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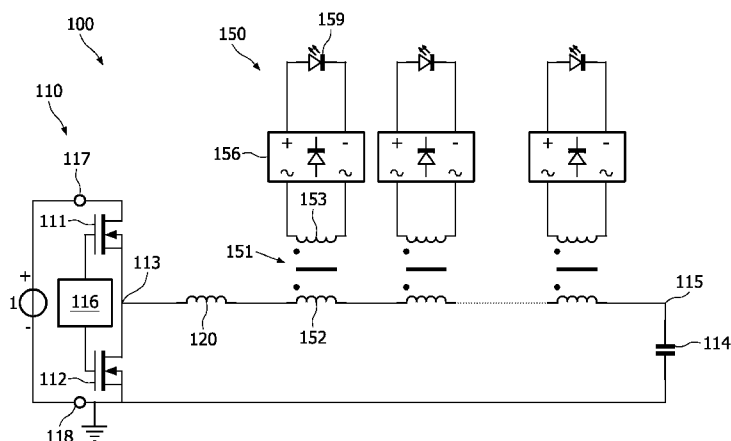


FIG. 1

(57) Abstract: A driver circuit (100; 200) for driving a plurality of LEDs (159) comprises: a series arrangement of two controllable switches (111, 112) connected between said two input terminals (117, 118); a controller (116) for alternatively and in counterphase controlling said two switches; an inductor (120) coupled to a first node (113) between said two switches; a plurality of LED circuits (150; 250), each LED circuit comprising at least one LED and a secondary transformer winding (153; 262), and a rectifying circuit (156) arranged between said secondary transformer winding and said LED; transformer means (151; 260) comprising at least one winding (152; 261) arranged in series with said inductor (120), said transformer means being designed for coupling current from said inductor (120) to said secondary transformer windings (153; 262); wherein the inductivity of said at least one winding (152; 261) is smaller than the inductivity of said inductor (120).

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Driver device for driving a plurality of LEDs

FIELD OF THE INVENTION

The present invention relates in general to a driver circuit for LED arrays.

BACKGROUND OF THE INVENTION

5 In the field of illumination, LEDs are replacing other types of light sources. For many applications, one LED is not sufficient to produce the required light output, so a lighting system needs to have a plurality of LEDs.

 For powering a LED from mains, it is known to design a driver which comprises a rectifying stage for rectifying mains alternating voltage, and a converter stage for
10 converting the rectified voltage to an alternating voltage. Further, in order to reduce distortion of the mains voltage by a non-harmonic load, a power factor correction stage is required.

 For powering an array of LEDs, it is of course possible to have individual drivers for the individual LEDs, but this would be very costly, impractical, and it would be
15 difficult to have the same current for each LED.

 US patent application 2004/0257838 discloses a circuit having a common converter for multiple outputs. A transformer has a common input winding connected in series with a switch. This series arrangement receives DC voltage, and the switch converts this to an alternating voltage over the input transformer winding. The transformer has
20 multiple secondary windings, each producing an alternating output voltage, which is subsequently rectified to produce a DC output voltage. In such an arrangement, it is difficult to assure that the output currents in all output branches are mutually equal. Further, it is difficult to implement power factor correction function with such circuit.

25 SUMMARY OF THE INVENTION

 It is a general objective of the present invention to overcome or at least reduce the above problems.

 According to an important aspect of the present invention, a driver circuit for multiple LEDs comprises a current transformer having a plurality of output windings

producing output current. A series inductor is arranged in series with the transformer primary, the series inductor having an inductance substantially larger than the inductance of the transformer primary, so that the current in the transformer primary is substantially only determined by the inductance of the series inductor. Thus, the behavior of the load has little or no influence on the current behavior in the primary circuit, and it is easily possible to implement a power factor correction function in the primary circuit. Further advantageous elaborations are mentioned in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects, features and advantages of the present invention will be further explained by the following description of one or more preferred embodiments with reference to the drawings, in which same reference numerals indicate same or similar parts, and in which:

figure 1 is a block diagram schematically illustrating a first embodiment of a driver circuit;

figure 2 is a block diagram schematically illustrating a second embodiment of a driver circuit.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 is a block diagram schematically illustrating a first embodiment 100 of a driver circuit according to the present invention. The circuit comprises a DC/AC converter stage 110, having input terminals 117, 118 for receiving DC input voltage from a DC voltage source 1, and producing AC output current. In this example, the converter stage 110 is implemented as a half-bridge circuit, but as an alternative it is possible to use a full-bridge circuit or any other type of circuit capable of generating a symmetrical voltage without any DC component. Since half-bridge converter circuits are known per se, an explanation of the circuit and its functioning will be kept to a minimum.

