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(54) LED LIGHTING APPARATUS DRIVEN DIRECTLY FROM THE PUBLIC AC GRID

DIREKT VOM ÖFFENTLICHEN WECHSELSTROMNETZ BETRIEBENE
LED-BELEUCHTUNGSVORRICHTUNG

APPAREIL D'ÉCLAIRAGE À LED ALIMENTÉ DIRECTEMENT PAR LE RÉSEAU PUBLIC AC

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EP 3 440 892 B1

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Description

[0001] The invention is defined by the independent claims and relates to LED lighting apparatuses driven directly from the public AC grid, wherein the harmonic content of the currents sunk from the public AC grid by the light emitting diodes is compliant with the EN61000-3-2 harmonic standard. Some embodiments of the LED lighting apparatuses according to the invention have a parallel connection of multiple power supplies, in order to obtain higher power supplies compliant too with said harmonic standard.

[0002] According to the present invention, hereinafter the term "LED" is the abbreviation of the light emitting diode and the term "Direct AC power supply" refers to a low power constant current integrated power supply.

[0003] It should be appreciated, however, that the embodiments described below are illustrations of LED driving apparatuses used therein to give a concrete form to technical ideas of the invention, and the LED driving apparatuses of the invention are not specifically limited to the description below. Furthermore, it should be appreciated that the members shown in claims attached hereto are not specifically limited to members in the embodiments. Unless otherwise specified, any dimensions, materials, shapes and relative arrangements of the parts described in the embodiments are given as an example and not as a limitation.

[0004] LED lighting technology is maturing fast, in the last 2 years becoming commercially available over 10 direct AC integrated circuits (abbreviated: IC). Direct AC technology is attractive because of its low cost, of its simplicity allowing the manufacturing of complete light engines on single printed circuit boards, because of lack of reactive components and due to its good electric parameters: high electrical efficiency (typically 90%) and good power factor (typically higher than 0.95).

[0005] Since the power supplied by the available direct AC ICs does not exceed 20W, in order to achieve higher rated power it is known the scaling method, i.e. the parallel connection of several small power sources. When the harmonic content of currents sunk by the direct AC integrated power supplies exceeds the limits imposed by the harmonic standard (EN61000-3-2), the scaling method cannot be applied for powers higher than 25W. Figure 1 exhibits the electric diagram of a LED light source driven by a 10W and 4 LED segments direct AC integrated power supply and Figure 2 exhibits the known method of scaling of several direct AC power sources in order to obtain higher-power sources. Figure 3 exhibits the time domain variation of the current sunk by the apparatus in Figure 1 and Figure 4 exhibits its harmonic content together with the individual harmonic limits, as they are set by the EN61000-3-2 harmonic standard. Acknowledging the standard is only recommended for powers lower than 25W but is mandatory for powers higher than 25W, a lighting apparatus having a rated power higher than 25W and manufactured by simply scaling of any number of

not compliant and low power direct AC integrated power sources, is still not compliant and not usable. The not compliant harmonic content is mainly due to the fact that given technological and practical reasons, the ratios of currents sunk by the integrated circuit from the grid is fixed, having the first step/current jump of higher value relative to next steps, which condition a relatively tight ratio of number of LEDs that make up each of the 4 LED segments. Each LED segment includes one LED device or a plurality of LED devices, which are connected to each other in series. Needless to say, a plurality of LED devices can be connected to each other in series inside a LED package as the LED segment. The time domain variation of current sunk by the direct AC integrated power supply as shown in Figure 3 is characteristic to a series of common, cheap and very popular integrated power supplies, characterized by the following currents ratio: $I_{OUT1}/I_{OUT2}/I_{OUT3}/I_{OUT4} = 61/77/94/100$.

[0006] Each LED segment can include an arbitrary number of LED devices (at least one LED device). The LED device can be a single LED chip, or a single package including a plurality of collectively-arranged LED chips. In this embodiment, that fixed currents ratio requires the approximate number of LEDs of each constituent segment $S_1, \dots, S_4$ as following: S_1 contains about 55 LEDs, S_2 contains about 18 LEDs, S_3 contains about 16 LEDs and S_4 contains about 6 LEDs. The example is not limitative, and the LED segments may also contain other combinations of numbers of LEDs.

[0007] For a power of 10W, the set resistor $R = 15$ ohms is selected in accordance with the datasheet, and therefore the levels of sunk currents become: $I_{OUT1} = 36.7\text{mA}$, $I_{OUT2} = 46.7\text{mA}$, $I_{OUT3} = 56.7\text{mA}$ and $I_{OUT4} = 60.0\text{mA}$.

[0008] The fixed ratios of sunk currents (61/77/94/100) in conjunction with the high level of the first sunk current, requires on one hand the LED segment S_1 to contain a large number of LEDs, which in turn determines the apparatus to start sinking current later, with a delay greater than 1.3ms from the zero crossing of sine grid voltage, and on the other hand, it makes the first step / current jump, corresponding to segment S_1 to be much higher (about 3-fold) than the following steps/levels of sunk current; both effects (late entry into conduction and the first current step of higher value relative to next steps) contribute decisively to the increased levels of odd harmonics of the sunk current, thus exceeding the limits imposed by EN61000-3-2 standard.

[0009] Document US 2015/208474 A1 discloses a method of taking power with low-voltage bypass for supplying low-voltage power to an IC and an IC for AC direct driving LEDs, which is applicable to the method of taking power with low-voltage bypass. The method allows the increase of the number of LED segments by adding an associated IC for each new segment, and each LED segment is controlled independently of the other LED segments. A priori this method does not provide EN61000-3-2 harmonic compliance. Harmonic compli-

ance might be achieved only by using five or more integrated circuits and carefully chosen resistors values. However, this method is totally different of the present claimed invention.

[0010] Document DE 11 2014 002534 T5 refers to a LED lighting device capable to endure a supply voltage whose value is the double of the supply voltage value of a single integrated circuit/driver. Thus, the internal parts of the device are prevented from being damaged by an overvoltage. However, the device is not EN61000-3-2 compliant.

[0011] Document EP2665341A1 discloses the general operating method of a LED direct AC integrated circuit driver. The LED segments connection/disconnection to/from the circuit is managed exclusively by the mains supply voltage, and not by the current sunk by the LEDs. The apparatus associated to the method does not meet EN61000-3-2 harmonic standards. Moreover, it does not meet EN55014 electro magnetic interference standard.

[0012] No method or apparatus for decreasing the harmonic content is disclosed.

[0013] KR 101 582 450 B1 discloses a direct-AC lighting apparatus that can be used in different electric power environments (namely 110 V AC voltage and 220 V AC voltage) specific to different countries or regions. The apparatus comprises two lighting circuitries. The proposed solution consists in the parallel-connection of the apparatus circuitries in case of the first supply voltage and in the series-connection of the apparatus circuitries in case of using the second supply voltage. However the apparatus is not EN61000-3-2 compliant. No method or apparatus for decreasing the harmonic content is disclosed.

[0014] The technical problem solved by the present invention is the decrease of the harmonic content of the currents sunk by direct AC power sources driving LED strings below the limits required by EN61000-3-2 standard.

[0015] The LED Lighting apparatuses according to the invention have the following advantages:

- allow manufacturing of EN61000-3-2 compliant power supplies by using non-compliant direct AC power supplies;
- allow-direct grid connection of apparatuses having the rated power higher than 25W
- exhibit high electric efficiency of over 90%;
- exhibit an improved, close to unity (0.995) power factor, higher than the power factor of known and not compliant topologies;
- decrease the time during which LEDs don't lit, when compared with the known and not compliant topologies;
- improve the flicker index when compared to the known direct AC not compliant integrated solutions;
- high power supplies can be manufactured on the same printed circuit board where the LEDs are placed, dramatically simplifying the production of the

entire high power light engine;

- the life time of the power supply has the same order of magnitude to the lifetime of the LEDs;
- are unlimited scalable in power as they comply with the EN61000-3-2 harmonic standard;
- are particularly cheap as they use specialized, low power integrated direct AC power supplies.

[0016] Several embodiments of LED lighting apparatuses according to the invention are detailed below, in connection with the figures which represent:

Figure 1: is a circuit schematic diagram showing a known light engine with the LED string driven by a 4 LED segments low power integrated direct AC power supply.

Figure 2: is a circuit schematic diagram showing the known scaling method, used to increase the rated power.

Figure 3: is a graph showing the time variation of the current sunk by the apparatus in Figure 1.

Figure 4: is a graph showing the frequency spectrum of the current in Figure 3.

Figure 5: is a circuit schematic diagram showing the wiring of a first preferred embodiment of a LED lighting apparatus according to the invention, having seven LED segments.

Figure 6: is a graph showing the time domain variation of the current sunk by the apparatus in Figure 5.

Figure 7: is a graph showing the frequency spectrum of the current in Figure 6.

Figure 8: is a circuit schematic diagram showing the wiring of a second preferred embodiment, consisting of the scaling of the power supply in Figure 5 according to the invention, having seven LED segments.

Figure 9: is a circuit schematic diagram showing the wiring of a third preferred embodiment as an alternative example of scaling of the power supply in Figure 5, according to the invention, having six LED segments.

Figure 10: is a circuit schematic diagram showing the wiring of a fourth preferred embodiment as an alternative example of scaling of the power supply in Figure 5, according to the invention, having five LED segments.

[0017] Apparatuses in Figures 5, 8, 9 and 10 are all compliant to EN61000-3-2 standard.

[0018] Figure 5 exhibits the wiring diagram of a first preferred embodiment of a LED lighting apparatus powered directly from the public grid, according to the invention and comprising:

a bridge rectifier PR having a first input lead and a second input lead connected to a supply voltage U_{AB} of the public AC grid, having a first output lead series connected to the anode of a series connected LED

string, and a second output lead connected to the ground, the series connected LED string consisting, in order, of a first LED segment S_{1f1} , a second LED segment S_{1f2} , a third LED segment S_{1f3} , a fourth LED segment S_{1f4} , a circuit element Z, a fifth LED segment S_2 , a sixth LED segment S_3 and a seventh LED segment S_4 , (wherein the LED segments S_{1f1} , S_{1f2} , S_{1f3} and S_{1f4} form together a so-called "complex" LED segment S_1 ; in other words, the complex LED segment S_1 consists of the LED segments S_{1f1} , S_{1f2} , S_{1f3} and S_{1f4}),

a primary direct AC integrated power supply IC1 for driving said LED string, whose internal current sources are connected respectively to the anode of the first LED of the fifth LED segment S_2 , respectively to the anode of the first LED of the sixth LED segment S_3 , respectively to the anode of the first LED of the seventh LED segment S_4 , respectively to the cathode of the last LED of the string (i.e. of the seventh LED segment S_4 , wherein the ground pin GND of the primary direct AC integrated power supply IC1, together with the first end of its current set resistor R1 are connected to ground,

wherein at the increase of voltage U_{AB} over the respective threshold voltages of the LED segments, the complex LED segment S_1 , the fifth LED segment S_2 , the sixth LED segment S_3 and the seventh LED segment S_4 , are successively and sequentially switched in by the primary direct AC integrated power supply IC1, and at the decrease of voltage U_{AB} below the respective threshold voltages of the LED segments, the seventh LED segment S_4 , the sixth LED segment S_3 , the fifth LED segment S_2 and the complex LED segment S_1 , are successively and sequentially switched out by the primary direct AC integrated power supply IC1

the apparatus further comprising a secondary direct AC integrated power supply IC2 whose internal current sources are connected to the taps between the first LED segment S_{1f1} and the second LED segment S_{1f2} , respectively between the second LED segment S_{1f2} and the third LED segment S_{1f3} , respectively between the third LED segment S_{1f3} and the fourth LED segment S_{1f4} , respectively between the fourth LED segment S_{1f4} and the circuit element Z, where the ground GND pin of the secondary direct AC integrated power supply IC2, together with the first end of its current set resistor R2 are connected to the tap between the circuit element Z and the fifth LED segment S_2 .

