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(54) LED LIGHTING DEVICE

(57) The present invention relates to a LED lighting device that comprises a rectifying circuit (101) configured to rectify an AC input voltage, at least three LED circuits (102, 103, 104, 105), a switching circuit (106, 107, 108, 109) for each LED circuit (102, 103, 104, 105), a constant current regulating circuit (110) configured to regulate the current fed to the LED circuits (102, 103, 104, 105), and a compensating circuit (115) connected to the LED circuit (102) having the lowest number of LEDs or to the LED circuit having the second lowest number of LEDs and configured to feed current to said LED circuit (102) when the voltage at a node between the constant current regulating circuit (110) and the LED circuit (102) having the lowest number of LEDs is smaller than a compensating threshold voltage.

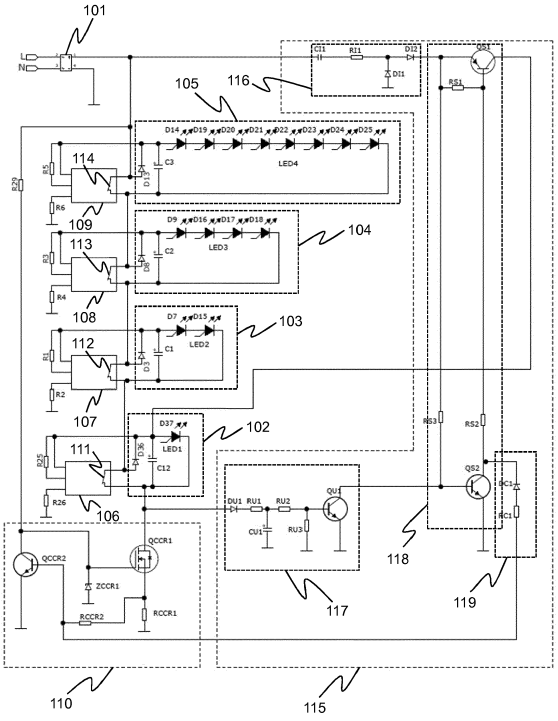

Fig. 1

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a LED lighting device according to the preamble of the appended independent claim.

BACKGROUND OF THE INVENTION

[0002] Many lighting devices that involve series-connected LEDs (Light Emitting Diodes) are known in the prior art. These lighting devices use different techniques to drive the series-connected LEDs. One known technique used in offline LED lighting applications is to divide the series-connected LEDs into groups and to switch the LED groups on and off according to the rectified AC input voltage.

[0003] In one known lighting device utilising the above-mentioned driving technique, one switching unit is connected to each LED group and the switching units are configured to switch the LED groups on and off in a particular switching order as the rectified AC input voltage changes. Each switching unit steers electrical current through or away from the corresponding LED group independently of the other switching units. The number of LEDs in the LED groups is such that the second LED group has twice the number of LEDs compared to the first LED group; the third LED group has twice the number of LEDs compared to the second LED group, etc.

[0004] In the known lighting device, the LEDs are chosen in such a manner that the sum of the threshold voltages of the LEDs is smaller than the peak value of the rectified AC input voltage, whereby all the LEDs can be switched on simultaneously at a certain time interval of the voltage cycle. Since the peak voltage of the AC mains typically varies with time, resulting thus variations in the peak value of the rectified AC input voltage, the LEDs are normally optimised using a voltage value that is smaller than the nominal peak voltage. This, however, results in power dissipation in the lighting device when the peak value of the rectified AC input voltage is higher than the nominal peak voltage. If the LEDs were optimised using a voltage value that is larger than the nominal peak voltage, this would result in another problem, namely to brightness variations due to shorter times the LED groups having the lowest number of LEDs are on. In fact, in this case when the peak value of the rectified AC input voltage is lower than the nominal peak voltage, all the LEDs could not be selected to be on simultaneously during the voltage cycle. The disadvantages of the known lighting device are thus power dissipation and brightness variations between which a compromise must be made.

