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(54) Benævnelse: **LED-LYSKILDE**

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DESCRIPTION

FIELD OF THE INVENTION

[0001] The invention relates to the field of LED light sources. More in particular, the invention relates to LED light sources equipped with a standby function, in other words the operation of the LED light source can be stopped while the mains supply is still connected to it.

BACKGROUND OF THE INVENTION

[0002] Lighting systems based on LEDs are used on an increasing scale. LEDS have a high efficiency and a long life time. In many lighting systems, LEDs also offer a higher optical efficiency than other light sources. As a consequence, LEDs offer an interesting alternative for the well known light sources such as fluorescent lamps, high intensity discharge lamps or incandescent lamps.

[0003] LED light sources are often comprised in a lighting system, wherein the operation of the LED light sources is controlled by control commands. Such control commands include commands for activating the LED light source and commands for stopping the operation of the LED light source, i.e. commands to start generating a LED current and commands to stop generating a LED current, respectively. In the latter case, operation is not stopped by interrupting the connection of the LED light source to the mains supply but by stopping for instance the operation of a converter circuit comprised in the LED light source. In this latter case, the LED light source is said to be in standby mode. One example in this respect is provided by US2008/284349. In this standby mode, since the mains supply is still connected to the LED light source, the LED light source is still capable to receive further commands and process those commands. At the same time, however, the mains supply may cause a leakage current through parasitic capacitances and (part of) the LED load comprised in the LED light source. This leakage current can cause the LED string to generate a small amount of light resulting in a glow effect that is often undesirable.

[0004] US 2008/0111528 A1 discloses a driving device suitable for providing power to drive a load, wherein the driver device comprises a switching circuit and a power converting unit, wherein the switching circuit is coupled to the power converting unit and has a control terminal to receiving a first control signal. The power converting circuit is coupled to the switching circuit and transforms the power into a drive signal to receive the load according to a second control signal.

SUMMARY OF THE INVENTION

[0005] It is an object of the invention to provide a LED light source that does not generate a small amount of light caused by leakage currents when it is in standby mode.

[0006] The invention is set out in the appended set of claims.

[0007] During operation, a current supplying the LEDs can flow through the current control element and also through the first controllable switch that is maintained in the conductive state. In case the LED current supplied to the LED load by the converter is stopped, the LED light source is in a standby state and the first controllable switch is rendered non-conductive. As a result, leakage currents flowing from the mains supply to the LED load via parasitic capacitances are effectively suppressed, so that the LEDs do not generate a small amount of light during the standby state.

[0008] In case the operation of the DC-DC-converter is stopped because the LED light source is going into standby mode, the voltage between the converter output terminals decreases, so that also the voltage at the control electrode of the controllable switch drops to a voltage so low that the first controllable switch becomes non-conductive.

[0009] The current control element is preferably implemented as a diode or a further controllable switch having a control electrode coupled to further control circuitry for rendering the further controllable switch non-conductive in case the LED light source is in standby mode. Both the current control element and the first controllable switch may comprise a FET or a relais.

[0010] In a further preferred embodiment, the DC-DC-converter comprises a transformer equipped with a primary winding and a secondary winding and a capacitor is coupled between the primary winding and the secondary winding.

[0011] The capacitor can be a separate component, for instance a capacitor for suppressing EMI. The capacitor can also be a parasitic capacitor.

[0012] The transformer causes the LED light source to become an isolated LED light source. Although the transformer provides isolation between the LED load and the mains supply, due to the presence of the capacitor coupled between primary and secondary winding, the transformer does not sufficiently suppress leakage currents that flow from the mains supply through parasitic capacitances and through the LEDs to prevent that the LEDs generate a small amount of light. However, it has been found that the present invention also effectively suppresses leakage currents in isolated LED light sources in case they are in the standby state.

[0013] In another preferred embodiment of a LED light source according to the invention, the standby mode is entered by stopping the operation of the DC-DC converter, and the control circuitry for rendering the first controllable switch non-conductive in case the LED light source is in standby mode, is comprised in a converter control circuit comprised in the DC-DC converter, and the control electrode of the first controllable switch is coupled to an output terminal of the converter control circuit.

[0014] Since the first controllable switch needs to be rendered conductive when the operation of the DC-DC converter is stopped, it is efficient to control both the operation of the DC-DC converter and the conductive state of the first controllable switch, using the converter control circuit of the DC-DC converter.

