of a low cost and high efficiency, etc.

Fig. 1 shows the application of a single-stage charge pump circuit in the prior art. The single-stage charge pump circuit comprises a power source input end AC_{in}, a capacitor C_X, a capacitor C_{11}, a capacitor C_{12}, a capacitor C_{13}, a single-phase rectifier bridge BD_{10} and a diode D_{17}, wherein a live line and a neutral line of the input end AC_{in} are connected to a pin 3 and a pin 4 of the single-phase rectifier bridge BD_{10}; the capacitor C_X is provided between the live line and the neutral line; a pin 1 of the single-phase rectifier bridge BD_{10} is connected to a V_{bus+} line of a series oscillation circuit; one end of each of the capacitor C_{11}, the capacitor C_{12} and the diode D_{17} is respectively connected to a pin 2 of the single-phase rectifier bridge BD_{10}, wherein the other end of each of the capacitor C_{12} and the diode D_{17} is respectively connected to a V_{bus-} line of the series oscillation circuit, and the other end of the capacitor C_{11} is connected in series with a resonant inductance L_{30} and a transformer T_{31} in the series oscillation circuit; and a plurality of parallel resistors R_{32}, R_{33} and R_{34} for monitoring a resonant current may be provided in series between the capacitor C_{11} and the resonant inductance L_{30}. During the working process of the above-mentioned circuit, the resonant inductance L_{30} generates a resonant current I_r flowing to the capacitor C_{11}, and after the capacitor C_{11} is charged, the resonant current I_r changes into a current I_{r1} flowing to the capacitor C_{12} to charge same. The charging process lasts until when the sum of a voltage V_{C12} across the capacitor C_{12} and an input end voltage V_{ACin} is equal to the sum of a voltage V_{C13} across the capacitor C_{13} and a voltage V_{BD10} across the single-phase rectifier bridge BD_{10}, the current I_{r1} no longer charges the capacitor C_{12} and changes into a current I_{r2} flowing to the single-phase rectifier bridge BD_{10} and charges the capacitor C_{13}, and at this moment, the input end current is equal to the current I_{r2}. The single-stage charge pump circuit has the advantages of a simple structure and low cost, and is a commonly used PFC solution; however, where the output range is wider, there are the problems that the total harmonic distortion is larger and the harmonic does not satisfy the IEC standard.

Fig. 2 shows the application of a second-stage charge pump circuit in the prior art. The second-stage charge pump circuit is based on the above-mentioned first-stage charge pump circuit with a capacitor C_{10} and three diode devices D_{14}, D_{15} and D_{16} added. Compared with the single-stage charge pump circuit, the second-stage and multi-stage charge pump circuits can prevent the problem of the existence of total harmonic distortion and a harmonic in a wider output range; however, it can be seen from Fig. 2 that it is only for widening the output range of the charge pump circuit to satisfy the IEC standard that a plurality of components are added to the second-stage charge pump circuit, which makes the circuit structure thereof more complicated, thus increasing the production cost and product volume, and this does not meet the development trend of miniaturization and precision of modern electronic products.

Summary of the Invention

It is an object of the present invention to make an improvement based on the common single-stage charge pump circuit, so as to solve the problems of the total harmonic distortion and harmonics existing in a first-stage charge pump circuit in a wider output range.

The driver for lighting means, preferably light emitting diodes, comprising a charge pump circuit operating as power factor correction circuit (PFC circuit) provided in the present invention comprises a power source input end, a single-phase rectifier bridge, a diode, a first capacitor, a second capacitor, a third capacitor, a fourth capacitor and a fifth capacitor, wherein the power source input end comprises two input lines, namely a live line and a neutral line; the single-phase rectifier bridge comprises a first pin, a second pin, a third pin and a fourth pin, and the first pin is mutually diagonal to the second pin, the third pin and the fourth pin; the live line and the neutral line are respectively connected to the third pin and the fourth pin of the single-phase rectifier bridge; the first capacitor is provided between the live line and the neutral line; the first pin of the single-phase rectifier bridge is connected to a V_{bus+} line of a series oscillation circuit (LLC) or oscillation circuit (LC) switch module; a first end of each of the second capacitor, the third capacitor and the diode is respectively connected to the second pin of the single-phase current bridge, a second end of the second capacitor is connected to one end of a resonant inductance or a transformer away from the switch module in the series oscillation circuit (LLC) or the oscillation circuit (LC), and a second end of each of the third capacitor and the diode is connected to a V_{bus-} line of the series oscillation circuit (LLC) or oscillation circuit (LC) switch module; the fourth capacitor is provided between the V_{bus+} line and the V_{bus-} line; and the fifth capacitor is provided between the power source input end and the series oscillation circuit (LLC) or oscillation circuit (LC) to provide a compensation current for an input current of the power source input end.