OBJECTIVES OF THE INVENTION

[0005] It is the main objective of the present invention to reduce or even eliminate prior art problems presented above.

[0006] It is an objective of the present invention to provide an offline LED lighting device with improved energy efficiency. It is also an objective of the invention to minimise both brightness differences and power dissipation in a LED lighting device.

[0007] It is a further objective of the present invention to provide a LED lighting device enabling to maintain constant brightness with minimal power dissipation, even when the peak voltage of the AC voltage supplied to the LED lighting device varies from its nominal value.

[0008] In order to realise the above-mentioned objectives, the LED lighting device according to the invention is characterised by what is presented in the characterising part of the appended independent claim. Advantageous embodiments of the invention are described in the dependent claims.

DESCRIPTION OF THE INVENTION

[0009] A typical LED lighting device according to the invention comprises:

- a rectifying circuit configured to rectify an AC input voltage,
- at least three LED circuits, each LED circuit comprising a series connection of at least one LED, a capacitor connected in parallel with said series connection, and a blocking diode connected in series with said parallel connection, the at least three LED circuits having unequal numbers of series-connected LEDs and being connected in series in an order determined by the number of the series-connected LEDs in each LED circuit,
- a switching circuit for each LED circuit, the switching circuits being configured to control the flow of current to the corresponding LED circuit,
- a constant current regulating circuit configured to regulate the current fed to the LED circuits, and
- a first compensating circuit connected to the LED circuit having the lowest number of LEDs or to the LED circuit having the second lowest number of LEDs and configured to feed current to said LED circuit when the voltage at a node between the constant current regulating circuit and the LED circuit having the lowest number of LEDs is smaller than a first compensating threshold voltage.

[0010] The LED lighting device according to the invention is an AC-driven lighting device that is based on a LED driving technique, in which the LEDs of the lighting device are divided into a plurality of groups and each group is selectively switched on and off according to the rectified AC input voltage. The AC voltage supplied to

the LED lighting device is rectified with the rectifying circuit that is a full-wave rectifier.

[0011] In the LED lighting device according to the invention the LEDs are divided into the at least three LED circuits, which are controlled by the switching circuits. Each switching circuit is connected in parallel with the corresponding LED circuit and configured to direct current either through the LED circuit or through itself, depending on a voltage at the anode of the at least one series-connected LED. By the anode of the at least one series-connected LED is meant the anode of the first LED in the series connection of the at least one LED. The operation of a switching circuit can be based on using one or two switching threshold voltages that define voltages at which the switching circuit changes its state. If the switching circuit is based on using one switching threshold voltage, the operation is as follows. When the voltage at the anode of the at least one series-connected LED is larger than a switching threshold voltage specific to the switching circuit, current is directed through the forward-connected blocking diode and the parallel connection of the capacitor and the at least one series-connected LED to the next switching stage. When the voltage at the anode of the at least one series-connected LED is smaller than the switching threshold voltage specific to the switching circuit, current is directed through the switching circuit to the next switching stage. In this case the capacitor discharges through the at least one series-connected LED. The blocking diode prevents the capacitor from discharging through the switching circuit. As the rectified AC input voltage changes, the LED circuits are switched on and off in a particular switching order.

[0012] In the LED lighting device according to the invention, the LED circuits are connected in series in an order determined by the number of the series-connected LEDs in each LED circuit. The first LED circuit has the lowest and the last LED circuit has the highest number of series-connected LEDs. The LED circuit having the highest number of series-connected LEDs is connected to the positive terminal of the rectifying circuit. The LED circuit having the lowest number of LEDs is connected to a regulating transistor of the constant current regulating circuit. Preferably, the second LED circuit has twice the number of LEDs compared to the first LED circuit; the third LED circuit has twice the number of LEDs compared to the second LED circuit, etc. If a LED circuit comprises one series-connected LED, it means that the LED circuit comprises one LED.