[0019] The circuit element Z, on which falls the minimum voltage required to bias the internal circuitry of the direct AC integrated power supply IC2, may be a resistor, a few volts reverse polarized zenner diode or even a forward biased LED.

[0020] At the increase of voltage U_{AB} over the respective threshold voltages of the LED segments S_{1f1} , S_{1f2} ,

S_{1f3} , S_{1f4} , before switching them in by the primary direct AC integrated power supply IC1, the LED segments S_{1f1} , S_{1f2} , S_{1f3} , and S_{1f4} are successively and sequentially switched in by the secondary direct AC integrated power supply IC2, and at the decrease of voltage U_{AB} below the respective threshold voltages of LED segments S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4} , after the successive and sequential switch out of the LED segments S_4 , S_3 , S_2 and complex segment S_1 by the primary direct AC integrated power supply IC1, the LED segments S_{1f4} , S_{1f3} , S_{1f2} and S_{1f1} are successively and sequentially switched out by the secondary direct AC integrated power supply IC2.

[0021] Considering the fixed ratios of sunk currents, for a 10W power supply the set resistor values are: $R1 = 15$ ohms and $R2 = 30$ ohms. These values ensure the maximum leap between any two consecutive sunk constant current levels is less than 10mA, meaning that it provides a quasi linear increasing set of currents $I_{OUT1-IC2}$, $I_{OUT2-IC2}$, $I_{OUT3-IC2}$, $I_{OUT4-IC2}$, $I_{OUT1-IC1}$, $I_{OUT2-IC1}$, $I_{OUT3-IC1}$, $I_{OUT4-IC1}$ sunk by the apparatus. The additional current levels corresponding to IC2 and set resistor $R2 = 30$ ohms are $I_{OUT1-IC2} = 18.3mA$, $I_{OUT2-IC2} = 23.3mA$, $I_{OUT3-IC2} = 28.3mA$ and $I_{OUT4-IC2} = 30mA$, the initial IC1 levels remaining unchanged i.e. currents: $I_{OUT1-IC1} = 36.7mA$, $I_{OUT2-IC1} = 46.7mA$, $I_{OUT3-IC1} = 56.7mA$ and $I_{OUT4-IC1} = 60mA$.

[0022] After the level of sunk current levels are determined, it is selected the number of LEDs consisting each LED segment S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4} , so that the current sunk by the apparatus to vary in steps, approximately linearly over time, as seen in Figure 6. The number of LEDs in each segment S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4} resulting in the sunk current variation as shown in Figure 6 is: S_{1f1} contains 15 LEDs, S_{1f2} contains 18 LEDs, S_{1f3} contains 9 LEDs, S_{1f4} contains 6 LEDs and circuit element Z contains 1 single LED. The fact that the complex LED segment S_1 consists of four LED segments S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4} as shown above is not unique, several divisions being possible, as well as several levels of set currents sunk by IC2; the frequency harmonics of sunk current given the variation indicated above are compliant to harmonic standard.

[0023] Each LED segment can include an arbitrary number of LED devices (at least one LED device). The LED device can be a single LED chip, or a single package including a plurality of collectively-arranged LED chips.

[0024] The LED driving apparatus wherein the complex LED segment S_1 consists of four LED segments S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4} , each including the indicated number of LEDs, is compliant to the current harmonic standard for $I_{OUT4} = 30mA$.

[0025] The example is not limitative, as the LED segments may also contain other numbers of LEDs, including but not limited to an equal numbers of LEDs in each LED segment (except for complex LED segment S_1). In another embodiment, the complex LED segment S_1 may include 54 LED chips divided in 4 LED segments S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4} as following: LED segment S_{1f1} in-

cludes 21 LEDs, and each of the following LED segments S_{1f2} , S_{1f3} and S_{1f4} includes 10 LEDs, or all LED segments may include an equal number of LEDs.

[0026] It is considered that when connecting the supply voltage U_{AB} at the AB terminals, the AC grid voltage passes through zero. It is also considered that at the AB terminals it is applied a 230Vef and 50Hz sinusoidal AC voltage. We reckon the LEDs threshold voltage is about 2.8V and respectively the forward directional (anode to cathode) voltage drop at nominal current is about 3.2V.

[0027] By increasing the voltage U_{AB} between 0 volts and up to 42V (the threshold voltage of LED segment S_{1f1} is 42V, 15LED x cca. 2.8V) the apparatus does not sink any current from the grid. By further increasing the U_{AB} voltage over the threshold voltage of S_{1f1} , through LEDs that constitute the segment S_{1f1} it starts flowing a current determined by the voltage to current characteristic of the 15 LEDs constituting the segment S_{1f1} ; the current flowing through the circuit closes to the ground via the internal current source of IC2 which is connected between its terminals I_{OUT1} and Rext, through the set resistor R2, through the internal current source of IC1 which is connected between its terminals I_{OUT1} and Rext and through the set resistor R1. As U_{AB} voltage continues to increase, the current flowing through S_{1f1} segment also increases until it reaches the maximum value limit $I_{OUT1-IC2} = 18.3mA$ of the internal current source. While the voltage U_{AB} further increases, the current sunk by the apparatus stays constant and limited to those 18.3mA, meaning the forward voltage drop across LED segment S_{1f1} also stays constant. The voltage difference between U_{AB} and the voltage forward directional voltage drop on LED segment S_{1f1} is found on IC2, across the terminals I_{OUT1} and GND. Thus, the variation (increase) of the U_{AB} voltage translates into the variation (increase) of the voltage drop at the IC2 terminals. When the voltage drop at the IC2 terminals reaches the threshold voltage of LED segment S_{1f2} (about 50.4V, 18LED x 2.8V), through the LED segment S_{1f2} starts flowing a current passing through the internal current source of IC2 connected between the terminal I_{OUT2} and Rext, through resistor R2 and closing to the ground on the same route as the current sunk by IC2 through I_{OUT1} . According to the internal configuration of IC, as the current sunk through the terminal I_{OUT2} increases, the current sunk through the terminal I_{OUT1} decreases by an equal amount so that at U_{AB} voltage the current sunk by the terminal I_{OUT1} drops to zero. At the further increase of the U_{AB} voltage the current flowing through the LED segments S_{1f1} and S_{1f2} of the complex LED segment S_1 , S_{1f1} and S_{1f2} now connected in series, increases up to the current level set and limited I_{OUT2} , namely 23.3mA.

[0028] At a further increase of the voltage U_{AB} the current drawn by the apparatus stays constant, as well as the forward directional voltage drop at the terminals of the series connected LED segments S_{1f1} and S_{1f2} , the voltage variation being found across the terminals I_{OUT2} and GND of IC2. As U_{AB} voltage further increases, the

LED segment S_{1f3} begins to lit, and then S_{1f4} , similarly.

[0029] Up to this point the operation of the apparatus is typical for the operation of a direct AC integrated power supply with 4 LED segments.

[0030] At the further increase of the U_{AB} voltage the forward directional voltage drop on the four series connected S_{1f1} , S_{1f2} , S_{1f3} and S_{1f4} stays constant, the variation of the voltage U_{AB} being found in the variation of the voltage drop between the I_{OUT4} and GND terminals of IC2. When this voltage drop exceeds some 2,8V, the LED which forms the circuit element Z starts to conduct. The entry into conduction of the circuit element Z leads to the situation in which through the series connected S_{1f1} , S_{1f2} , S_{1f3} and S_{1f4} pass both the current set at 30mA by the IC plus the current flowing through the circuit element Z. The current passing through the circuit element Z also closes to the ground via the terminal $I_{OUT1-IC1}$, Rext and resistor R1 so the sum of the current flowing through the circuit element Z and 30mA will be limited to the first level set by IC1 which in this exemplary embodiment is 36.7mA.

[0031] At a further increase of U_{AB} voltage the primary direct AC power supply IC1 operates classically, successively sinking the current in well-established constant levels through the already switched in LED segments S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4} that constitute the complex LED segment S_1 , as well as through the sequentially switched in LED segments S_2 - S_4 .

[0032] At the decrease of the U_{AB} grid voltage the functioning occurs in reverse, the apparatus both successively switching out the LED segments as well as the LED segments that constitute the complex LED segment S_1 in reverse order, and sinking a descending current in the same well established constant levels and at the same well-established moments in time.

[0033] Figure 6 exhibits the time domain variation of the current sunk by the apparatus in Figure 5, Figure 7 exhibits the frequency spectrum of the current sunk by the apparatus in Figure 5 where it is seen that its harmonics are lower than the limits set by EN61000-3-2, and Figure 8 exhibits a circuit schematic diagram showing the wiring of a second preferred embodiment consisting of the scaling of the power supply in Figure 5, according to the invention, having its complex LED segment S_1 divided into four LED segments. By way of example, the commercial optimum number of integrated circuits needed to manufacture a 30W power supply is 4, a 60W power supply is $2 \times 4 = 8$ and a 90W power supply is $4 \times 3 = 12$; it stems from the fact that all direct AC power supply integrated circuits are identical and from the fact that the secondary direct AC power supply integrated circuits sunk a maximum current equal to between one third and a half of the maximum current sunk by the primary direct AC power supply integrated circuits.

[0034] Figure 9 is a circuit schematic diagram showing the wiring of a third preferred embodiment of a LED lighting apparatus powered directly from the public AC grid as an alternative example of scaling the power supply in

Figure 5, which differs from the wiring diagram shown in Figure 8 as follows:

- the complex LED segment S_1 consists of three LED segments S_{1f1} , S_{1f2} , S_{1f3}
- the circuit element Z is serially connected between the fourth LED segment S_2 and the fifth LED segment S_3

[0035] As an example, for the wiring diagram in Figure 9, all LED segments S_{1f1} , S_{1f2} , S_{1f3} , S_2 , S_3 and S_4 may have an equal number of LEDs. As a preferred example (given by the large availability of the 50V direct forward bias voltage multichip LEDs packageing in a single capsule 14 LED junctions, but without limiting the invention only to this example), S_{1f1} , S_{1f2} , S_{1f3} , S_2 , S_3 and S_4 may each have 14 LEDs; the number of LEDs in the LED segments is not limited to 14, it varies between 13 and 16 depending on the maximum grid voltage; thus, at rated power, the direct forward voltage drop for all the LEDs connected in series in the string has to be equal to or slightly smaller than the maximum, peak voltage, of the grid at nominal voltage.

[0036] Figure 10 is a circuit schematic diagram showing the wiring of a fourth preferred embodiment as an alternative example of scaling of the power supply in Figure 5, which differs from the diagram in Figure 8 as follows:

- the complex LED segment S_1 consists of 2 LED segments S_{1f1} , S_{1f2}
- the circuit element Z is serially connected between the fourth LED segment S_3 and the fifth LED segment S_4

[0037] As an example, for the diagram in Figure 10 all LED segments S_{1f1} , S_{1f2} , S_2 , S_3 and S_4 can consist of an equal number of LEDs. As a preferred example (but without limiting the invention only to this example) each of S_{1f1} , S_{1f2} , S_2 , S_3 and S_4 can consist of 19 LEDs.