The converter stage 110 comprises a series arrangement of two controllable switches 111 and 112 connected between said two input terminals 117, 118, typically MOSFETs, with a first output node 113 between these two switches, said series arrangement receiving the input voltage from source 1. The converter stage 110 further comprises a capacitor 114 having one terminal connected to one of the supply lines and having its other end connected to a second output node 115. Possibly, but not shown, the converter stage 110 comprises a further capacitor having one terminal connected to the other one of the supply

lines and having its other end connected to said second output node 115. The converter stage 110 further comprises a controller 116 for controlling the switches 111, 112 such as to be alternatively conductive and non-conductive (ON and OFF), such that the switches are never conductive simultaneously. As a result, the first output node 113 alternatively carries the high voltage level and the low voltage level of the voltage source 1. The capacity of the capacitor 114 is sufficiently high such that the voltage at the second output node 115 is substantially constant. As a result, a square wave output voltage is generated over the output nodes 113, 115, the frequency of this square wave output voltage being determined by the (relatively high) switching frequency of the controller 116.

An inductor 120 is connected in series with the output nodes 113, 115. The square wave output voltage over the inductor 120 results in a triangular current through the inductor 120.

An LED circuit is indicated at reference numeral 150. The driver circuit 100 comprises a plurality of mutually substantial identical LED circuits 150. If this would increase clarity, individual LED circuits will be individually distinguished by addition of an index between brackets, and the same shall apply to their components. For sake of simplicity, figure 1 only shows three LED circuits, but the number of LED circuits may easily be in the order of 100 or more.

Each LED circuit 150 basically comprises a current transformer 151 having a primary winding 152 and a secondary winding 153, and a rectifier 156 having its input connected to the secondary transformer winding 153. The rectifier 156 may have any suitable configuration, for instance a diode bridge, as known per se. An LED 159 is connected to the output of the rectifier 156. For sake of simplicity, the figure shows one LED 159 connected to the output of the rectifier 156, but typically a string of multiple LEDs may be connected to the output of the rectifier 156.

In each LED circuit 150, the transformer 151 will be designed to produce the required LED (string) current. This comes into expression in a certain ratio between the number of secondary turns and the number of primary turns in the secondary winding 153 and the primary winding 152, respectively.

The primary windings 152 of all LED circuits 150 are connected in series with each other and in series with the inductor 120 between said output nodes 113, 115. This means that all primary windings 152 receive the same current.

The current amplitude depends, apart from the voltage and the frequency, on the inductance value between output nodes 113, 115, i.e. the summation of the inductance of

the inductor 120 and all inductances of all primary windings 152. However, in each transformer 151, the number of primary turns in the primary winding 152 is relatively small, so that the inductance of each primary winding 152 is negligible. Even the summation of all inductances of all primary windings 152 is small compared to the inductance of the inductor 120, so that the current amplitude is substantially determined by the inductance of the inductor 120 alone. This means that adding or removing a LED circuit 150 has no noticeable influence on the current, and has thus no noticeable influence on the LED current. Further, the load for the voltage source 1 is not affected by adding or removing a LED circuit 150, nor by variations in the forward voltage of the LEDs. It is noted that, generally, the constant voltage source 1 will itself be powered from mains, and that it must be designed properly such as to provide a correct load to mains. In the design according to the present invention, the load to mains is not influenced by the LED strings so that a separate power correction function is not required.