[0013] It has now been found that a LED lighting device that is both energy efficient and is able to maintain constant brightness can be achieved by providing the LED lighting device with the first compensating circuit that is connected to the LED circuit having the lowest number of LEDs or to the LED circuit having the second lowest number of LEDs and is configured to feed current to said LED circuit when the voltage at a node between the constant current regulating circuit and the LED circuit having the lowest number of LEDs is smaller than the first compensating threshold voltage. A purpose of the first compensating circuit is to feed current to the LED circuit when the rectified AC input voltage is too low to keep the LED circuit switched on for a needed time during the voltage cycle. The information when the current should be fed to the LED circuit is obtained by monitoring the voltage at the node between the constant current regulating circuit and the LED having the lowest number of LEDs. The voltage at this node is indicative of the peak value of the rectified AC input voltage. Preferably, the node at which the voltage is monitored situates between a regulating transistor of the constant current regulating circuit and the LED circuit. The cathode of the at least one series-connected LED is connected to the regulating transistor. By the cathode of the at least one series-connected LED is meant the cathode of the last LED in the series connection of the at least one LED.

[0014] Because of the compensating circuit, the LEDs of the lighting device can be optimised for a higher voltage compared to the lighting device of the prior art. This improves energy efficiency, because the power dissipation is minimal also in a situation where the peak value of the rectified AC input voltage is above its nominal value. Also the brightness variations are minimal, because the compensating circuit minimises the brightness differences between the LED circuits.

[0015] According to an embodiment of the invention the first compensating circuit is connected to the LED circuit having the lowest number of LEDs, and the LED lighting device comprises a second compensating circuit connected to the LED circuit having the second lowest number of LEDs and configured to feed current to said LED circuit when the voltage at a node between the constant current regulating circuit and the LED circuit having the lowest number of LEDs is smaller than a second compensating threshold voltage.

[0016] According to an embodiment of the invention the first compensating threshold voltage is larger than the second compensating threshold voltage.

[0017] According to an embodiment of the invention the compensating circuit comprises a current generating circuit configured to generate current for the LED circuit, a voltage monitoring circuit configured to monitor the voltage at the node between the constant current regulating circuit and the LED circuit having the lowest number of LEDs, and a controlling circuit configured, based on the monitored voltage value, to control the flow of current from the current generating circuit to the LED circuit. The circuits can be implemented using discrete components or integrated circuits, or their combinations.

[0018] According to an embodiment of the invention the current generating circuit comprises a series connection of a capacitor and a resistor, said series connection being connected to the anode of the at least one series-connected LED via a transistor of the controlling circuit.

[0019] According to an embodiment of the invention the compensating circuit comprises a current adjusting circuit configured, during the time when the compensat-

ing circuit feeds current to the LED circuit, to increase the current provided by the constant current regulating circuit. When the compensating circuit feeds current to the LED circuit having the lowest number of LEDs, the current that flows through the other LED circuits is slightly decreased. This is compensated by increasing the current provided by the constant current regulating circuit.

[0020] According to an embodiment of the invention the LED circuits are connected between the positive terminal of the rectifying circuit and the drain of the regulating transistor of the constant current regulating circuit.

[0021] According to an embodiment of the invention the switching circuits are configured to direct current through the corresponding LED circuit when the voltage at the anode of the at least one series-connected LED exceeds a first switching threshold voltage specific to each switching circuit, and configured to shunt the current away from the corresponding LED circuit when the voltage at the anode of the at least one series-connected LED falls below a second switching threshold voltage specific to each switching circuit.