[0015] In yet another preferred embodiment of a LED light source according to the invention, the standby mode is entered by stopping the operation of the DC-DC converter, and the further control circuitry used for rendering the further controllable switch non-conductive in case the LED light source is in standby mode, is comprised in a converter control circuit comprised in the DC-DC converter, and the control electrode of the further controllable switch is coupled to a second output terminal of the converter control circuit.

[0016] Since also the further controllable switch needs to be rendered conductive when the operation of the DC-DC converter is stopped, it is efficient to control both the operation of the DC-DC converter and the conductive state of the further controllable switch, using the converter control circuit of the DC-DC converter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

[0018] In the drawings:

Fig. 1 shows a schematic representation of an embodiment of a LED light source according to the prior art, similarly to US 2008/284349,

Figs. 2-5 respectively show schematic representations of a first, second and third embodiment of a LED light source according to the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0019] In Fig. 1, K1 and K2 are input terminals for connection to a mains supply source. Diodes D1-D4 form a rectifier RB comprising rectifier output terminals. The rectifier output terminals are connected to respective converter input terminals of a DC-DC converter CONV for generating a DC-current out of the rectified mains supply voltage. The converter CONV comprises a first converter output terminal A and a second converter output terminal B. The converter input terminals are connected by means of a capacitor Cin and the first and second converter output terminals are connected by means of a capacitor Cout.

[0020] Converter CONV is equipped with an input terminal K3 for receiving a control signal that activates or stops the operation of a converter control circuit comprised in the DC-DC converter and thereby, respectively, starts the operation of the LED light source or causes the LED light source to go into standby mode. The control signal can for instance be generated by light control circuitry in a lighting system of which the LED light source forms part.

[0021] The first converter output terminal A is connected to an anode of a LED load LL. In Fig. 1, the LED load LL is schematically represented by two LEDs, LED1 and LED2. In practice, the LED load will generally comprise a far higher number of LEDs. A cathode of the LED load LL is connected to the second converter output terminal B.

[0022] The LED light source shown in Fig. 1 is very suitable to be used in a luminaire. For safety reasons such a luminaire is usually connected to a protective earth PE, which in turn is connected to the "neutral" of the mains supply source. The inventor has found that the LED load often couples with the luminaire and thus also with the protective earth PE by means of parasitic capacitances. The parasitic capacitances are schematically represented in Fig. 1 as Cpar1, Cpar2 and Cpar3.

[0023] During normal operation of the LED light source shown in Fig. 1, the mains supply voltage is rectified by rectifier RB, and DC-DC converter CONV generates, out of the rectified mains supply voltage, a DC current that is supplied to the LED load LL. This DC current causes the LEDs to generate light.

[0024] However, in case a control signal that stops the operation of the DC-DC converter is received at terminal K3, the DC current that flows through the LEDs is no longer generated and the LED light source is in standby mode.

[0025] Since the input terminals of the LED light source are still connected to the mains supply source, the parasitic capacitances coupling the protective earth to the LED load cause an AC leakage current to flow.

[0026] In case the voltage at terminal K2 is higher than the voltage at terminal K1, a first current flows from terminal K2 through parasitic capacitance Cpar3 and diode D3 to input terminal K1. A second current flows from input terminal K2, through Cpar2, LED2 and diode D3 to input terminal K1. A third current flows from terminal K2, through parasytic capacitance Cpar1, capacitor Cout and diode D3 to input terminal K1.These currents charge the parasitic capacitances.

[0027] In case the voltage at input terminal K1 is higher than that at input terminal K2, a current flows from terminal K1, through diode D1 and capacitor Cin to converter output terminal B. From converter output terminal B a first current flows through capacitor Cout and parasitic capacitance Cpar1 to input terminal K2. A second current flows from converter output terminal B through capacitor Cout, LED1 and parasitic capacitance Cpar2 to input terminal K2. A third current flows from converter output terminal B through parasitic capacitance Cpar3 to terminal K2. These currents discharge the parasitic capacitances.

[0028] The leakage current thus flows through the parasytic capacitances and also partly through the LEDs and thereby causes the LEDs to generate a small amount of light that is considered undesirable.

[0029] The LED light source shown in Fig. 2 differs from the prior art LED light source shown in Fig. 1 in that the LED light source of Fig. 2 further comprises resistors R1 and R2, diode D5, first controllable switch M1 and zener diode Z1. In the embodiment shown in Fig. 2, the first controllable switch is a FET. The converter output terminals of DC-DC converter CONV are connected by means of a series arrangement of resistor R1 and resistor R2. A common terminal of resistor R1 and resistor R2 is connected to a control electrode of first controllable switch M1 and resistor R2 is shunted by zener diode Z1. Resistor R1, resistor R2 and zener diode Z1 together form first control circuitry for rendering the controllable switch M1 non-conductive in case the operation of the DC-DC converter is stopped and the LED light source is in standby mode.