[0038] In the embodiments exhibited in Figures 8, 9 and 10, the internal current sources of the at least one secondary direct AC power supply integrated circuits $IC2_1$, $IC2_2$, ..., $IC2_n$ are connected to the taps between the first LED segment and the second LED segment, respectively between the second LED segment and the third LED segment, respectively between the third LED segment and the fourth LED segment, respectively between the fourth LED segment and the circuit element Z.

[0039] The total number of the primary direct AC power supply integrated circuits $IC1_1$, $IC1_2$, ..., may differ from the total number of the secondary direct AC power supply integrated circuits $IC2_1$, $IC2_2$, ..., in all preferred embodiments depicted in Figures 8, 9 and 10.

[0040] All the embodiments presented in Figures 8, 9 and 10 use the same operating mode as they were described for the embodiment in Figure 5.

[0041] In all embodiments, circuit element Z is con-

nected between the last LED segment driven by the secondary direct AC power supply integrated circuits (I_{OUT4} in that case) and their ground GND pin, together with the first terminal of the set resistor of these secondary direct AC power supply integrated circuits.

[0042] It should be apparent to those with an ordinary skill in art that while various preferred embodiments of the invention have been shown and described, it is contemplated that the invention is not limited to the particular embodiments disclosed, which are deemed to be merely illustrative of the inventive concepts and should not be interpreted as limiting the scope of the invention, and which are suitable for all modifications and changes falling within the scope of the invention as defined in the apprehended claims. The advantage that the complex LED segment S_1 consists of four segments S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4} is obtaining maximum performances in terms of the harmonic content of the current sunk; namely, the harmonic content of the current sunk is the lowest possible.

[0043] In the embodiments where the complex LED segment S_1 consists of three S_{1f1} , S_{1f2} , S_{1f3} or respectively two segments S_{1f1} , S_{1f2} , although maximum performance is not achieved, the harmonic content of the current sunk remains in accordance with the EN61000-3-2 standard but the cost of the associated apparatuses is much lower given the possibility of using exclusively cheaper multichip packaged LEDs.

Claims

1. LED lighting apparatus driven directly from the public AC grid, comprising:

- a bridge rectifier (PR) having a first input lead and a second input lead configured to be connected to a supply voltage (U_{AB}) of the public AC grid, having a first output lead series connected to an anode of a series connected LED string, and a second output lead connected to ground,

- the series connected LED string consisting, in order, of a first LED segment (S_{1f1}), a second LED segment (S_{1f2}), a third LED segment (S_{1f3}), a fourth LED segment (S_{1f4}), a circuit element (Z), a fifth LED segment (S_2), a sixth LED segment (S_3) and a seventh LED segment (S_4),

- at least one primary direct AC power supply integrated circuit ($IC1_1$, $IC1_2$, ..., $IC1_n$) for driving said LED string, each of the at least one primary direct AC power supply integrated circuits ($IC1_1$, $IC1_2$, ..., $IC1_n$) having: a first internal current source connected to an anode of a first LED constituent of the fifth LED segment (S_2), a second

internal current source connected to an anode of a first LED constituent of the sixth LED segment (S_3), a third internal current source connected to an anode of a first LED constituent of the seventh LED segment (S_4), a fourth internal current source connected to a cathode of a last LED constituent of the seventh LED segment (S_4),

- each of the at least one primary direct AC power supply integrated circuit ($IC1_1, IC1_2, \dots, IC1_n$) being provided with:

a ground pin (**GND**) connected to a first end of a respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$), and with a current set pin (R_{EXT}) connected to a second end of said respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$), wherein the ground pin (**GND**) of each of the at least one primary direct AC power supply integrated circuits ($IC1_1, IC1_2, \dots, IC1_n$) together with the first end of its respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$) are connected to the ground,

- each primary direct AC power supply integrated circuit ($IC1_1, IC1_2, \dots, IC1_n$) being configured to successively and sequentially switch in the first four LED segments ($S_{1f1}, S_{1f2}, S_{1f3}, S_{1f4}$), the fifth LED segment (S_2), the sixth LED segment (S_3) and the seventh LED segment (S_4), and also being configured to successively and sequentially switch out the seventh LED segment (S_4), the sixth LED segment (S_3), the fifth LED segment (S_2), and the first four LED segments ($S_{1f1}, S_{1f2}, S_{1f3}, S_{1f4}$),

- at least one secondary direct AC power supply integrated circuit ($IC2_1, IC2_2, \dots, IC2_n$) for driving said LED string, each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) being provided with:

a ground pin (**GND**) connected to a first end of a respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$), and with a current set pin (R_{EXT}) connected to a second end of said respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$),

- each secondary direct AC power supply integrated circuit ($IC2_1, IC2_2, \dots, IC2_n$) being configured to successively and sequentially switch in the first LED

segment (S_{1f1}), the second LED segment (S_{1f2}), the third LED segment (S_{1f3}) and the fourth LED segment (S_{1f4}) and also being configured to successively and sequentially switch out the fourth LED segment (S_{1f4}), the third LED segment (S_{1f3}), the second LED segment (S_{1f2}) and the first LED segment (S_{1f1}),

characterized in that:

- each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) has: a first internal current source connected to a tap between the first LED segment (S_{1f1}) and the second LED segment (S_{1f2}), a second internal current source connected to a tap between the second LED segment (S_{1f2}) and the third LED segment (S_{1f3}), a third internal current source connected to a tap between the third LED segment (S_{1f3}) and the fourth LED segment (S_{1f4}), a fourth internal current source connected to a tap between the fourth LED segment (S_{1f4}) and the circuit element (Z),
- the ground pin (**GND**) of each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) together with the first end of its respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$) are connected together to a tap between the circuit element (Z) and the fifth LED segment (S_2).

2. LED lighting apparatus driven directly from the public AC grid, comprising:

- a bridge rectifier (**PR**) having a first input lead and a second input lead configured to be Z connected to a supply voltage (U_{AB}) of the public AC grid, having a first output lead series connected to an anode of a series connected LED string, and a second output lead connected to ground,

- the series connected LED string consisting, in order, of a first LED segment (S_{1f1}), a second LED segment (S_{1f2}), a third LED segment (S_{1f3}), a fourth LED segment (S_2), a circuit element (Z), a fifth LED segment (S_3), and a sixth LED segment (S_4),

- at least one primary direct AC power supply integrated circuit ($IC1_1, IC1_2, \dots, IC1_n$) for driving said LED string, each of the at least one primary direct AC power supply integrated circuits ($IC1_1, IC1_2, \dots, IC1_n$) having: a first internal current source connected to an anode of a first LED constituent of the fourth LED segment (S_2), a sec-

ond internal current source connected to an anode of a first LED constituent of the fifth LED segment (S_3), a third internal current source connected to an anode of a first LED constituent of the sixth LED segment (S_4), a fourth internal current source connected to a cathode of a last LED constituent of the sixth LED segment (S_4),

- each of the at least one primary direct AC power supply integrated circuit ($IC1_1, IC1_2, \dots, IC1_n$) being provided with:

a ground pin (**GND**) connected to a first end of a respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$), and with a current set pin (R_{EXT}) connected to a second end of said respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$), wherein the ground pin (**GND**) of each of the at least one primary direct AC power supply integrated circuits ($IC1_1, IC1_2, \dots, IC1_n$) together with the first end of its respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$) are connected to the ground,

- each primary direct AC power supply integrated circuit ($IC1_1, IC1_2, \dots, IC1_n$) being configured to successively and sequentially switch in the first three LED segments ($S_{1f1}, S_{1f2}, S_{1f3}$), the fourth LED segment (S_2), the fifth LED segment (S_3) and the sixth LED segment (S_4), and also being configured to successively and sequentially switch out the sixth LED segment (S_4), the fifth LED segment (S_3), the fourth LED segment (S_2), and the first three LED segments ($S_{1f1}, S_{1f2}, S_{1f3}$),

- at least one secondary direct AC power supply integrated circuit ($IC2_1, IC2_2, \dots, IC2_n$) for driving said LED string, each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) being provided with:

a ground pin (**GND**) connected to a first end of a respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$), and with a current set pin (R_{EXT}) connected to a second end of said respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$),

- each secondary direct AC power supply integrated circuit ($IC2_1, IC2_2, \dots, IC2_n$) being configured to successively and sequentially switch in the first LED segment (S_{1f1}), the second LED segment (S_{1f2}), the third LED segment (S_{1f3}) and the fourth LED segment (S_2) and also being configured to successively and sequentially

switch out the fourth LED segment (S_2), the third LED segment (S_{1f3}), the second LED segment (S_{1f2}) and the first LED segment (S_{1f1}),

characterized in that:

- each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) has: a first internal current source connected to a tap between the first LED segment (S_{1f1}) and the second LED segment (S_{1f2}), a second internal current source connected to a tap between the second LED segment (S_{1f2}) and the third LED segment (S_{1f3}), a third internal current source connected to a tap between the third LED segment (S_{1f3}) and the fourth LED segment (S_2), a fourth internal current source connected to a tap between the fourth LED segment (S_2) and the circuit element (**Z**),

- the ground pin (**GND**) of each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) together with the first end of its respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$) are connected together to a tap between the circuit element (**Z**) and the fifth LED segment (S_3).

3. LED lighting apparatus driven directly from the public AC grid, comprising:

- a bridge rectifier (**PR**) having a first input lead and a second input lead configured to be connected

to a supply voltage (U_{AB}) of the public AC grid, having a first output lead series connected to an anode of a series connected LED string, and a second output lead connected to ground,

- the series connected LED string consisting, in order, of a first LED segment (S_{1f1}), a second LED segment (S_{1f2}), a third LED segment (S_2), a fourth LED segment (S_3), a circuit element (**Z**), and a fifth LED segment (S_4),

- at least one primary direct AC power supply integrated circuit ($IC1_1, IC1_2, \dots, IC1_n$) for driving said LED string, each of the at least one primary direct AC power supply integrated circuits ($IC1_1, IC1_2, \dots, IC1_n$) having: a first internal current source connected to an anode of a first LED constituent of the third LED segment (S_2), a second internal current source connected to an anode of a first LED constituent of the fourth LED segment (S_3), a third internal current source connected to an anode of a first LED constituent of the fifth LED segment (S_4), a fourth internal current source connected to a cathode of a last LED

constituent of the fifth LED segment (S_4),

- each of the at least one primary direct AC power supply integrated circuit ($IC1_1, IC1_2, \dots, IC1_n$) being provided with:

a ground pin (**GND**) connected to a first end of a respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$), and with a current set pin (R_{EXT}) connected to a second end of said respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$),

wherein the ground pin (**GND**) of each of the at least one primary direct AC power supply integrated circuits ($IC1_1, IC1_2, \dots, IC1_n$) together with the first end of its respective primary current set resistor ($R1_1, R1_2, \dots, R1_n$) are connected to the ground,

- each primary direct AC power supply integrated circuit ($IC1_1, IC1_2, \dots, IC1_n$) being configured to successively and sequentially switch in the first two LED segments (S_{1f1}, S_{1f2}), the third LED segment (S_2), the fourth LED segment (S_3) and the fifth LED segment (S_4), and also being configured to successively and sequentially switch out the fifth LED segment (S_4), the fourth LED segment (S_3), the third LED segment (S_2) and the first two LED segments (S_{1f1}, S_{1f2}),

- at least one secondary direct AC power supply integrated circuit ($IC2_1, IC2_2, \dots, IC2_n$) for driving said LED string, each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) being provided with:

a ground pin (**GND**) connected to a first end of a respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$), and with a current set pin (R_{EXT}) connected to a second end of said respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$),

- each secondary direct AC power supply integrated circuit ($IC2_1, IC2_2, \dots, IC2_n$) being configured to successively and sequentially switch in the first LED segment (S_{1f1}), the second LED segment (S_{1f2}), the third LED segment (S_2) and the fourth LED segment (S_3), and also being configured to successively and sequentially switch out the fourth LED segment (S_3), the third LED segment (S_2), the second LED segment (S_{1f2}) and the first LED segment (S_{1f1}),

characterized in that:

- each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) has: a first internal current source connected to a tap between the first LED segment (S_{1f1}) and the second LED segment (S_{1f2}), a second internal current source connected to a tap between the second LED segment (S_{1f2}) and the third LED segment (S_2), a third internal current source connected to a tap between the third LED segment (S_2) and the fourth LED segment (S_3), a fourth internal current source connected to a tap between the fourth LED segment (S_3) and the circuit element (**Z**),
- the ground pin (**GND**) of each of the at least one secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$) together with the first end of its respective secondary current set resistor ($R2_1, R2_2, \dots, R2_n$) are connected together to a tap between the circuit element (**Z**) and the fifth LED segment (S_4).