[0022] Each switching circuit has specific first and second switching threshold voltages to allow for proper LED circuit control. The voltage at the anode of the at least one series-connected LED is compared to these thresholds. The first switching threshold voltage determines when the switching transistor turns off and allows current to charge the capacitor and to flow through the at least one series-connected LED. The first switching threshold voltage should be larger than the sum of the threshold voltages of the at least one series-connected LED in the corresponding LED circuit. Typically, the first switching threshold voltage is set 6-10 V (for 120 VAC application) or 8-12 V (for 230 VAC application) larger than the sum of the threshold voltages of the at least one series-connected LED. The second switching threshold voltage determines when the switching transistor turns on to shunt the at least one series-connected LED and allow the capacitor to discharge through the at least one series-connected LED. The blocking diode prevents the capacitor from discharging through the switching circuit. Typically, the second switching threshold voltage is 4-6 V.

[0023] According to an embodiment of the invention the switching circuit comprises a switching transistor, the drain of the switching transistor being connected to the anode of the blocking diode and the source of the switching transistor being connected to the cathode of the at least one series-connected LED.

[0024] According to an embodiment of the invention the LED lighting device comprises a rectifying circuit configured to rectify an AC input voltage, at least three LED circuits, each comprising at least one series-connected LED connected in parallel with a capacitor, and a blocking diode connected in series with said parallel connection, the at least three LED circuits having unequal numbers of series-connected LEDs and being connected in series in an order determined by the number of the series-connected LEDs in each LED circuit, a switching circuit for each LED circuit, the switching circuits being configured to control the flow of current to the corresponding LED circuit, a constant current regulating circuit configured to regulate the current fed to the LED circuits, and a first compensating circuit connected to the LED circuit having the lowest number of LEDs and configured to feed current to said LED circuit when the voltage at a node between the constant current regulating circuit and said LED circuit is smaller than a first compensating threshold voltage.

[0025] The exemplary embodiments of the invention presented in this text are not interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" is used in this text as an open limitation that does not exclude the existence of also unrecited features. The features recited in the dependent claims are mutually freely combinable unless otherwise explicitly stated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

Fig. 1 illustrates a circuit diagram of a LED lighting device according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0027] Fig. 1 illustrates a circuit diagram of a LED lighting device according to an embodiment of the invention. The LED lighting device is AC-driven and comprises a full-wave rectifying circuit 101 that rectifies an AC voltage applied to its input terminals and outputs the rectified AC voltage at its output terminals to four LED circuits 102, 103, 104, 105 that are connected in series. To each of the LED circuits 102, 103, 104, 105 is connected a switching circuit 106, 107, 108, 109 that controls the flow of current through the corresponding LED circuit 102, 103, 104, 105. The current fed to the LED circuits 102, 103, 104, 105 is regulated with a constant current regulating circuit 110.

[0028] The first LED circuit 102 comprises one LED D37 that is connected in parallel with a capacitor C12. This parallel connection is connected in series with a blocking diode D36 in such a manner that the cathode of the blocking diode D36 is coupled to the anode of the LED D37. The anode of the blocking diode D36 is connected to the drain of a switching transistor 111 of the first switching circuit 106. The cathode of the LED D37 is connected to the source of the switching transistor 111 and to the drain of a regulating transistor QCCR1 of the constant current regulating circuit 110.

[0029] The second LED circuit 103 comprises two series-connected LEDs D7, D15 that are connected in parallel with a capacitor C1. This parallel connection is connected in series with a blocking diode D3 in such a manner that the cathode of the blocking diode D3 is coupled

to the anode of the series-connected LEDs. The anode of the blocking diode D3 is connected to the drain of a switching transistor 112 of the second switching circuit 107. The cathode of the series-connected LEDs is connected to the source of the switching transistor 112 and to the anode of the blocking diode D36 of the first LED circuit 102.

[0030] The third LED circuit 104 comprises four series-connected LEDs D9, D16, D17, D18 that are connected in parallel with a capacitor C2. This parallel connection is connected in series with a blocking diode D8 in such a manner that the cathode of the blocking diode D8 is coupled to the anode of the series-connected LEDs. The anode of the blocking diode D8 is connected to the drain of a switching transistor 113 of the third switching circuit 108. The cathode of the series-connected LEDs is connected to the source of the switching transistor 113 and to the anode of the blocking diode D3 of the second LED circuit 103.