As an alternative, the fifth capacitor being provided between the power source input end and the series oscillation circuit (LLC) or oscillation circuit (LC) comprises: a first end of the fifth capacitor being connected to the live line or the neutral line of the power source input end, and a second end of the fifth capacitor being connected to the second end of the second capacitor.

As an alternative, providing a compensation current for an input current of the power source input end comprises: the resonant inductance in the series oscillation circuit (LLC) or oscillation circuit (LC) generating a resonant current flowing to the second capacitor and the fifth capacitor, and when the sum of a voltage across the third capacitor and a voltage across the power source input end is greater than or equal to a voltage across the fourth capacitor, the resonant current branching out the compensation current to flow to the power source input end along the line where the fifth capacitor is located, until the single-phase rectifier bridge is turned on.

The present invention has the advantages as follows: by adding, to a first-stage charge pump circuit structure, a capacitor device for connection to a power source input end of the charge pump circuit and a series oscillation circuit (LLC) or an oscillation circuit (LC), providing a compensation current for the power source input end, widening an input angle of a power input current and smoothing the input current, so as to improve the problems, that a total harmonic distortion is larger and the harmonic does not satisfy the IEC standard, existing in a single-stage charge pump circuit where the output range is wider. Also, compared with a second-stage charge pump circuit that can achieve the equivalent PFC effect, the charge pump circuit disclosed in the present invention omits three diode devices and the corresponding connecting wires thereof, and has the advantages of a lower cost and smaller circuit volume.

Brief Description of the Drawings

Fig. 1 is a schematic diagram of application of a single-stage charge pump circuit in the prior art;

Fig. 2 is a schematic diagram of application of a second-stage charge pump circuit in the prior art;

Fig. 3 is a schematic diagram of application of a driver comprising a charge pump circuit for PFC provided by the embodiments of the present invention.

Detailed Description of the Drawings

The present invention will be further described in detail below with reference to the accompanying drawings and in combination with specific embodiments.

The driver for lighting means, preferably light emitting diodes, provided in an embodiment of the present invention, as shown in Fig. 3, comprises a charge pump circuit. It comprises a power source input end (AC_{in}), a single-phase rectifier bridge (BD_{10}), a series oscillation circuit (LLC) or oscillation circuit (LC) comprising a switch module, preferably formed by a half-bridge, and resonant inductance (L_{30}) or a transformer (T_{31}). It further a diode (D_{17}), a first capacitor (C_X), a second capacitor (C_{11}), a third capacitor (C_{12}), a fourth capacitor (C_{13}) and a fifth capacitor (C_{14}), wherein the power source input end (AC_{in}) comprises two input lines, namely a live line (L) and a neutral line (N); the single-phase rectifier bridge (BD_{10}) comprises a first pin (1), a second pin (2), a third pin (3) and a fourth pin (4), wherein the first pin (1) is mutually diagonal to the second pin (2), the third pin (3) and the fourth pin (4); the live line (L) and the neutral line (N) are respectively connected to the third pin (3) and the fourth pin (4) of the single-phase rectifier bridge (BD_{10}); the first capacitor (C_X) is provided between the live line (L) and the neutral line (N); the first pin (1) of the single-phase rectifier bridge (BD_{10}) is connected to a positive direct current supply line (V_{bus+} line) of a series oscillation circuit (LLC) or oscillation circuit (LC) switch module; a first end of each of the second capacitor (C_{11}), the third capacitor (C_{12}) and the diode (D_{17}) is respectively connected to the second pin (2) of the single-phase current bridge (BD_{10}), a second end of the second capacitor (C_{11}) is connected to one end of a resonant inductance (L_{30}) or a transformer (T_{31}) away from a switch module in the series oscillation circuit (LLC) or oscillation circuit (LC), and a second end of each of the third capacitor (C_{12}) and the diode (D_{17}) is connected to a V_{bus-} line of the series oscillation circuit (LLC) or the oscillation circuit (LC) switch module; the fourth capacitor (C_{13}) is provided between the V_{bus+} line and the V_{bus-} line; and the fifth capacitor (C_{14}) is provided between the power source input end (AC_{in}) and the series oscillation circuit (LLC) or oscillation circuit (LC) to provide a compensation current for an input current of the power source input end (AC_{in}). The charge pump circuit works as a power factor correction circuit (PFC circuit).