Figure 2 is a block diagram schematically illustrating a second embodiment 200 of a driver circuit according to the present invention. In contrast to the individual transformers 151 for the individual LED circuits 150, this embodiment comprises a single transformer 260 with a single primary winding 261 and a plurality of secondary windings 262. In order to assure that the output currents provided by the secondary windings 262 are mutually equal, the LED circuits 250 are provided with equalizer transformers. Particularly, for each pair of LED circuits 250(i) and 250(i+1), there will be an equalizer transformer 270(i) having a first winding 271(i) connected in series with the secondary winding 262(i) and having a second winding 272(i) connected in series with the secondary winding 262(i+1), wherein the number of turns in the first winding 271(i) equals the number of turns in the second winding 272(i). Since the concept of equalizer transformers is known per se, a more elaborate explanation is not needed here.

Thus, each LED circuit 250(i) is coupled to one neighbor 250(i+1) through a first equalizer transformer 270(i) and is coupled to its other neighbor 250(i-1) through a second equalizer transformer 270(i-1). As a result, the current in the LED circuits 250 remains the same regardless of variations in the LED voltages, even if one circuit 250 fails to an open circuit.

In the case of the first embodiment, if one circuit 150 fails to an open circuit, the voltage over the circuit may increase and/or the corresponding transformer may saturate.

In order to prevent this, it is possible to implement a crowbar design that shorts the secondary winding 153 above a suitably selected threshold voltage.

An advantage of the first embodiment 100 is that it offers more flexibility in removing or adding a LED string. An advantage of the second embodiment 200 is that it may be cheaper to implement and that, in the case of many LED strings, it is easier to obtain a low impedance.

In both cases, it may be desirable or necessary to implement current control. To this end, a current sensor (not shown for sake of simplicity) can provide a current sense signal for the controller 116, which in response may amend the current for the LEDs, for instance by adapting its switching frequency: a higher frequency results in a lower current, and vice versa.

Such current sensor may be arranged in series with the primary winding(s) of the current transformer(s) between nodes 113 and 115, to sense the primary current.

Since ultimately the secondary current is more important, it is possible to arrange a current sensor in series with one of the secondary transformer windings. Now a practical problem may be that safety precautions may be needed in view of the fact that the sensor will be in contact with the LED surroundings while the controller will be coupled to mains voltage.

Instead of a current sensor arranged in one of the LED circuits 150, 250, it is possible to include a separate measuring module. In the case of the first embodiment 100, such current measuring module would contain the combination of at least a primary winding arranged in series with the inductor 120, a secondary winding, and a sensor sensing the current in the secondary winding, possibly after rectifying. In the case of the second embodiment 200, such current measuring module would contain the combination of at least a secondary winding coupled to the primary winding 261, and a sensor sensing the current in the secondary winding, possibly after rectifying.

Summarizing, the present invention provides a driver circuit 100; 200 for driving a plurality of LEDs 159, which driver comprises:

a series arrangement of two controllable switches 111, 112 connected between said two input terminals 117, 118;

a controller 116 for alternatively and in counterphase controlling said two switches;

an inductor 120 coupled to a first node 113 between said two switches;
a plurality of LED circuits 150; 250, each LED circuit comprising at least one LED and a
secondary transformer winding 153; 262, and a rectifying circuit 156 arranged between said
secondary transformer winding and said LED;

5 transformer means 151; 260 comprising at least one winding 152; 261
arranged in series with said inductor 120, said transformer means being designed for coupling
current from said inductor 120 to said secondary transformer windings 153; 262;
wherein the inductivity of said at least one winding 152; 261 is smaller than the inductivity of
said inductor 120.

10 While the invention has been illustrated and described in detail in the drawings
and foregoing description, it should be clear to a person skilled in the art that such illustration
and description are to be considered illustrative or exemplary and not restrictive. The
invention is not limited to the disclosed embodiments; rather, several variations and
15 modifications are possible within the protective scope of the invention as defined in the
appending claims.

For instance, instead of a DC voltage source 1, it is also possible that the
voltage source 1 provides a rectified AC voltage, having a frequency (for instance 50 Hz or
60 Hz) much lower than the switching frequency of the controller 116, so that, on the time
20 scale of the switching period of the switches 111, 112, the input voltage may be considered
constant. With such alternating input voltage, the current magnitude in the inductor 120 will
also be alternating.