[0031] The fourth LED circuit 105 comprises eight series-connected LEDs D14, D19, D20, D21, D22, D23, D24, D25 that are connected in parallel with a capacitor C3. This parallel connection is connected in series with a blocking diode D13 in such a manner that the cathode of the blocking diode C3 is coupled to the anode of the series-connected LEDs. The anode of the blocking diode C3 is connected to the drain of a switching transistor 114 of the fourth switching circuit 109 and to the positive terminal of the rectifying circuit 101. The cathode of the series-connected LEDs is connected to the source of the switching transistor 114 and to the anode of the blocking diode D8 of the third LED circuit 104.

[0032] The switching circuits 106, 107, 108, 109 switch the LED circuits 102, 103, 104, 105 on and off according to the voltage values at the anodes of the series-connected LED(s). Each switching circuit 106, 107, 108, 109 has specific first and second switching threshold voltages to allow for proper LED circuit control. The voltage at the anode of the series-connected LED(s) is compared to these threshold voltages. The first switching threshold voltage determines when the switching transistor 111, 112, 113, 114 turns off and allows current to charge the capacitor C12, C1, C2, C3 and to flow through the LED(s). The first switching threshold voltage is larger than the sum of the threshold voltages of the LED(s) in the corresponding LED circuit. The first switching threshold voltages are set for each switching circuit 106, 107, 108, 109 with resistors R25, R1, R3 and R5. The second switching threshold voltage determines when the switching transistor turns on to shunt the LED(s) and allow the capacitor C12, C1, C2, C3 to discharge through the LED(s). The blocking diode D36, D3, D8, D13 prevents the capacitor C12, C1, C2, C3 from discharging through the switching circuit 106, 107, 108, 109. The second switching threshold voltages are set for each switching circuit 106, 107, 108, 109 with resistors R26, R2, R4, R6.

[0033] The LED lighting device comprises a compensating circuit 115 that feeds current to the first LED circuit 102 when the voltage at the drain of the regulating transistor QCCR1, which is an n-channel MOSFET, is smaller than a compensating threshold voltage. The purpose of the compensating circuit 115 is to compensate the negative effects of a too low AC voltage applied to the device. The compensating circuit 115 comprises a current generating circuit 116 for generating current for the first LED circuit 102, a voltage monitoring circuit 117 for monitoring the voltage at the drain of the regulating transistor QCCR1, a controlling circuit 118 for controlling, based on the monitored voltage value, the flow of current from the current generating circuit 116 to the first LED circuit 102, and a current adjusting circuit 119 for adjusting the current provided by the constant current regulating circuit 110.

[0034] The current generating circuit 116 comprises the following components: a capacitor CI1, a resistor RI1, and diodes DI1 and DI2. The first terminal of the capacitor CI1 is connected to the positive output terminal of the rectifying circuit 101, and the second terminal of the capacitor CI1 is connected to the first terminal of the resistor RI1. The second terminal of the resistor RI1 is connected to the cathode of the diode DI1 and to the anode of the diode DI2. The anode of the diode DI1 is connected to the ground, and the cathode of the diode DI2 is connected to the emitter of a transistor QS1, and through a resistor RS3 to the collector of the transistor QU1 and to the base of a transistor QS2. The cathode of the diode DI2 is also connected through a resistor RS1 to the base of the transistor QS1, and through the resistors RS1 and RS2 to the collector of the transistor QS2.