The charge pump circuit for a driver for lighting means, preferably light emitting diodes, provided in an embodiment of the present invention is a first-stage charge pump circuit in the prior art when the fifth capacitor (C_{14}) is not added thereto, and the first-stage charge pump circuit can basically satisfy the application requirements in the driver circuit; however, where the output range is wider, there are problems that the total harmonic distortion is larger and the harmonic does not satisfy the IEC standard. The charge pump circuit for the driver provided in an embodiment of the present invention provides, by adding the fifth capacitor (C_{14}), connecting the power source input end (AC_{in}) and the LLC or LC circuit and introducing a partial resonant current generated by a resonant inductance in the LLC or LC circuit to the power source input end (AC_{in}), a compensation current for the power input current, widens an input angle of the input current and smooths the input current, so that the circuit achieves a better power factor, total harmonic distortion and harmonic effects in a wider input range and also satisfies the IEC standard.

Optionally, the fifth capacitor being provided between the power source input end and the series oscillation circuit (LLC) or oscillation circuit (LC) comprises: a first end of the fifth capacitor being connected to the live line or the neutral line of the power source input end, and a second end of the fifth capacitor being connected to the second end of the second capacitor. As shown in Fig. 3, a first end of the fifth capacitor (C_{14}) is connected to the neutral line (N) of the power source input end (AC_{in}) and a second end of the fifth capacitor (C_{14}) is connected to the second end of the second capacitor (C_{11}), that is, the second ends of the fifth capacitor (C_{14}) and the second capacitor (C_{11}) are jointly connected to one end of the resonant inductance (L_{30}) away from the switch module in the series oscillation circuit (LLC) or oscillation circuit (LC).

Fig. 3 shows an example of a clocked converter comprising a switch module and a transformer T_{31} according to the invention. The clocked converter comprising a switch module and a transformer (T_{31}) according to the invention may form a part of a driver for operating a light source, preferably a LED. The clocked converter may be also formed by a flyback converter or another isolated converter topology comprising a transformer (T_{31}) which is fed with a voltage provided by the V_{bus+} line and chopped at high frequency by the switch module. The transformer (T_{31}) and optionally the resonant inductance (L_{30}) of the clocked converter is coupled to the charge pump circuit according to this invention comprising a second capacitor (C_{11}) and a fifth capacitor (C_{14}).

Optionally, providing a compensation current for an input current of the power source input end comprises: the resonant inductance in the series oscillation circuit (LLC) or oscillation circuit (LC) generating a resonant current flowing to the second capacitor and the fifth capacitor, and when the sum of a voltage across the third capacitor and a voltage across the power source input end is greater than or equal to a voltage across the fourth capacitor, the resonant current branching out the compensation current to flow to the power source input end along the line where the fifth capacitor is located, until the single-phase rectifier bridge is turned on. As shown in Fig. 3, the resonant inductance (L_{30}) in the series oscillation circuit (LLC) or oscillation circuit (LC) generates a resonant current (I_r) flowing to the second capacitor (C_{11}) and the fifth capacitor (C_{14}), and when the sum of a voltage across the third capacitor (C_{12}) and a voltage across the power source input end (AC_{in}) $\geq$ a voltage across the fourth capacitor (C_{13}), the resonant current (I_r) branches out a compensation current (I_{rC}) to flow to the power source input end (AC_{in}) along the line where the fifth capacitor (C_{14}) is located until the single-phase rectifier bridge (BD_{10}) is turned on. The compensation current (I_{rC}) widens an input angle of a power input current and smooths the input current, so as to improve the problems, that a total harmonic distortion is larger and the harmonic does not satisfy the IEC standard, existing in a single-stage charge pump circuit where the output range is wider. Also, compared with a second-stage charge pump circuit that can achieve the equivalent PFC effect, the charge pump circuit disclosed in the present invention omits three diode devices and the corresponding connecting wires thereof, and has the advantages of a lower cost and smaller circuit volume.