[0030] During normal operation of the LED light source shown in Fig. 2, the voltage across capacitor Cout and thus across the series arrangement of resistor R1 and resistor R2 is high enough to maintain the first controllable switch M1 in a conductive state. As a consequence, the normal operation of the LED light source shown in Fig. 2 is very similar to the normal operation of the prior art LED light source shown in Fig. 1, since the diode D5 and the controllable switch M1 conduct the DC current generated by the DC-DC converter CONV.

[0031] In case the DC-DC converter receives a control signal at its terminal K3 to change from normal operation to standby mode, the operation of the DC-DC converter is stopped, the DC current supplying the LED load is no longer generated and the voltage between the converter output terminals decreases so that the first controllable switch M1 becomes non-conductive. Diode D5 and the body diode of controllable switch M1 block the leakage current, so that the parasitic capacitances are no longer charged and discharged, and the LEDs no longer generate a small amount of light, when the LED light source is in standby mode, so that the glow effect is effectively suppressed.

[0032] It is noted that in case the diode D5 were dispensed with, the LEDs would still generate a small amount of light. This is because the LEDs would carry a reverse current flowing from their cathode to their anode for a high momentary magnitude of the mains voltage, when the voltage at terminal K2 is higher than the voltage at terminal K1. This current charges the parasitic capacitances. The LEDs would subsequently carry a current discharging the parasitic capacitances and flowing from their anode to their cathode in case the voltage at terminal K1 is higher than the voltage at terminal K2. In the embodiment shown in Fig. 2, the reverse current flowing through the LEDs is blocked by diode D5.

[0033] The embodiment shown in Fig. 3 differs from that shown in Fig. 2 in that the DC-DC converter comprises a transformer T with a primary winding Lp and a secondary winding Ls. The primary winding Lp is connected to the secondary winding Ls by means of a capacitor C-EMI to suppress interference. Because of the presence of the transformer, the LED driver is an isolated LED driver, meaning that the circuitry and the LEDs on the secondary side of the transformer are isolated from the mains supply.

[0034] The operation of the LED light source shown in Fig. 3 is very similar to that of the LED light source shown in Fig. 2. The only difference is that in the standby state, the capacitor C-EMI will also be charged to a DC voltage.

[0035] The LED light source shown in Fig. 4 differs from the one shown in Fig. 2 in that resistors R1 and R2 are dispensed with and that the conductive state of controllable switch M1 is controlled by a signal at a third output terminal of DC-DC converter CONV. When the operation of the DC-DC converter is stopped and the LED light source is in standby mode, the signal at this third output terminal renders the controllable switch M1 non-conductive.

[0036] The LED light source shown in Fig. 5 differs from that shown in Fig. 4 in that diode D5 has been replaced by a further controllable switch SW2. The FET forming the first controllable switch has been replaced by a more general symbol for the first controllable switch and zener diode Z1 is dispensed with. The first controllable switch and the further controllable switch are controlled by means of, respectively, a signal present at a third output terminal and a signal present at a fourth output terminal of DC-DC-converter CONV. To this end, switches SW1 and SW2 are connected to, respectively, the third and the fourth output terminal of the DC-DC converter CONV. When the LED light source is in standby mode, the switches SW1 and SW2 are both rendered non-conductive. Switches SWland SW2 may be formed by any type of switch, such as a FETs or a relais or another type of switch. It is noted that in case one or both of the controllable switches are implemented by a relais, current conduction in both directions is blocked when the switch is rendered non-conductive. Also in this case an effective suppression of the leakage currents is realized.