[0035] The voltage monitoring circuit 117 comprises the following components: a diode DU1, resistors RU1, RU2 and RU3, a capacitor CU1 and a transistor QU1. The anode of the diode DU1 is connected to the drain of the regulating transistor QCCR1, and the cathode of the diode DU1 is connected to the resistor RU1. The resistor RU1 and the capacitor CU1 constitute a low-pass filter. The resistors RU2 and RU3 form a voltage divider. The base of the transistor QU1 is coupled to a node between the resistors RU2 and RU3. The voltage at the base of the transistor QU1 thus follows the voltage at the drain of the regulating transistor QCCR1.

[0036] The controlling circuit 118 comprises the following components: transistors QS1 and QS2, and resistors RS1, RS2 and RS3. The collector of the transistor QS1 is connected to the anode of the LED D37 of the first LED circuit 102. The base of the transistor QS1 is connected to the collector of the transistor QS2. The base of the transistor QS2 is connected to the collector of the transistor QU1.

[0037] The current adjusting circuit 119 comprises a diode DC1 and a resistor RC1 that are connected in series. The cathode of the diode DC1 is connected to the collector of the transistor QS2. The resistor RC1 is connected to the base of a transistor QCCR2 and through a resistor RCCR2 to the source of the regulating transistor QCCR1.

[0038] The compensating circuit 115 functions as follows. When the voltage at the drain of the regulating transistor QCCR1 is so high that the voltage at the base of the transistor QU1 keeps the transistor QU1 in a conducting state, the transistor QS2 is in a non-conducting state. As a result of this, the transistor QS1 is also in a non-conducting state, whereby the flow of current from the current generating circuit 116 to the first LED circuit 102 is prevented. As the voltage at the drain of the regulating transistor QCCR1 decreases, so does the voltage at the base of the transistor QU1. When the voltage at the drain of the regulating transistor QCCR1 decreases so low that the transistor QU1 goes into a non-conducting state, the increased voltage at the base of the transistor QS2 drives the transistor QS2 into a conducting state. The value of the drain voltage at which the transistor QU1 changes its state is called a compensating threshold voltage. The transistor QS2 drives the transistor QS1 into a conducting state, whereby current flows from the current generating circuit 116 through the transistor QS1 to the first LED circuit 102. The feed of current to the first LED circuit 102 decreases the current that flows through the other LED circuits 103, 104, 105. This is compensated by increasing the current provided by the constant current regulating circuit 110. This is achieved using the current adjusting circuit 119.

[0039] Only advantageous exemplary embodiments of the invention are described in the figures. It is clear to a person skilled in the art that the invention is not restricted only to the examples presented above, but the invention may vary within the limits of the claims presented hereafter. Some possible embodiments of the invention are described in the dependent claims, and they are not to be considered to restrict the scope of protection of the invention as such.

Claims

1. A LED lighting device, comprising:

- a rectifying circuit configured to rectify an AC input voltage,
- at least three LED circuits, each LED circuit comprising a series connection of at least one LED, a capacitor connected in parallel with said series connection, and a blocking diode connected in series with said parallel connection, the at least three LED circuits having unequal numbers of series-connected LEDs and being connected in series in an order determined by the number of the series-connected LEDs in each LED circuit,
- a switching circuit for each LED circuit, the switching circuits being configured to control the flow of current to the corresponding LED circuit, and
- a constant current regulating circuit configured to regulate the current fed to the LED circuits,

characterised in that the LED lighting device comprises:

- a first compensating circuit connected to the LED circuit having the lowest number of LEDs or to the LED circuit having the second lowest number of LEDs and configured to feed current to said LED circuit when the voltage at a node between the constant current regulating circuit and the LED circuit having the lowest number of LEDs is smaller than a first compensating threshold voltage.

2. The LED lighting device according to claim 1, **characterised in that**:

- the first compensating circuit is connected to the LED circuit having the lowest number of LEDs, and
- the LED lighting device comprises a second compensating circuit connected to the LED circuit having the second lowest number of LEDs and configured to feed current to said LED circuit when the voltage at a node between the constant current regulating circuit and the LED circuit having the lowest number of LEDs is smaller than a second compensating threshold voltage.