It should be finally illustrated that the above embodiments are only used to illustrate the technical solutions of the present invention, but not as a limitation to the present invention. A person of ordinary skill in the art should know that the technical solutions stated in the above-mentioned embodiments may still be modified or equivalent replacements may be made to some or even all of the technical features without making any creative efforts, and these modifications or replacements do not make the essence of the corresponding technical solutions depart from the scope of the technical solutions of the present invention.

Claims

1. Driver for lighting means, preferably light emitting diodes, comprising a charge pump circuit for characterized by comprising a power source input end, a single-phase rectifier bridge, a diode, a first capacitor, a second capacitor, a third capacitor, a fourth capacitor and a fifth capacitor, wherein the power source input end comprises two input lines, namely a live line and a neutral line; the single-phase rectifier bridge comprises a first pin, a second pin, a third pin and a fourth pin, and the first pin is mutually diagonal to the second pin, the third pin and the fourth pin; the live line and the neutral line are respectively connected to the third pin and the fourth pin of the single-phase rectifier bridge; the first capacitor is provided between the live line and the neutral line; the first pin of the single-phase rectifier bridge is connected to a V_{bus+} line of a series oscillation circuit (LLC) or oscillation circuit (LC) switch module; a first end of each of the second capacitor, the third capacitor and the diode is respectively connected to the second pin of the single-phase current bridge, a second end of the second capacitor is connected to one end of a resonant inductance or a transformer away from the switch module in the series oscillation circuit (LLC) or the oscillation circuit (LC), and a second end of each of the third capacitor and the diode is connected to a V_{bus-} line of the series oscillation circuit (LLC) or oscillation circuit (LC) switch module; the fourth capacitor is provided between the V_{bus+} line and the V_{bus-} line; and the fifth capacitor is provided between the power source input end and the series oscillation circuit (LLC) or oscillation circuit (LC) to provide a compensation current for an input current of the power source input end.

2. Driver according to Claim 1, characterized in that the fifth capacitor being provided between the power source input end and the series oscillation circuit (LLC) or oscillation circuit (LC) comprises: a first end of the fifth capacitor being connected to the live line or the neutral line of the power source input end, and a second end of the fifth capacitor being connected to the second end of the second

capacitor.

3. Driver according to Claim 2, characterized in that providing a compensation current for an input current of the power source input end comprises: the resonant inductance in the series oscillation circuit (LLC) or oscillation circuit (LC) generating a resonant current flowing to the second capacitor and the fifth capacitor, and when the sum of a voltage across the third capacitor and a voltage across the power source input end is greater than or equal to a voltage across the fourth capacitor, the resonant current branching out the compensation current to flow to the power source input end along the line where the fifth capacitor is located, until the single-phase rectifier bridge is turned on.