[0037] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. 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. 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. Any reference signs in the claims should not be construed as limiting the scope.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US2008284349A **[0003] [0018]**
- US20080111528A1 **[0004]**

Patentkrav

1. Belysningsarmatur omfattende en LED-lyskilde, hvor LED-lyskilden omfatter:

- indgangsterminaler (K1, K2) til forbindelse med en netspændingsforsyningskilde,
- en beskyttende jordtilslutning til kobling med en nulleder i netspændingsforsyningskilden, idet den beskyttende jordtilslutning kobles til belysningsarmaturet,
- en ensretter (RB) koblet til indgangsterminalerne for at ensrette netforsyningsspændingen leveret af netforsyningsspændingskilden og omfattende ensrettetudgangsterminaler,
- en DC-DC-omformer (CONV) til at generere en jævnstrøm fra den ensrettede netforsyningsspænding, omfattende omformerindgangsterminaler forbundet med ensretterudgangsterminaler og omfattende en første omformerudgangsterminal (A) og en anden omformerudgangsterminal (B),
- en LED-belastning (LL) med en anode koblet til den første omformerudgangsterminal via et strømstyreelement (D5) for at blokere en strøm, der flyder fra anoden af LED-belastningen til den første omformerudgangsterminal, og med en katode koblet til den anden omformerudgangsterminal via en første styrbar omskifter (M1) med en styreelektrode koblet til første styrekreds for at gøre den styrbare kontakt ikkeledende, hvis LED-lyskilden er i standby mode, hvor LED-belastningen (LL) kobles til belysningsarmaturet ved hjælp af parasitiske kapaciteter.

2. LED-lyskilde ifølge krav 1, hvor strømstyreelementet er en diode (D5).

3. LED-lyskilde ifølge krav 1, hvor strømstyreelementet er en yderligere styrbar kontakt (SW2) med en styreelektrode koblet til yderligere styrekreds for at gøre den yderligere styrbare kontakt ikkeledende, hvis LED-lyskilden er i standby mode.

4. LED-lyskilde ifølge krav 1, hvor den første styrbare kontakt omfatter en FET.

5. LED-lyskilde ifølge krav 3, hvor den yderligere styrbare kontakt omfatter en FET.

6. LED-lyskilde ifølge krav 3, hvor den første styrbare kontakt og strømstyreelementet hver omfatter et relæ.

7. LED-lyskilde ifølge krav 1, hvor den første styrekreds omfatter en spændingsdeler omfattende en seriekonfiguration af en første modstand (R1) og en anden modstand (R2), der forbinder den første omformerudgangsterminal med den anden omformerudgangsterminal, og en styreelektrode af den styrbare kontakt kobles til en terminal mellem den første modstand og den anden modstand.

8. LED-lyskilde ifølge krav 1, hvor DC-DC-omformeren omfatter en transformer (T) udstyret med en primær vikling (Lp) og en sekundær vikling (Ls), og en kondensator (C_EMI) kobles mellem den primære vikling og den sekundære vikling.

9. LED-lyskilde ifølge krav 1, hvor standby-mode aktiveres ved at stoppe driften af DC-DC-omformeren, og hvor styrekredsen til at gøre den første styrbare kontakt ikkeledende, hvis LED-lyskilden er i standby-mode, indgår i en omformerstyrekreds omfattet af DC-DC-omformeren, og styreelektroden af den første styrbare kontakt kobles til en udgangsterminal af omformerstyrekredsen.

10. LED-lyskilde ifølge krav 3, hvor standby-mode aktiveres ved at stoppe driften af DC-DC-omformeren, og hvor den yderligere styrekreds til at gøre den yderligere styrbare kontakt ikkeledende, hvis LED-lyskilden er i standby-mode, indgår i en omformerstyrekreds omfattet af DC-DC-omformeren, og styreelektrodeen af den yderligere styrebare kontakt kobles til en anden udgangsterminal i omformerstyrekredsen.