- LED lighting apparatus according to any of the claims 1 - 3, wherein the total number of the primary AC power supply integrated circuits ($IC1_1, IC1_2, \dots, IC1_n$) may differ from the total number of secondary direct AC power supply integrated circuits ($IC2_1, IC2_2, \dots, IC2_n$).

- LED lighting apparatus according to any of the claims 1 - 4, wherein the circuit element (**Z**) is a resistor, or a reverse polarized Zener diode, or a forward biased LED.

Patentansprüche

- LED-Beleuchtungsanordnung, welche direkt aus dem öffentlichen Wechselstromnetz gespeist wird und welche Folgendes umfasst:

- einen Brückengleichrichter (**PR**) mit einer ersten Eingangszuleitung und einer zweiten Eingangszuleitung, die so konfiguriert sind, dass sie mit einer Versorgungsspannung (U_{AB}) des öffentlichen Wechselstromnetzes verbunden sind, mit einer ersten Ausgangszuleitung, die mit einer Anode einem in Reihe geschalteten LED-Streifen in Reihe geschaltet ist, und mit einer zweiten Ausgangszuleitung, die mit Masse verbunden ist,
- wobei der in Reihe geschaltete LED-Streifen, in Reihenfolge, aus einem ersten LED-Segment (S_{1f1}), einem zweiten LED-Segment (S_{1f2}), einem dritten LED-Segment (S_{1f3}), einem vierten LED-Segment (S_{1f4}), einem Schaltungselement (**Z**), einem fünften LED-Segment (S_2), einem sechsten LED-Segment (S_3) und einem siebten LED-Segment (S_4) besteht,

- mindestens eine integrierte primäre direkte Wechselstromversorgungsschaltung ($IC1_1, IC1_2, \dots, IC1_n$) zum Antreiben des jeweiligen LED-Streifens, wobei jede der mindestens einer integrierten primären direkten Wechselstromversorgungsschaltungen ($IC1_1, IC1_2, \dots, IC1_n$) Folgendes aufweist: eine erste interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des fünften LED-Segments (S_2) verbunden ist, eine zweite interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des sechsten LED-Segments (S_3) verbunden ist, eine dritte interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des siebten LED-Segments (S_4) verbunden ist, eine vierte interne Stromquelle, die mit einer Kathode eines letzten LED-Bestandteils des siebten LED-Segments (S_4) verbunden ist,

- wobei jede der mindestens einer integrierten primären direkten Wechselstromversorgungsschaltung ($IC1_1, IC1_2, \dots, IC1_n$) Folgendes aufweist:

einen Erdungsstift (**GND**), der mit einem ersten Ende eines entsprechenden primären Stromeinstellwiderstands ($R1_1, R1_2, \dots, R1_n$) verbunden ist, und einen Stromeinstellstift (R_{EXT}), der mit einem zweiten Ende des jeweiligen primären Stromeinstellwiderstandes ($R1_1, R1_2, \dots, R1_n$) verbunden ist, wobei der Erdungsstift (**GND**) jeder der mindestens einer integrierten primären Wechselstromversorgungsschaltungen ($IC1_1, IC1_2, \dots, IC1_n$) zusammen mit dem ersten Ende ihres jeweiligen primären Stromeinstellwiderstandes ($R1_1, R1_2, \dots, R1_n$) mit Masse verbunden sind,

- wobei jede integrierte primäre Wechselstromversorgungsschaltung ($IC1_1, IC1_2, \dots, IC1_n$) so konfiguriert ist, dass sie nacheinander und sequentiell die ersten vier LED-Segmente ($S_{1f1}, S_{1f2}, S_{1f3}, S_{1f4}$), das fünfte LED-Segment (S_2), das sechste LED-Segment (S_3) und das siebte LED-Segment (S_4) einschaltet, und auch so konfiguriert ist, dass sie nacheinander und sequentiell das siebte LED-Segment (S_4), das sechste LED-Segment (S_3), das fünfte LED-Segment (S_2) und die ersten vier LED-Segmente ($S_{1f1}, S_{1f2}, S_{1f3}, S_{1f4}$) ausschaltet,

- mindestens eine integrierte sekundäre direkte Wechselstromversorgungsschaltung ($IC2_1,$

$IC2_2, \dots, IC2_n$), wobei jede der mindestens einer integrierten sekundären direkten Wechselstromversorgungsschaltungen ($IC2_1, IC2_2, \dots, IC2_n$) Folgendes aufweist:

einen Erdungsstift (**GND**), der mit einem ersten Ende eines entsprechenden sekundären Stromeinstellwiderstands ($R2_1, R2_2, \dots, R2_n$) verbunden ist, und einen Stromeinstellstift (R_{EXT}), der mit einem zweiten Ende des jeweiligen sekundären Stromeinstellwiderstandes ($R2_1, R2_2, \dots, R2_n$) verbunden ist, - wobei jede integrierte sekundäre Wechselstromversorgungsschaltung ($IC2_1, IC2_2, \dots, IC2_n$) so konfiguriert ist, dass sie nacheinander und sequentiell das erste LED-Segment (S_{1f1}), das zweite LED-Segment (S_{1f2}), das dritte LED-Segment (S_{1f3}) und das vierte LED-Segment (S_{1f4}) einschaltet, und auch so konfiguriert ist, dass sie nacheinander und sequentiell das vierte LED-Segment (S_{1f4}), das dritte LED-Segment (S_{1f3}), das zweite LED-Segment (S_{1f2}) und das erste LED-Segment (S_{1f1}) ausschaltet,

dadurch gekennzeichnet, dass:

- jede der mindestens einer integrierten sekundären direkten Wechselstromversorgungsschaltungen ($IC2_1, IC2_2, \dots, IC2_n$) Folgendes aufweist: eine erste interne Stromquelle, die mit einem Abgriff zwischen dem ersten LED-Segment (S_{1f1}) und dem zweiten LED-Segment (S_{1f2}) verbunden ist, eine zweite interne Stromquelle, die mit einem Abgriff zwischen dem zweiten LED-Segment (S_{1f2}) und dem dritten LED-Segment (S_{1f3}) verbunden ist, eine dritte interne Stromquelle, die mit einem Abgriff zwischen dem dritten LED-Segment (S_{1f3}) und dem vierten LED-Segment (S_{1f4}) verbunden ist, eine vierte interne Stromquelle, die mit einem Abgriff zwischen dem vierten LED-Segment (S_{1f4}) und dem Schaltungselement (**Z**) verbunden ist, - wobei der Erdungsstift (**GND**) jeder der wenigstens einer integrierten sekundären direkten Wechselstromversorgungsschaltungen ($IC2_1, IC2_2, \dots, IC2_n$) zusammen mit dem ersten Ende ihres jeweiligen sekundären Stromeinstellwiderstandes ($R2_1, R2_2, \dots, R2_n$) mit einem Abgriff zwischen dem Schaltungselement (**Z**) und dem fünften LED-Segment (S_2) verbunden sind.

2. LED-Beleuchtungsvorrichtung, welche direkt aus

dem öffentlichen Wechselstromnetz gespeist wird und welche Folgendes umfasst:

- einen Brückengleichrichter (**PR**) mit einer ersten Eingangszuleitung und einer zweiten Eingangszuleitung, die so konfiguriert sind, dass sie mit einer Versorgungsspannung (**U_{AB}**) des öffentlichen Wechselstromnetzes verbunden sind, mit einer ersten Ausgangszuleitung, die mit einer Anode einem in Reihe geschalteten LED-Streifen in Reihe geschaltet ist, und mit einer zweiten Ausgangszuleitung, die mit Masse verbunden ist,

- wobei der in Reihe geschaltete LED-Streifen, in Reihenfolge, aus einem ersten LED-Segment (**S_{1f1}**), einem zweiten LED-Segment (**S_{1f2}**), einem dritten LED-Segment (**S_{1f3}**), einem vierten LED-Segment (**S₂**), einem Schaltungselement (**Z**), einem fünften LED-Segment (**S₃**) und einem sechsten LED-Segment (**S₄**) besteht,

- mindestens eine integrierte primäre direkte Wechselstromversorgungsschaltung (**IC₁**, **IC₂**,..., **IC_{1n}**) zum Antreiben des jeweiligen LED-Streifens, wobei jede der mindestens einer integrierten primären direkten Wechselstromversorgungsschaltungen (**IC₁**, **IC₂**,..., **IC_{1n}**) Folgendes aufweist: eine erste interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des vierten LED-Segments (**S₂**) verbunden ist, eine zweite interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des fünften LED-Segments (**S₃**) verbunden ist, eine dritte interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des sechsten LED-Segments (**S₄**) verbunden ist, eine vierte interne Stromquelle, die mit einer Kathode eines letzten LED-Bestandteils des sechsten LED-Segments (**S₄**) verbunden ist, - wobei jede der mindestens einer integrierten primären direkten Wechselstromversorgungsschaltung (**IC₁**, **IC₂**,..., **IC_{1n}**) Folgendes aufweist:

einen Erdungsstift (**GND**), der mit einem ersten Ende eines entsprechenden primären Stromeinstellwiderstands (**R₁**, **R₂**,..., **R_{1n}**) verbunden ist, und einen Stromeinstellstift (**R_{EXT}**), der mit einem zweiten Ende des jeweiligen primären Stromeinstellwiderstandes (**R₁**, **R₂**,..., **R_{1n}**) verbunden ist, wobei der Erdungsstift (**GND**) jeder der mindestens einer integrierten primären Wechselstromversorgungsschaltungen (**IC₁**, **IC₂**,..., **IC_{1n}**) zusammen mit dem ersten

Ende ihres jeweiligen primären Stromeinstellwiderstandes (**R₁**, **R₂**,..., **R_{1n}**) mit Masse verbunden sind,