3. The LED lighting device according to claim 2, **characterised in that** the first compensating threshold voltage is larger than the second compensating threshold voltage.

4. The LED lighting device according to any of the preceding claims, **characterised in that** the compensating circuit comprises:

- a current generating circuit configured to generate current for the LED circuit,
- a voltage monitoring circuit configured to monitor the voltage at the node between the constant current regulating circuit and the LED circuit having the lowest number of LEDs, and
- a controlling circuit configured, based on the monitored voltage value, to control the flow of current from the current generating circuit to the LED circuit.

5. The LED lighting device according to claim 4, **characterised in that** the current generating circuit comprises a series connection of a capacitor and a resistor, said series connection being connected to the anode of the at least one series-connected LED via a transistor of the controlling circuit.

6. The LED lighting device according to any of the pre-

ceding claims, **characterised in that** the compensating circuit comprises a current adjusting circuit configured, during the time when the compensating circuit feeds current to the LED circuit, to increase the current provided by the constant current regulating circuit.

7. The LED lighting device according to any of the preceding claims, **characterised in that** the LED circuits are connected between the positive terminal of the rectifying circuit and the drain of a regulating transistor of the constant current regulating circuit.

8. The LED lighting device according to any of the preceding claims, **characterised in that** the switching circuits are configured to direct current through the corresponding LED circuit when the voltage at the anode of the at least one series-connected LED exceeds a first switching threshold voltage specific to each switching circuit, and configured to shunt the current away from the corresponding LED circuit when the voltage at the anode of the at least one series-connected LED falls below a second switching threshold voltage specific to each switching circuit.

9. The LED lighting device according to any of the preceding claims, **characterised in that** the switching circuit comprises a switching transistor, the drain of the switching transistor being connected to the anode of the blocking diode and the source of the switching transistor being connected to the cathode of the at least one series-connected LED.