DRAWINGS

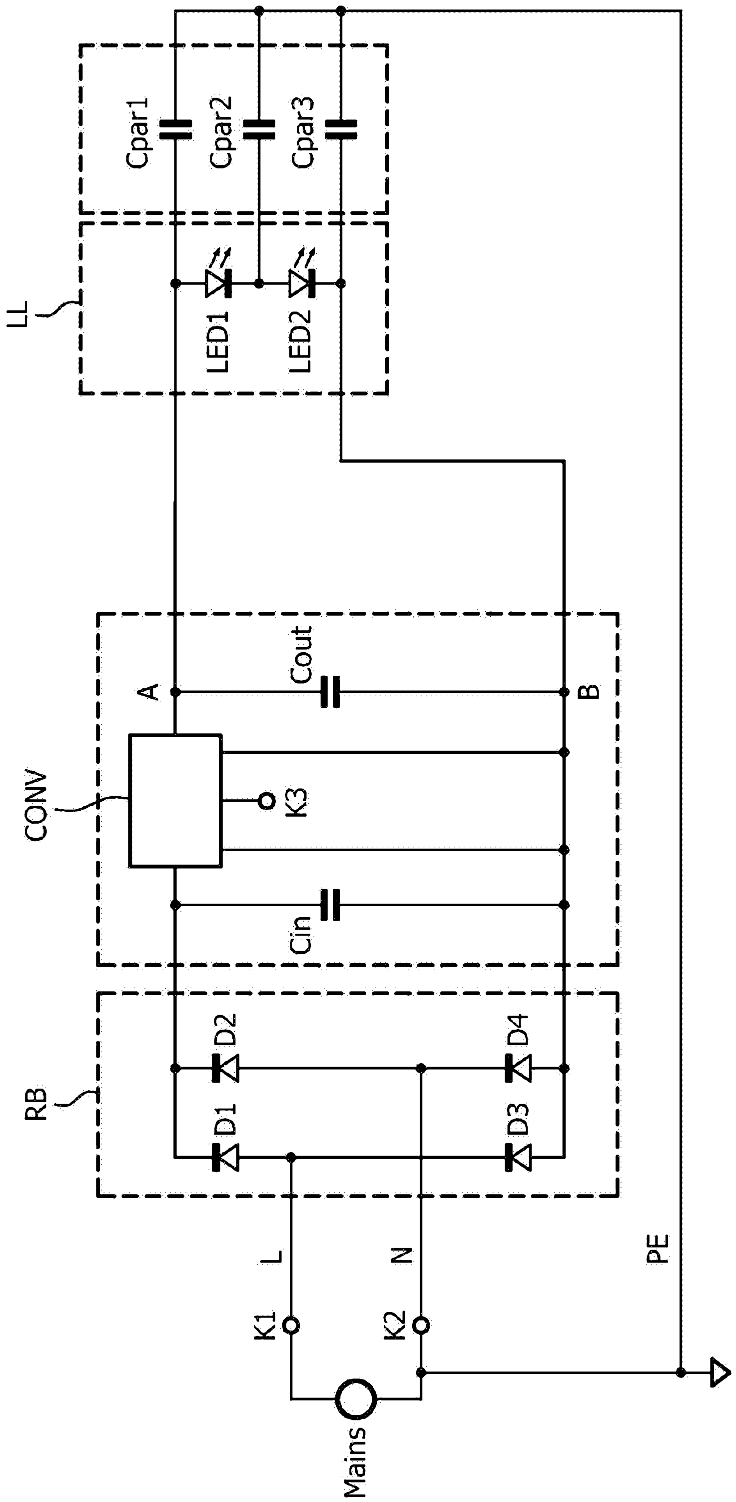


FIG. 1