- wobei jede integrierte primäre Wechselstromversorgungsschaltung (**IC₁**, **IC₂**,..., **IC_{1n}**) so konfiguriert ist, dass sie nacheinander und sequentiell die ersten drei LED-Segmente (**S_{1f1}**, **S_{1f2}**, **S_{1f3}**), das vierte LED-Segment (**S₂**), das fünfte LED-Segment (**S₃**) und das sechste LED-Segment (**S₄**) einschaltet, und auch so konfiguriert ist, dass sie nacheinander und sequentiell das sechste LED-Segment (**S₄**), das fünfte LED-Segment (**S₃**), das vierte LED-Segment (**S₂**) und die ersten drei LED-Segmente (**S_{1f1}**, **S_{1f2}**, **S_{1f3}**) ausschaltet, - mindestens eine integrierte sekundäre direkte Wechselstromversorgungsschaltung (**IC₂**, **IC₂**,..., **IC_{2n}**) zum Antreiben des jeweiligen LED-Streifens, wobei jede der mindestens einer integrierten sekundären direkten Wechselstromversorgungsschaltungen (**IC₂**, **IC₂**,..., **IC_{2n}**) Folgendes aufweist:

einen Erdungsstift (**GND**), der mit einem ersten Ende eines entsprechenden sekundären Stromeinstellwiderstands (**R₂**, **R₂**,..., **R_{2n}**) verbunden ist, und einen Stromeinstellstift (**R_{EXT}**), der mit einem zweiten Ende des jeweiligen sekundären Stromeinstellwiderstandes (**R₂**, **R₂**,..., **R_{2n}**) verbunden ist,

- wobei jede integrierte sekundäre Wechselstromversorgungsschaltung (**IC₂**, **IC₂**,..., **IC_{2n}**) so konfiguriert ist, dass sie nacheinander und sequentiell das erste LED-Segment (**S_{1f1}**), das zweite LED-Segment (**S_{1f2}**), das dritte LED-Segment (**S_{1f3}**) und das vierte LED-Segment (**S₂**) einschaltet, und auch so konfiguriert ist, dass sie nacheinander und sequentiell das vierte LED-Segment (**S₂**), das dritte LED-Segment (**S_{1f3}**), das zweite LED-Segment (**S_{1f2}**) und das erste LED-Segment (**S_{1f1}**) ausschaltet,

dadurch gekennzeichnet, dass:

- jede der mindestens einer integrierten sekundären direkten Wechselstromversorgungsschaltungen (**IC₂**, **IC₂**,..., **IC_{2n}**) Folgendes aufweist: eine erste interne Stromquelle, die mit einem Abgriff zwischen dem ersten LED-Segment (**S_{1f1}**) und dem zweiten LED-Segment (**S_{1f2}**) verbunden ist, eine zweite interne Stromquelle, die mit einem Abgriff zwischen dem zweiten LED-Segment (**S_{1f2}**) und dem dritten LED-Segment (**S_{1f3}**) verbunden ist, eine dritte interne Stromquelle, die mit einem Abgriff zwischen

- dem dritten LED-Segment (S_{1f3}) und dem vierten LED-Segment (S_2) verbunden ist, eine vierte interne Stromquelle, die mit einem Abgriff zwischen dem vierten LED-Segment (S_2) und dem Schaltungselement (Z) verbunden ist, 5
- wobei der Erdungsstift (GND) jeder der wenigstens einer integrierten sekundären direkten Wechselstromversorgungsschaltungen ($IC2_1, IC2_2, \dots, IC2_n$) zusammen mit dem ersten Ende ihres jeweiligen sekundären Stromeinstellwiderstandes ($R2_1, R2_2, \dots, R2_n$) mit einem Abgriff zwischen dem Schaltungselement (Z) und dem fünften LED-Segment (S_3) verbunden sind. 10
3. LED-Beleuchtungsvorrichtung, welche direkt aus dem öffentlichen Wechselstromnetz gespeist wird und welche Folgendes umfasst: 15
- einen Brückengleichrichter (PR) mit einer ersten Eingangszuleitung und einer zweiten Eingangszuleitung, die so konfiguriert sind, dass sie mit einer Versorgungsspannung (U_{AB}) des öffentlichen Wechselstromnetzes verbunden sind, mit einer ersten Ausgangszuleitung, die mit einer Anode einem in Reihe geschalteten LED-Streifen in Reihe geschaltet ist, und mit einer zweiten Ausgangszuleitung, die mit Masse verbunden ist, 20
- wobei der in Reihe geschaltete LED-Streifen, in Reihenfolge, aus einem ersten LED-Segment (S_{1f1}), einem zweiten LED-Segment (S_{1f2}), einem dritten LED-Segment (S_2), einem vierten LED-Segment (S_3), einem Schaltungselement (Z) und einem fünften LED-Segment (S_4) besteht, 25 30
- mindestens eine integrierte primäre direkte Wechselstromversorgungsschaltung ($IC1_1, IC1_2, \dots, IC1_n$) zum Antreiben des jeweiligen LED-Streifens, wobei jede der wenigstens einer integrierten primären direkten Wechselstromversorgungsschaltungen ($IC1_1, IC1_2, \dots, IC1_n$) Folgendes aufweist: eine erste interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des dritten LED-Segments (S_2) verbunden ist, eine zweite interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des vierten LED-Segments (S_3) verbunden ist, eine dritte interne Stromquelle, die mit einer Anode eines ersten LED-Bestandteils des fünften LED-Segments (S_4) verbunden ist, eine vierte interne Stromquelle, die mit einer Kathode eines letzten LED-Bestandteils des sechsten LED-Segments (S_4) verbunden ist, 35 40 45 50
- wobei jede der wenigstens einer integrierten primären direkten Wechselstromversorgungsschaltungen ($IC1_1, IC1_2, \dots, IC1_n$) Folgendes aufweist: 55

gungsschaltung ($IC1_1, IC1_2, \dots, IC1_n$) Folgendes aufweist:

einen Erdungsstift (GND), der mit einem ersten Ende eines entsprechenden primären Stromeinstellwiderstandes ($R1_1, R1_2, \dots, R1_n$) verbunden ist, und

einen Stromeinstellstift (R_{EXT}), der mit einem zweiten Ende des jeweiligen primären Stromeinstellwiderstandes ($R1_1, R1_2, \dots, R1_n$) verbunden ist, wobei der Erdungsstift (GND) jeder der wenigstens einer integrierten primären Wechselstromversorgungsschaltungen ($IC1_1, IC1_2, \dots, IC1_n$) zusammen mit dem ersten Ende ihres jeweiligen primären Stromeinstellwiderstandes ($R1_1, R1_2, \dots, R1_n$) mit Masse verbunden sind, 20

- wobei jede integrierte primäre Wechselstromversorgungsschaltung ($IC1_1, IC1_2, \dots, IC1_n$) so konfiguriert ist, dass sie nacheinander und sequentiell die ersten zwei LED-Segmente (S_{1f1}, S_{1f2}), das dritte LED-Segment (S_2), das vierte LED-Segment (S_3) und das fünfte LED-Segment (S_4) einschaltet, und auch so konfiguriert ist, dass sie nacheinander und sequentiell das fünfte LED-Segment (S_4), das vierte LED-Segment (S_3), das dritte LED-Segment (S_2) und die ersten zwei LED-Segmente (S_{1f1}, S_{1f2}) ausschaltet, 25

- mindestens eine integrierte sekundäre direkte Wechselstromversorgungsschaltung ($IC2_1, IC2_2, \dots, IC2_n$), wobei jede der wenigstens einer integrierten sekundären direkten Wechselstromversorgungsschaltung ($IC2_1, IC2_2, \dots, IC2_n$) Folgendes aufweist: 30

einen Erdungsstift (GND), der mit einem ersten Ende eines entsprechenden sekundären Stromeinstellwiderstandes ($R2_1, R2_2, \dots, R2_n$) verbunden ist, und

einen Stromeinstellstift (R_{EXT}), der mit einem zweiten Ende des jeweiligen sekundären Stromeinstellwiderstandes ($R2_1, R2_2, \dots, R2_n$) verbunden ist, 35

- wobei jede integrierte sekundäre Wechselstromversorgungsschaltung ($IC2_1, IC2_2, \dots, IC2_n$) so konfiguriert ist, dass sie nacheinander und sequentiell das erste LED-Segment (S_{1f1}), das zweite LED-Segment (S_{1f2}), das dritte LED-Segment (S_2) und das vierte LED-Segment (S_3) einschaltet, und auch so konfiguriert ist, dass sie nacheinander und sequentiell das vierte LED-Segment (S_3), das dritte LED-Seg- 40 45 50

ment (S_2), das zweite LED-Segment (S_{1f2}) und das erste LED-Segment (S_{1f1}) ausschaltet,

dadurch gekennzeichnet, dass:

- jede der mindestens einer integrierten sekundären direkten Wechselstromversorgungsschaltungen ($IC2_1, IC2_2, \dots, IC2_n$) Folgendes aufweist: eine erste interne Stromquelle, die mit einem Abgriff zwischen dem ersten LED-Segment (S_{1f1}) und dem zweiten LED-Segment (S_{1f2}) verbunden ist, eine zweite interne Stromquelle, die mit einem Abgriff zwischen dem zweiten LED-Segment (S_{1f2}) und dem dritten LED-Segment (S_2) verbunden ist, eine dritte interne Stromquelle, die mit einem Abgriff zwischen dem dritten LED-Segment (S_2) und dem vierten LED-Segment (S_3) verbunden ist, eine vierte interne Stromquelle, die mit einem Abgriff zwischen dem vierten LED-Segment (S_3) und dem Schaltungselement (Z) verbunden ist,

- wobei der Erdungsstift (GND) jeder der wenigstens einer integrierten sekundären direkten Wechselstromversorgungsschaltungen ($IC2_1, IC2_2, \dots, IC2_n$) zusammen mit dem ersten Ende ihres jeweiligen sekundären Stromeinstellwiderstandes ($R2_1, R2_2, \dots, R2_n$) mit einem Abgriff zwischen dem Schaltungselement (Z) und dem fünften LED-Segment (S_4) verbunden sind.

4. LED-Beleuchtungsvorrichtung nach einem der Ansprüche 1 bis 3, wobei die Gesamtzahl der integrierten primären direkten Wechselstromversorgungsschaltungen ($IC1_1, IC1_2, \dots, IC1_n$) von der Gesamtzahl der integrierten sekundären direkten Wechselstromversorgungsschaltungen ($IC2_1, IC2_2, \dots, IC2_n$) abweichen kann.

5. LED-Beleuchtungsvorrichtung nach einem der Ansprüche 1 bis 4, wobei das Schaltungselement (Z) ein Widerstand, eine sperrpolarisierte Zener-Diode oder eine in Vorwärtsrichtung vorgespannte LED ist.