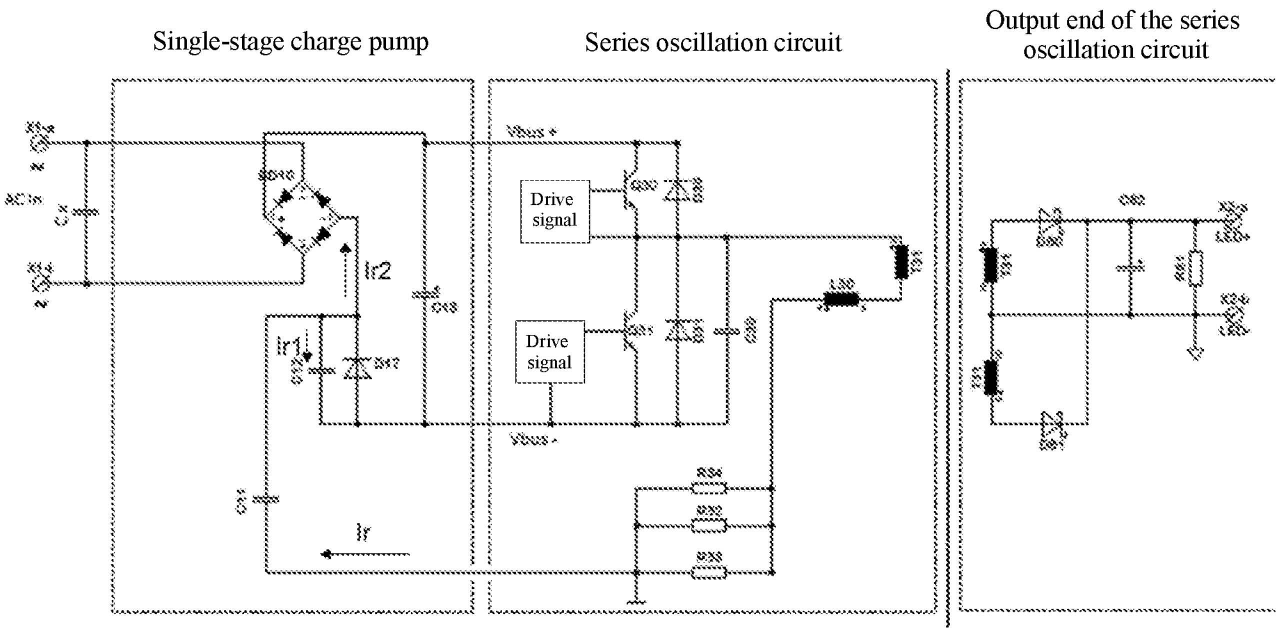

Single-stage charge pump
Series oscillation circuit
Output end of the series oscillation circuit
Drive signal
Drive signal
Ir2
Ir1
Ir