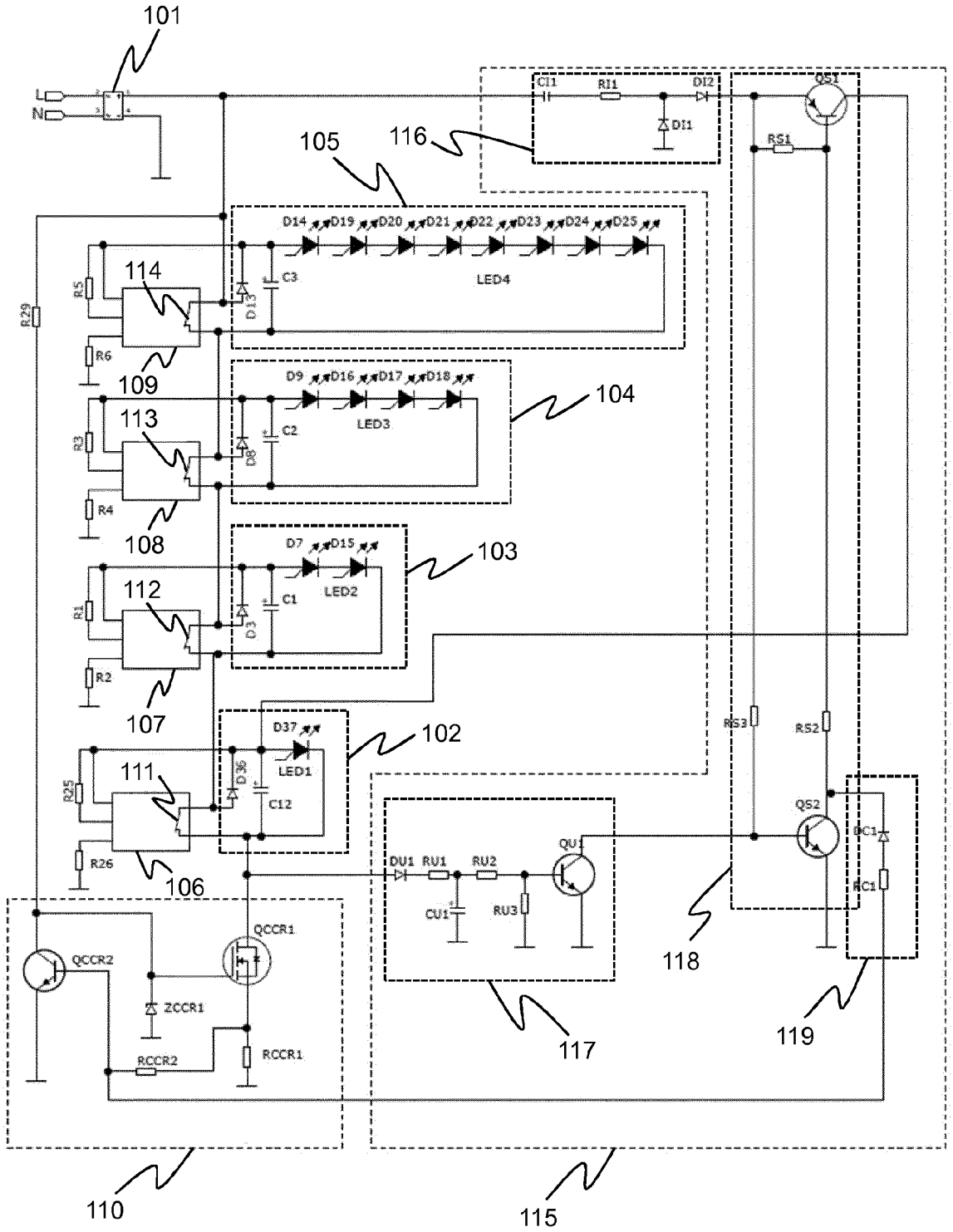
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Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 8220

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2008/252222 A1 (CUSINATO PAOLO [FR] ET AL) 16 October 2008 (2008-10-16) * claim 1; figure 1 * -----	1	INV. H05B33/08
A	DE 199 50 135 A1 (PATENT TREUHAND GES FUER ELEKTRISCHE GLUEHLAMPEN MBH [DE]) 19 April 2001 (2001-04-19) * abstract; figure 3 * -----	1	
A	EP 2 603 060 A1 (PANASONIC CORP [JP]) 12 June 2013 (2013-06-12) * claim 1; figure 1 * -----	1	
A	US 2011/084619 A1 (GRAY RICHARD LANDRY [US] ET AL) 14 April 2011 (2011-04-14) * abstract; figure 5 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)
H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	14 October 2015	Brown, Julian

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 16 8220

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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14-10-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008252222 A1	16-10-2008	US 2008252222 A1	16-10-2008
		US 2011204798 A1	25-08-2011
DE 19950135 A1	19-04-2001	AT 404035 T	15-08-2008
		CA 2354473 A1	26-04-2001
		DE 19950135 A1	19-04-2001
		EP 1151639 A1	07-11-2001
		JP 4914988 B2	11-04-2012
		JP 2003512733 A	02-04-2003
		JP 2012015123 A	19-01-2012
		US 6515434 B1	04-02-2003
		WO 0130119 A1	26-04-2001
EP 2603060 A1	12-06-2013	CN 103167688 A	19-06-2013
		EP 2603060 A1	12-06-2013
		JP 2013122846 A	20-06-2013
		US 2013147356 A1	13-06-2013
US 2011084619 A1	14-04-2011	CN 102045923 A	04-05-2011
		JP 5592749 B2	17-09-2014
		JP 2011087298 A	28-04-2011
		TW 201117665 A	16-05-2011
		US 2011084619 A1	14-04-2011

EPO FORM P0459

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