Revendications

1. Appareil d'éclairage à LED alimenté directement par le réseau public à courant alternatif, comprenant:

- un pont redresseur (**PR**) ayant un premier fil d'entrée et un deuxième fil d'entrée configurés pour être connectés à une tension d'alimentation (U_{AB}) du réseau public à courant alternatif, ayant un premier fil de sortie connecté en série à une anode d'une chaîne de LED connectée en série, et un deuxième fil de sortie connecté à la masse,

- la chaîne de LED connectée en série constituée, dans l'ordre, d'un premier segment de LED (S_{1f1}), d'un deuxième segment de LED (S_{1f2}), d'un troisième segment de LED (S_{1f3}), d'un quatrième segment de LED (S_{1f4}), d'un élément de circuit (Z), d'un cinquième segment de LED (S_2), d'un sixième segment de LED (S_3) et d'un septième segment de LED (S_4),

- au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1, IC1_2, \dots, IC1_n$) pour l'opération de ladite chaîne de LED, chacun des au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1, IC1_2, \dots, IC1_n$) ayant: une première source de courant interne connectée à une anode d'un premier constituant LED du cinquième segment de LED (S_2), une deuxième source de courant interne connectée à une anode d'un premier constituant LED du sixième segment de LED (S_3), une troisième source de courant interne connectée à une anode d'un premier constituant LED du septième segment de LED (S_4), une quatrième source de courant interne connectée à une cathode d'un dernier constituant LED du septième segment de LED (S_4),

- chacun de l'au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1, IC1_2, \dots, IC1_n$) étant fourni avec:

une broche de masse (**GND**) connectée à une première extrémité d'une résistance de réglage de courant primaire respective ($R1_1, R1_2, \dots, R1_n$), et avec une broche de réglage de courant (**R_{EXT}**) connectée à une seconde extrémité de ladite résistance de réglage de courant primaire respective ($R1_1, R1_2, \dots, R1_n$), dans lequel la broche de masse (**GND**) de chacun des au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1, IC1_2, \dots, IC1_n$) avec la première extrémité de sa résistance de réglage de courant primaire respective ($R1_1, R1_2, \dots, R1_n$) sont reliées à la masse,

- chaque circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1, IC1_2, \dots, IC1_n$) étant configuré pour commuter successivement et séquentiellement dans les quatre premiers segments de LED ($S_{1f1}, S_{1f2}, S_{1f3}, S_{1f4}$), le cinquième segment de LED (S_2), le sixième segment de LED (S_3) et le septième segment de LED (S_4), et étant également configurés pour

désactiver successivement et séquentiellement le septième segment de LED (S_4), le sixième segment de LED (S_3), le cinquième segment de LED (S_2) et les quatre premiers segments de LED (S_{1f1} , S_{1f2} , S_{1f3} , S_{1f4}),

- au moins un circuit intégré secondaire direct d'alimentation en courant alternatif ($IC2_1$, $IC2_2, \dots, IC2_n$) pour l'opération de ladite chaîne de LED, chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif ($IC2_1$, $IC2_2, \dots, IC2_n$) étant fourni avec:

une broche de masse (**GND**) connectée à une première extrémité d'une résistance de réglage de courant secondaire respective ($R2_1$, $R2_2, \dots, R2_n$), et

avec une broche de réglage de courant (R_{EXT}) connectée à une seconde extrémité de ladite résistance de réglage de courant secondaire respective ($R2_1$, $R2_2, \dots, R2_n$),

- chaque circuit intégré secondaire direct d'alimentation en courant alternatif ($IC2_1$, $IC2_2, \dots, IC2_n$) étant configuré pour commuter successivement et séquentiellement dans le premier segment de LED (S_{1f1}), le deuxième segment de LED (S_{1f2}), le troisième segment de LED (S_{1f3}) et le quatrième segment de LED (S_{1f4}) et étant également configuré pour désactiver successivement et séquentiellement le quatrième segment de LED (S_{1f4}), le troisième segment de LED (S_{1f3}), le deuxième segment de LED (S_{1f2}) et le premier segment de LED (S_{1f1}),

caractérisé en ce que:

- chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif ($IC2_1$, $IC2_2, \dots, IC2_n$) comporte: une première source de courant interne connectée à une prise entre le premier segment de LED (S_{1f1}) et le deuxième segment de LED (S_{1f2}), une deuxième source de courant interne connectée à une prise entre le deuxième segment de LED (S_{1f2}) et le troisième segment de LED (S_{1f3}), une troisième source de courant interne connectée à une prise entre le troisième segment de LED (S_{1f3}) et le quatrième segment de LED (S_{1f4}), une quatrième source de courant interne connectée à une prise entre le quatrième segment de LED (S_{1f4}) et l'élément de circuit (**Z**),

- la broche de masse (**GND**) de chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif ($IC2_1$, $IC2_2, \dots, IC2_n$) ainsi que la première extrémité de sa résistance de réglage de courant secondaire res-

pective ($R2_1$, $R2_2, \dots, R2_n$) sont connectés ensemble à une prise entre l'élément de circuit (**Z**) et le cinquième segment de LED (S_2).

- 5 2. Appareil d'éclairage à LED alimenté directement par le réseau public AC, comprenant:

- un pont redresseur (**PR**) ayant un premier fil d'entrée et un deuxième fil d'entrée configurés pour être connectés à une tension d'alimentation (U_{AB}) du réseau public à courant alternatif, ayant un premier fil de sortie connecté en série à une anode d'une chaîne de LED connectée en série, et un deuxième fil de sortie connecté à la masse,

- la chaîne de LED connectée en série constituée, dans l'ordre, d'un premier segment de LED (S_{1f1}), d'un deuxième segment de LED (S_{1f2}), d'un troisième segment de LED (S_{1f3}), d'un quatrième segment de LED (S_2), d'un élément de circuit (**Z**), d'un cinquième segment de LED (S_3), d'un sixième segment de LED (S_4),

- au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1$, $IC1_2, \dots, IC1_n$) pour l'opération de ladite chaîne de LED, chacun des au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1$, $IC1_2, \dots, IC1_n$) ayant: une première source de courant interne connectée à une anode d'une première constituant LED du quatrième segment de LED (S_2), une deuxième source de courant interne connectée à une anode d'un premier constituant LED du cinquième segment de LED (S_3), une troisième source de courant interne connectée à une anode d'un premier constituant LED du sixième segment de LED (S_4), une quatrième source de courant interne connectée à une cathode d'un dernier constituant LED du sixième segment de LED (S_4),

- chacun des au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1$, $IC1_2, \dots, IC1_n$) étant fourni avec:

une broche de masse (**GND**) connectée à une première extrémité d'une résistance de réglage de courant primaire respective ($R1_1$, $R1_2, \dots, R1_n$), et

avec une broche de réglage de courant (R_{EXT}) connectée à une seconde extrémité de ladite résistance de réglage de courant primaire respective ($R1_1$, $R1_2, \dots, R1_n$), dans lequel la broche de masse (**GND**) de chacun des au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC1_1$, $IC1_2, \dots, IC1_n$) ainsi que la pre-

mière extrémité de sa résistance de réglage de courant primaire respective (R_{11} , R_{12} , ..., R_{1n}) sont reliés à la masse,

- chaque circuit intégré primaire direct d'alimentation en courant alternatif (IC_{11} , IC_{12} , ..., IC_{1n}) étant configuré pour commuter successivement et séquentiellement dans les trois premiers segments de LED (S_{1f1} , S_{1f2} , S_{1f3}), le quatrième segment de LED (S_2), le cinquième segment de LED (S_3) et le sixième segment de LED (S_4), et étant également configurés pour désactiver successivement et séquentiellement le sixième segment de LED (S_4), le cinquième segment de LED (S_3), le quatrième segment de LED (S_2) et les trois premiers segments de LED (S_{1f1} , S_{1f2} , S_{1f3}),
- au moins un circuit intégré secondaire direct d'alimentation en courant alternatif (IC_{21} , IC_{22} , ..., IC_{2n}) pour l'opération de ladite chaîne de LED, chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif (IC_{21} , IC_{22} , ..., IC_{2n}) étant fourni avec:

une broche de masse (**GND**) connectée à une première extrémité d'une résistance de réglage de courant secondaire respective (R_{21} , R_{22} , ..., R_{2n}), et avec une broche de réglage de courant (R_{EXT}) connectée à une seconde extrémité de ladite résistance de réglage de courant secondaire respective (R_{21} , R_{22} , ..., R_{2n}),

- chaque circuit intégré secondaire direct d'alimentation en courant alternatif (IC_{21} , IC_{22} , ..., IC_{2n}) étant configuré pour commuter successivement et séquentiellement dans le premier segment de LED (S_{1f1}), le deuxième segment de LED (S_{1f2}), le troisième segment de LED (S_{1f3}) et le quatrième segment de LED (S_2) et étant également configuré pour désactiver successivement et séquentiellement le quatrième segment de LED (S_2), le troisième segment de LED (S_{1f3}), le deuxième segment de LED (S_{1f2}) et le premier segment de LED (S_{1f1}),

caractérisé en ce que:

- chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif (IC_{21} , IC_{22} , ..., IC_{2n}) comporte: une première source de courant interne connectée à une prise entre le premier segment de LED (S_{1f1}) et le deuxième segment de LED (S_{1f2}), une deuxième source de courant interne connectée à une prise entre le deuxième segment de LED (S_{1f2}) et le troisième segment de LED (S_{1f3}), une troisième source de courant interne connectée à

une prise entre le troisième segment de LED (S_{1f3}) et le quatrième segment de LED (S_2), une quatrième source de courant interne connectée à une prise entre le quatrième segment de LED (S_2) et l'élément de circuit (**Z**),

- la broche de masse (**GND**) de chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif (IC_{21} , IC_{22} , ..., IC_{2n}) ainsi que la première extrémité de sa résistance de réglage de courant secondaire respective (R_{21} , R_{22} , ..., R_{2n}) sont connectées ensemble à une prise entre l'élément de circuit (**Z**) et le cinquième segment de LED (S_3).

3. Appareil d'éclairage à LED alimenté directement par le réseau public AC, comprenant:

- un pont redresseur (**PR**) ayant un premier fil d'entrée et un deuxième fil d'entrée configurés pour être connectés à une tension d'alimentation (U_{AB}) du réseau public à courant alternatif, ayant un premier fil de sortie connecté en série à une anode d'une chaîne de LED connectée en série, et un deuxième fil de sortie connecté à la masse,

- la chaîne de LED connectée en série constituée, dans l'ordre, d'un premier segment de LED (S_{1f1}), d'un deuxième segment de LED (S_{1f2}), d'un troisième segment de LED (S_2), d'un quatrième segment de LED (S_3), d'un élément de circuit (**Z**), d'un cinquième segment de LED (S_4),

- au moins un circuit intégré primaire direct d'alimentation en courant alternatif (IC_{11} , IC_{12} , ..., IC_{1n}) pour l'opération de ladite chaîne de LED, chacun des au moins un circuit intégré primaire direct d'alimentation en courant alternatif (IC_{11} , IC_{12} , ..., IC_{1n}) ayant: une première source de courant interne connectée à une anode d'un premier constituant LED du troisième segment de LED (S_2), une deuxième source de courant interne connectée à une anode d'un premier constituant LED du quatrième segment de LED (S_3), une troisième source de courant interne connectée à une anode d'un premier constituant LED du cinquième segment de LED (S_4), une quatrième source de courant interne connectée à une cathode d'un dernier constituant LED du cinquième segment de LED (S_4),