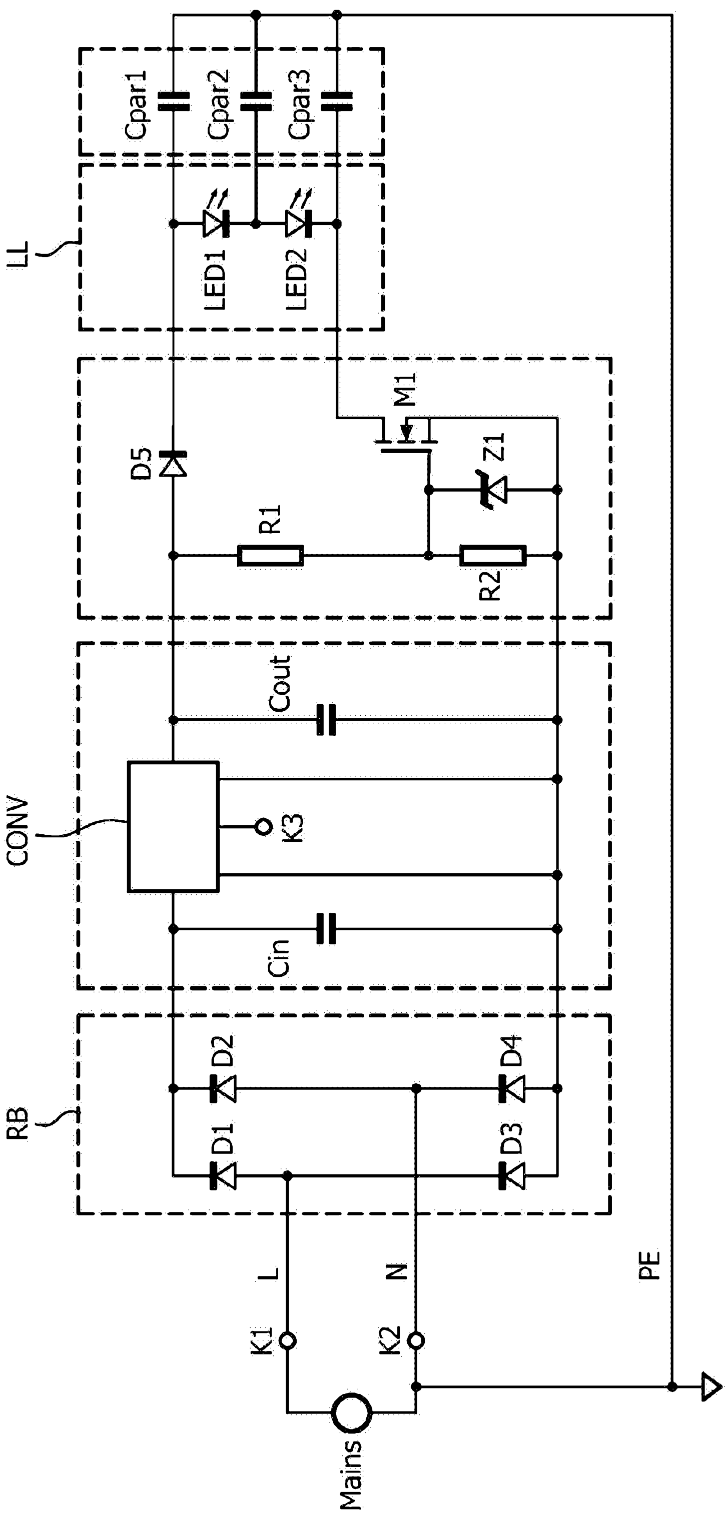
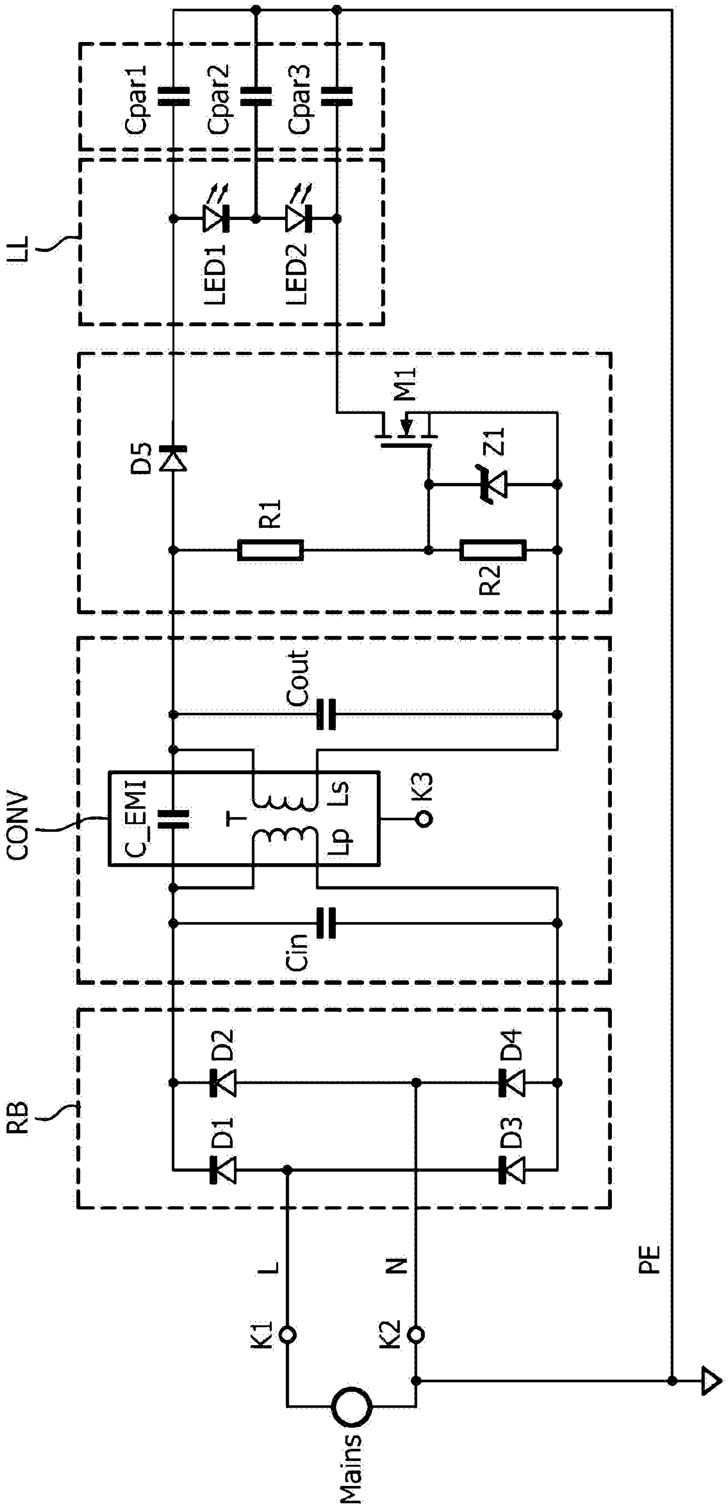