Further, instead of a half-bridge circuit with two switches 111, 112, it is
possible to employ a full-bridge circuit.

25 Further, it is noted that, when designing a circuit, the correct load for the
circuit must be taken into account. The correct load impedance translates into a certain
inductivity to be connected in series with the inductor 120; depending on the number of
strings to be controlled this translates into a certain ideal number of turns of the primary
winding(s) 152; 161 of the transformer(s) 151; 260 (lower, as the number of strings
30 increases). Considering that the LED current must remain the same, the number of secondary
windings increases as the number of strings increases.

Further, the circuit can easily be applied to use mains-isolation.

Further, the circuit can also be used to provide the power factor correction.

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. A computer program may be stored/distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems. Any reference signs in the claims should not be construed as limiting the scope.

In the above, the present invention has been explained with reference to block diagrams, which illustrate functional blocks of the device according to the present invention. It is to be understood that one or more of these functional blocks may be implemented in hardware, where the function of such functional block is performed by individual hardware components, but it is also possible that one or more of these functional blocks are implemented in software, so that the function of such functional block is performed by one or more program lines of a computer program or a programmable device such as a microprocessor, microcontroller, digital signal processor, etc.

CLAIMS:

1. Driver circuit (100; 200) for driving a plurality of LEDs (159), the circuit comprising:

input terminals (117, 118) for receiving an input voltage;

a converter stage (110) for converting input voltage to LED current, the converter stage comprising:

- a series arrangement of two controllable switches (111, 112) connected

between said two input terminals, said series arrangement having a first node (113) between said two switches;

- a controller (116) for alternatively and in counterphase controlling said two switches;

- an inductor (120) coupled to said first node;

the driver circuit further comprising a plurality of LED circuits (150; 250), each LED circuit comprising at least one LED (159) and a secondary transformer winding (153; 262), and a rectifying circuit (156) arranged between said secondary transformer winding and said at least one LED;

the driver circuit further comprising transformer means (151; 260) comprising at least one winding (152; 261) arranged in series with said inductor (120), said transformer means being designed for coupling current from said inductor (120) to said secondary transformer windings (153; 262);

wherein the inductivity of said at least one winding (152; 261) is smaller than the inductivity of said inductor (120).

2. Driver circuit according to claim 1, wherein the inductivity of said at least one winding (152; 261) is at least a factor 100 smaller than the inductivity of said inductor (120).

3. Driver circuit according to claim 1, wherein said transformer means (151) is implemented by individual transformers (151(i)) associated with each LED circuit (150(i)), each individual transformer (151(i)) having a corresponding primary transformer winding (152(i)) and a corresponding secondary transformer winding (153(i)), wherein all primary

transformer windings (152(i)) are connected in series with said inductor (120), and wherein the summation of the inductivities of all primary transformer windings (152(i)) is smaller than the inductivity of said inductor (120).

5 4. Driver circuit according to claim 1, wherein said transformer means (260) is implemented by a single transformer having one common primary transformer winding (261) and a plurality of secondary transformer windings (262).

10 5. Driver circuit according to claim 4, further comprising equalizer transformers.

6. Driver circuit according to claim 5, comprising, for each pair of a first LED circuit (250(i)) and a subsequent neighboring LED circuit (250(i+1)), an equalizer transformer (270(i)) having a first winding (271(i)) connected in series with the secondary winding (262(i)) of said first LED circuit (250(i)) and having a second winding (272(i))
15 connected in series with the secondary winding (262(i+1)) of said neighboring LED circuit (250(i+1)), wherein the number of turns in the first winding (271(i)) equals the number of turns in the second winding (272(i)).

20 7. Driver circuit according to claim 1, wherein the controller (116) is responsive to a current sense signal from a current sensor to adapt the current for the LEDs.

8. Driver circuit according to claim 7, wherein a current sensor is arranged in series with the inductor (120).

25 9. Driver circuit according to claim 7, wherein a current sensor is arranged in series with one of the secondary transformer windings.