Fig. 1

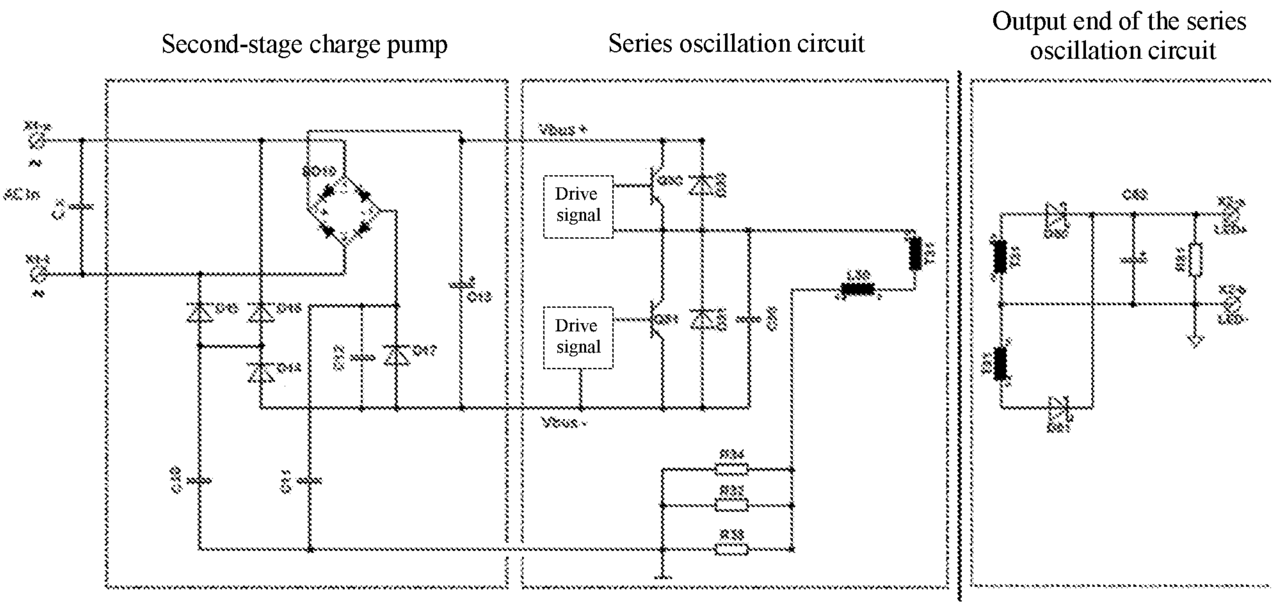
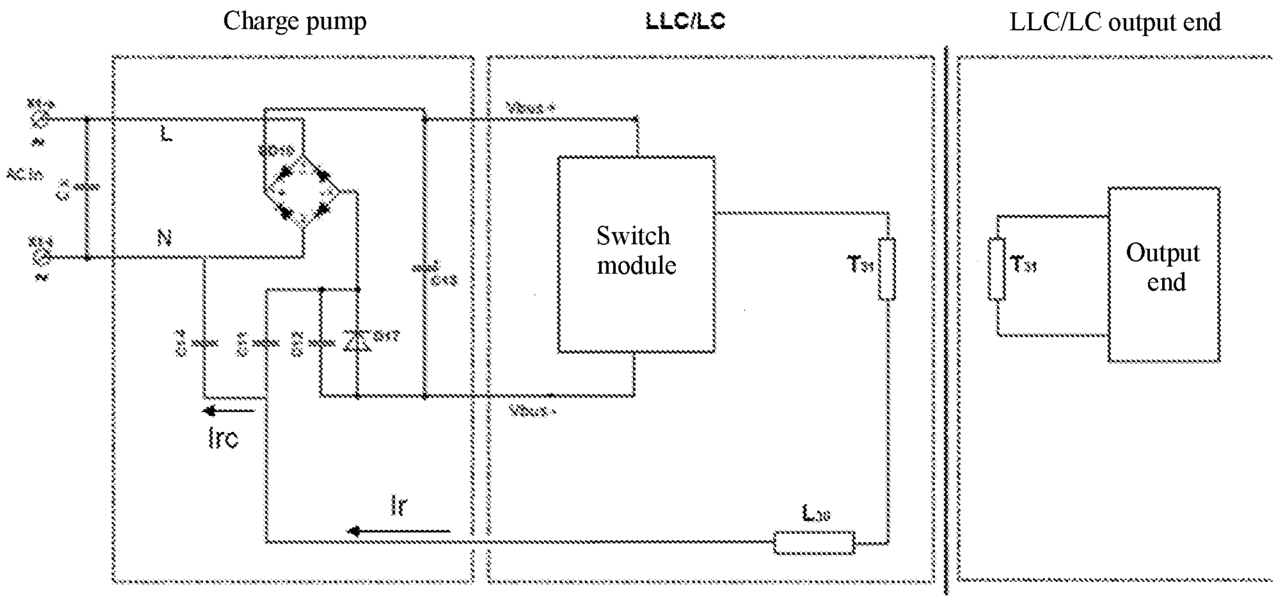

Second-stage charge pump
Series oscillation circuit
Output end of the series oscillation circuit
Drive signal
Drive signal

Fig. 2



Charge pump
LLC/LC
LLC/LC output end
L
N
Switch
module
Irc
Ir
Output
end

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/079172

A. CLASSIFICATION OF SUBJECT MATTER

H02M 1/12(2006.01)i

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)

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)

CNABS, DWPI, SIPOABS, CNKI, IEEE: light emitting diode?, LED, driv+, charge pump, power factor, capacitor, condenser, charg+, resonan+, oscillat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 102088810 A (OSARM GMBH) 08 June 2011 (2011-06-08) see description, paragraphs 0028 to 0044 and figures 1 to 3	1-3
A	CN 1682576 A (TRIDONICATCO GMBH & CO KG) 12 October 2005 (2005-10-12) the whole document	1-3
A	EP 2490511 A1 (NXP BV) 22 August 2012 (2012-08-22) the whole document	1-3
A	US 2012033451 A1 (SANKEN ELECTRIC CO LTD) 09 February 2012 (2012-02-09) the whole document	1-3

☐ 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
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 May 2018	**20 June 2018**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/079172

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