LL
Cpar1
Cpar2
Cpar3
LED1
LED2
D5
M1
Z1
R1
R2
Cout
CONV
K3
Cin
RB
D1
D2
D3
D4
L
N
PE
K1
K2
Mains

FIG. 2



RB
CONV
LL
C_EMI
Cpar1
Cpar2
Cpar3
LED1
LED2
D5
M1
Z1
R1
R2
Cout
T
Ls
Lp
K3
Cin
D1
D2
D3
D4
L
N
PE
K1
K2
Mains

FIG. 3

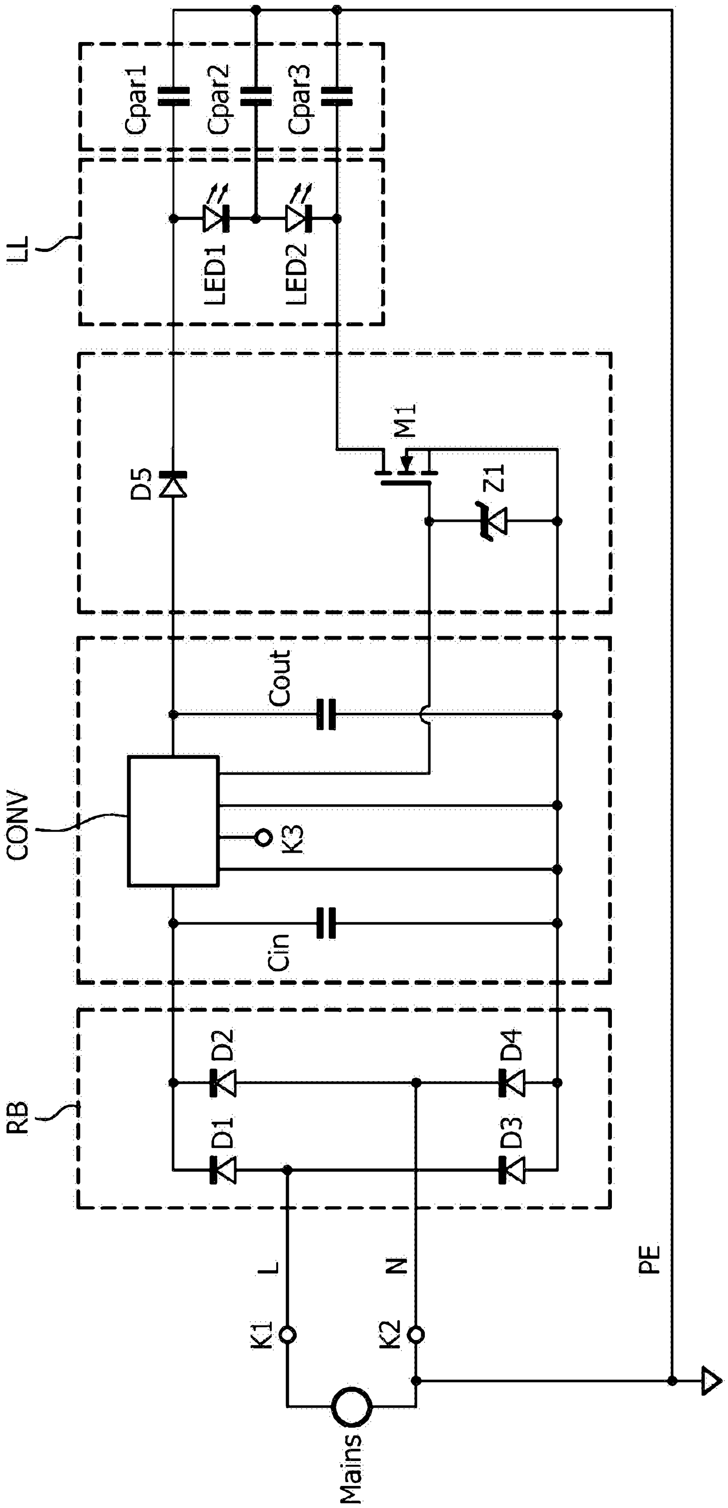