10. Driver circuit according to claim 1, wherein the circuit is adapted to provide a safe isolation between said LEDs and a mains power supply.

30

11. A switching power supply device for feeding a plurality of LEDs from a mains power supply, comprising a driver circuit according to claim 1 having one single converter stage (110) for providing both LED current and power factor correction.

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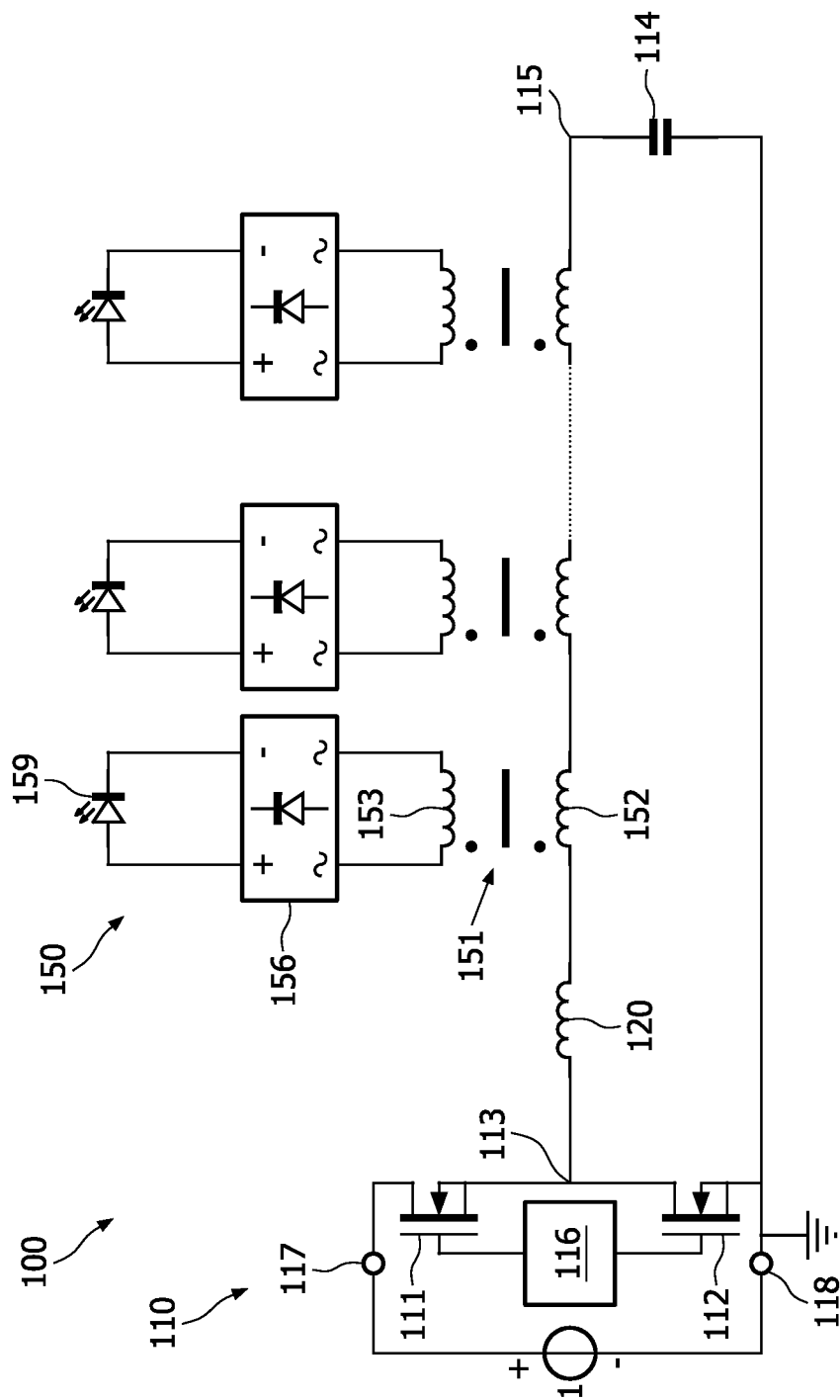


FIG. 1

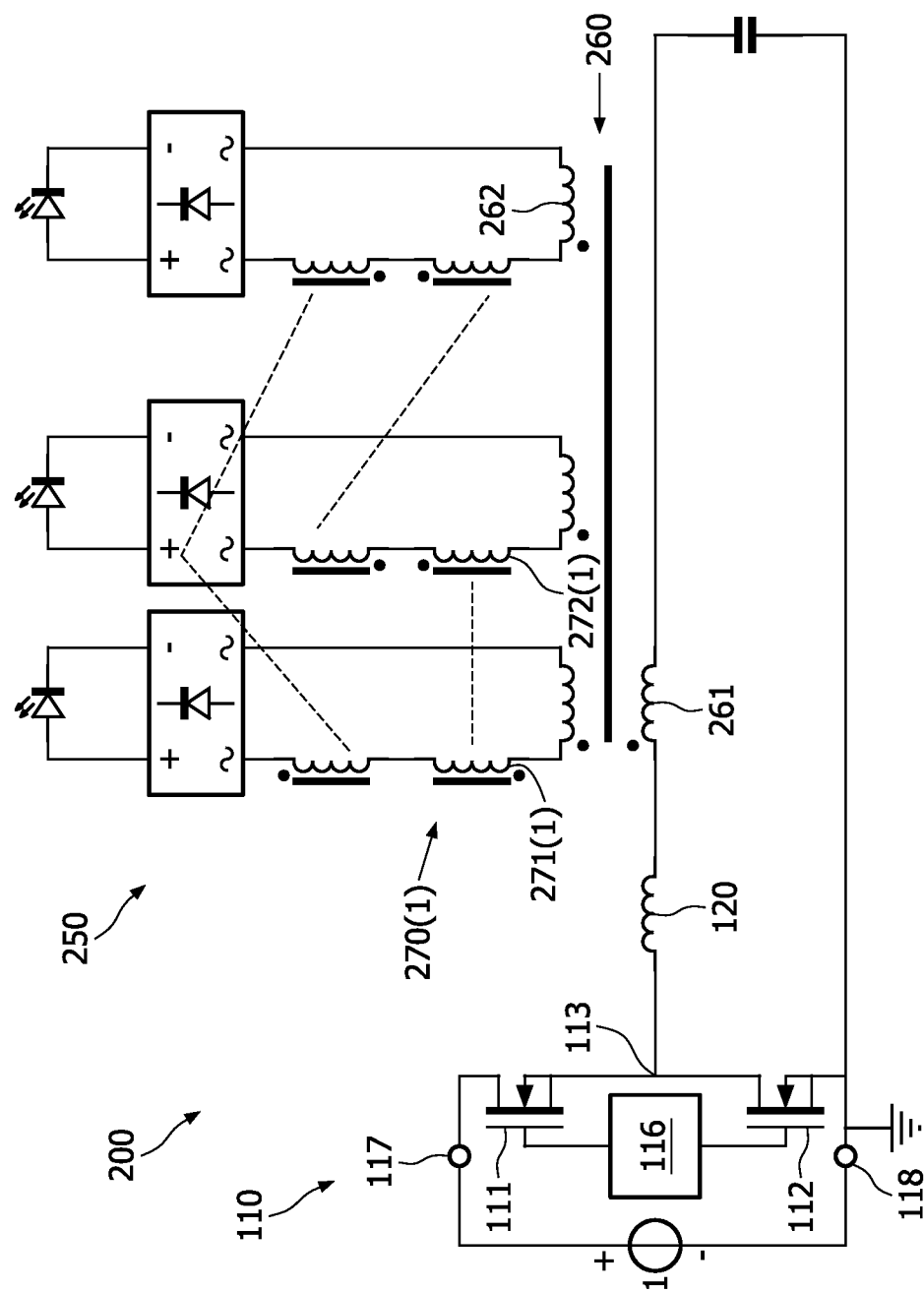


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/052136

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B33/08 H05B41/24

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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- "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

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INTERNATIONAL SEARCH REPORT

International application No

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