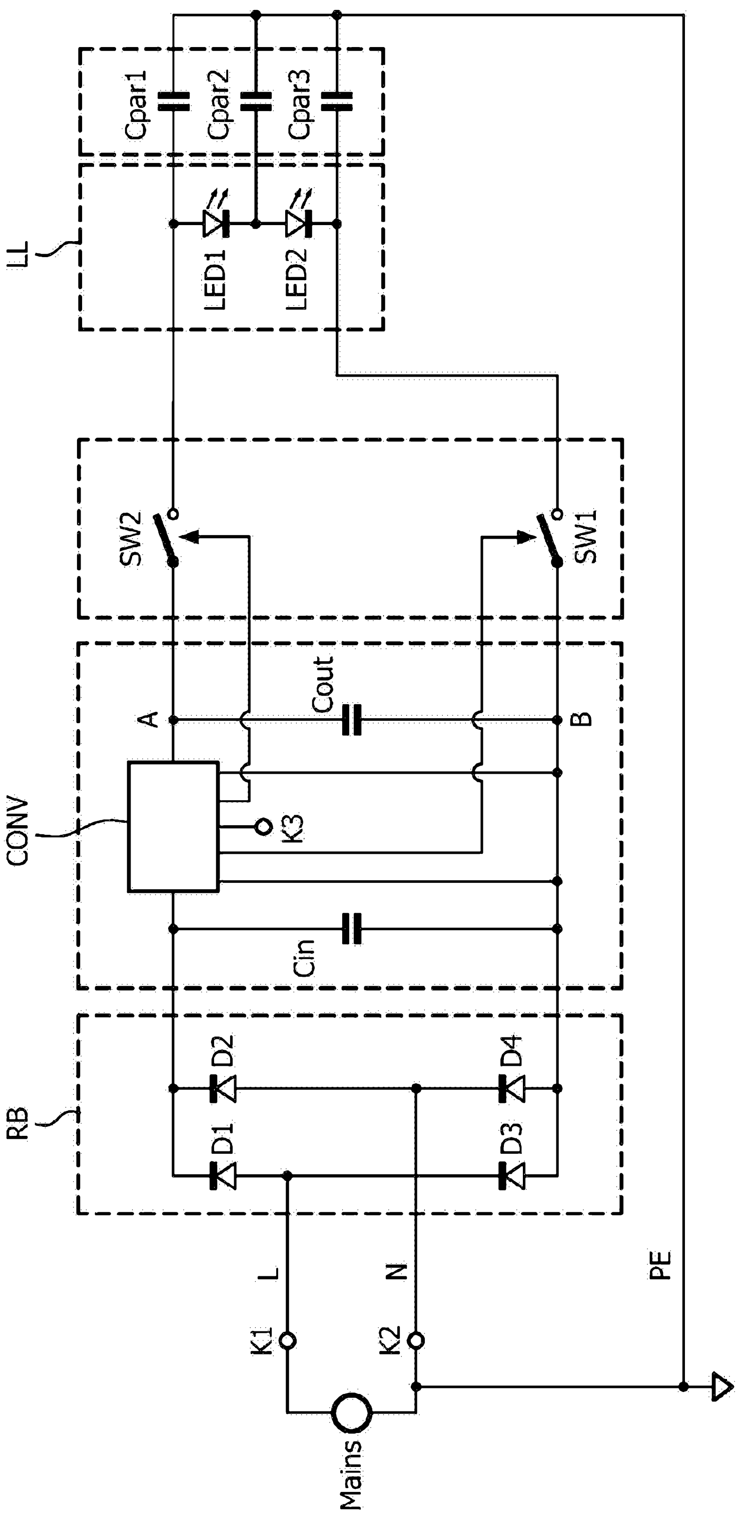

LL
Cpar1
Cpar2
Cpar3
LED1
LED2
D5
M1
Z1
CONV
Cout
K3
Cin
RB
D1
D2
D3
D4
L
N
PE
K1
K2
Mains

FIG. 4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LED2
Cpar1
Cpar2
Cpar3
SW2
SW1
CONV
A
B
Cout
K3
Cin
RB
D1
D2
D3
D4
L
N
PE
K1
K2
Mains

FIG. 5