- chacun des au moins un circuit intégré primaire direct d'alimentation en courant alternatif (IC_{11} , IC_{12} , ..., IC_{1n}) étant fourni avec:

une broche de masse (**GND**) connectée à une première extrémité d'une ré-

sistance de réglage de courant primaire respective ($R_{1_1}, R_{1_2}, \dots, R_{1_n}$), et une broche de réglage de courant (R_{EXT}) connectée à une seconde extrémité de ladite résistance de réglage de courant primaire respective ($R_{1_1}, R_{1_2}, \dots, R_{1_n}$),

dans lequel la broche de masse (GND) de chacun des au moins un circuit intégré primaire direct d'alimentation en courant alternatif ($IC_{1_1}, IC_{1_2}, \dots, IC_{1_n}$) ainsi que la première extrémité de sa résistance de réglage de courant primaire respective ($R_{1_1}, R_{1_2}, \dots, R_{1_n}$) sont reliées à la masse,

- chaque circuit intégré primaire direct d'alimentation en courant alternatif ($IC_{1_1}, IC_{1_2}, \dots, IC_{1_n}$) étant configuré pour commuter successivement et séquentiellement dans les deux premiers segments de LED (S_{1f1}, S_{1f2}), le troisième segment de LED (S_2), le quatrième segment de LED (S_3) et le cinquième segment de LED (S_4), et étant également configurés pour désactiver successivement et séquentiellement le cinquième segment de LED (S_4), le quatrième segment de LED (S_3), le troisième segment de LED (S_2) et les deux premiers segments de LED (S_{1f1}, S_{1f2}),
- au moins un circuit intégré secondaire direct d'alimentation en courant alternatif ($IC_{2_1}, IC_{2_2}, \dots, IC_{2_n}$) pour l'opération de ladite chaîne de LED, chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif ($IC_{2_1}, IC_{2_2}, \dots, IC_{2_n}$) étant fourni avec:

une broche de masse (GND) connectée à une première extrémité d'une résistance de réglage de courant secondaire respective ($R_{2_1}, R_{2_2}, \dots, R_{2_n}$), et avec une broche de réglage de courant (R_{EXT}) connectée à une seconde extrémité de ladite résistance de réglage de courant secondaire respective ($R_{2_1}, R_{2_2}, \dots, R_{2_n}$),

- chaque circuit intégré secondaire direct d'alimentation en courant alternatif ($IC_{2_1}, IC_{2_2}, \dots, IC_{2_n}$) étant configuré pour commuter successivement et séquentiellement dans le premier segment de LED (S_{1f1}), le deuxième segment de LED (S_{1f2}), le troisième segment de LED (S_2), le quatrième segment de LED (S_3) et étant également configuré pour désactiver successivement et séquentiellement le quatrième segment de LED (S_3), le troisième segment de LED (S_2), le deuxième segment de LED (S_{1f2}) et le premier segment de LED (S_{1f1}),

- chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif ($IC_{2_1}, IC_{2_2}, \dots, IC_{2_n}$) comporte: une première source de courant interne connectée à une prise entre le premier segment de LED (S_{1f1}) et le deuxième segment de LED (S_{1f2}), une deuxième source de courant interne connectée à une prise entre le deuxième segment de LED (S_{1f2}) et le troisième segment de LED (S_2), une troisième source de courant interne connectée à une prise entre le troisième segment de LED (S_2) et le quatrième segment de LED (S_3), une quatrième source de courant interne connectée à une prise entre le quatrième segment de LED (S_3) et l'élément de circuit (Z),

- la broche de masse (GND) de chacun des au moins un circuit intégré secondaire direct d'alimentation en courant alternatif ($IC_{2_1}, IC_{2_2}, \dots, IC_{2_n}$) ainsi que la première extrémité de sa résistance de réglage de courant secondaire respective ($R_{2_1}, R_{2_2}, \dots, R_{2_n}$) sont connectées ensemble à une prise entre l'élément de circuit (Z) et le cinquième segment de LED (S_4).

4. Appareil d'éclairage à LED selon l'une quelconque des revendications 1 à 3, dans lequel le nombre total de circuits intégrés primaires d'alimentation en courant alternatif ($IC_{1_1}, IC_{1_2}, \dots, IC_{1_n}$) peut différer du nombre total de circuits intégrés secondaires directs d'alimentation en courant alternatif ($IC_{2_1}, IC_{2_2}, \dots, IC_{2_n}$).
5. Appareil d'éclairage à LED selon l'une quelconque des revendications 1 à 4, dans lequel l'élément de circuit (Z) est une résistance, ou une diode Zener à polarisation inverse, ou une LED polarisée en direct.

caractérisé en ce que:

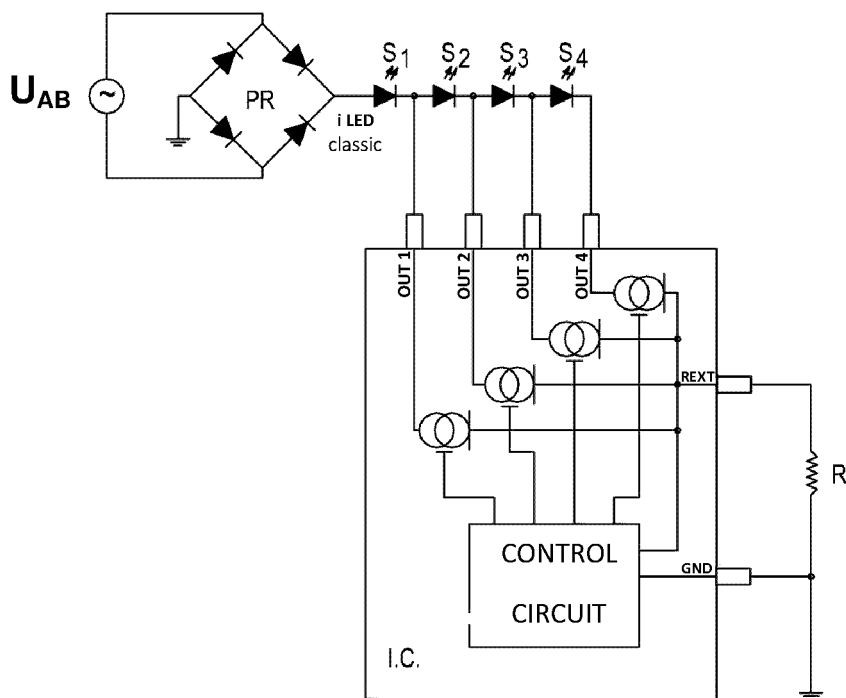


Fig. 1 – state of the art

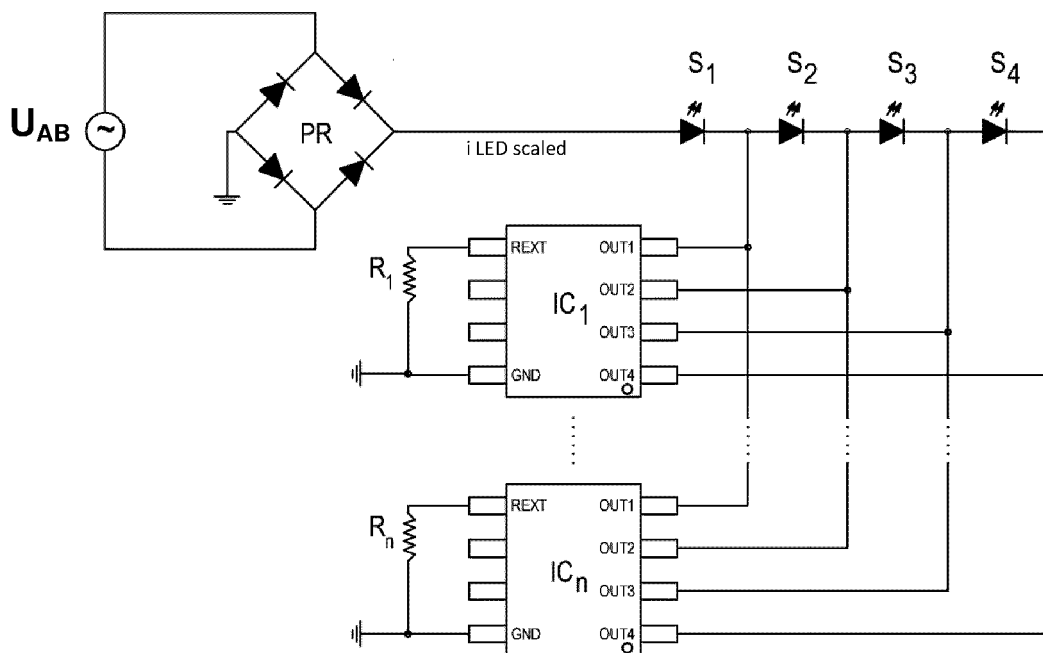


Fig. 2 – state of the art

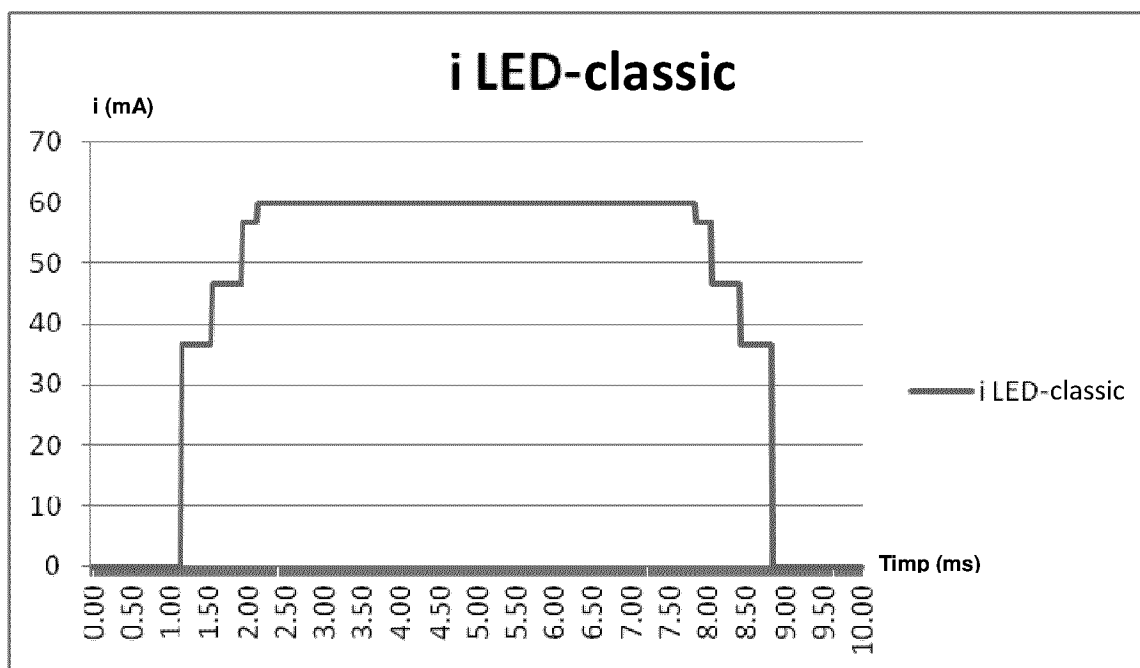


Fig. 3 – state of the art

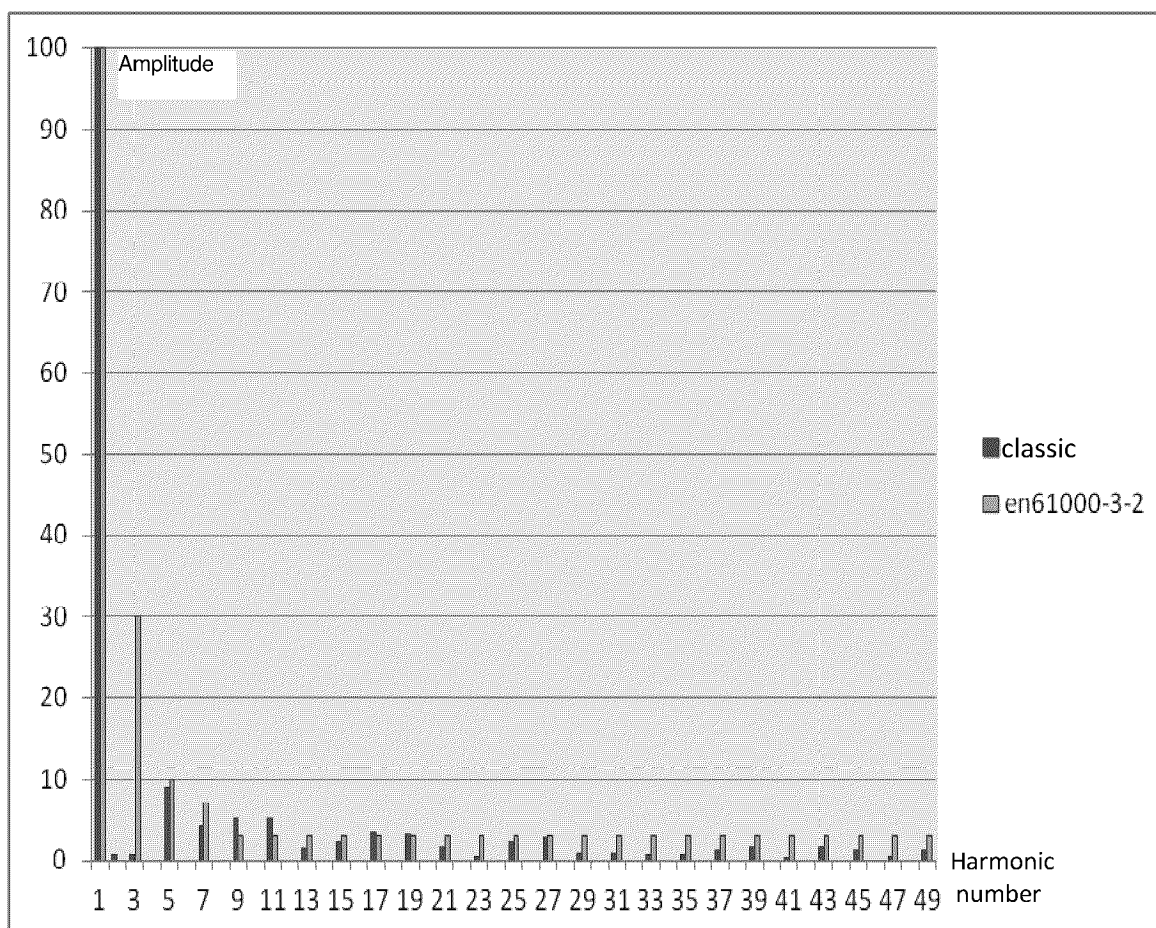


Fig. 4 – state of the art

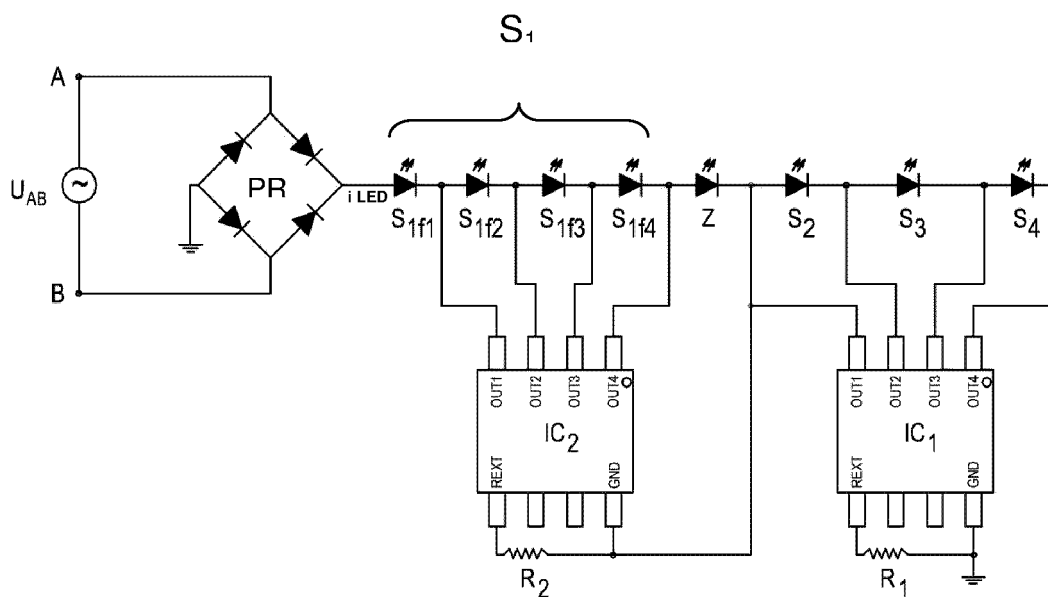


Fig. 5

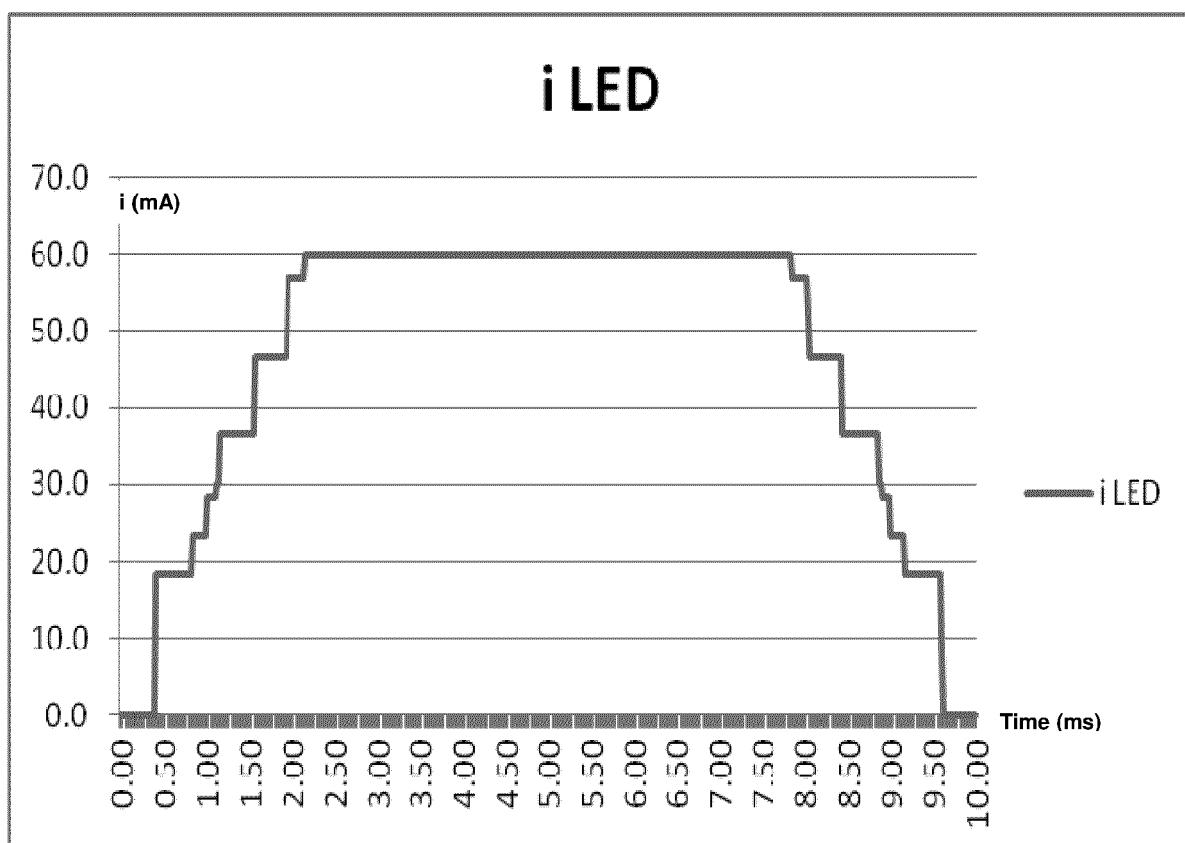


Fig. 6

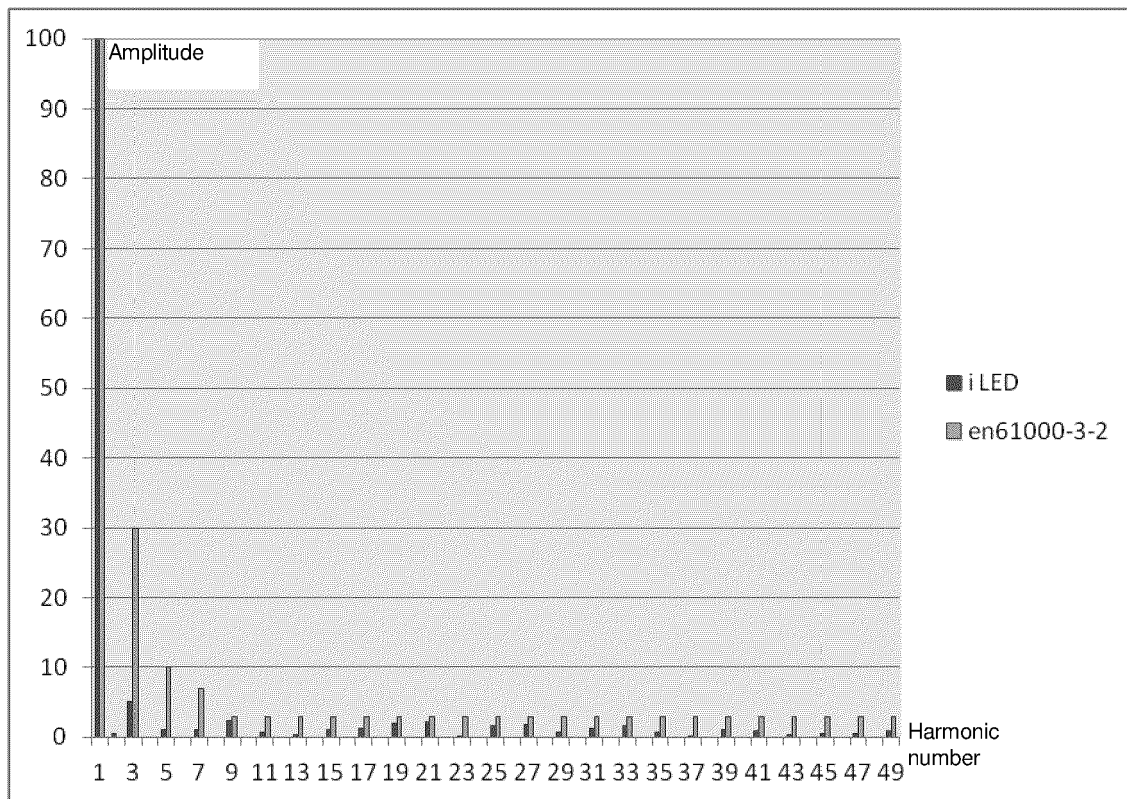


Fig. 7

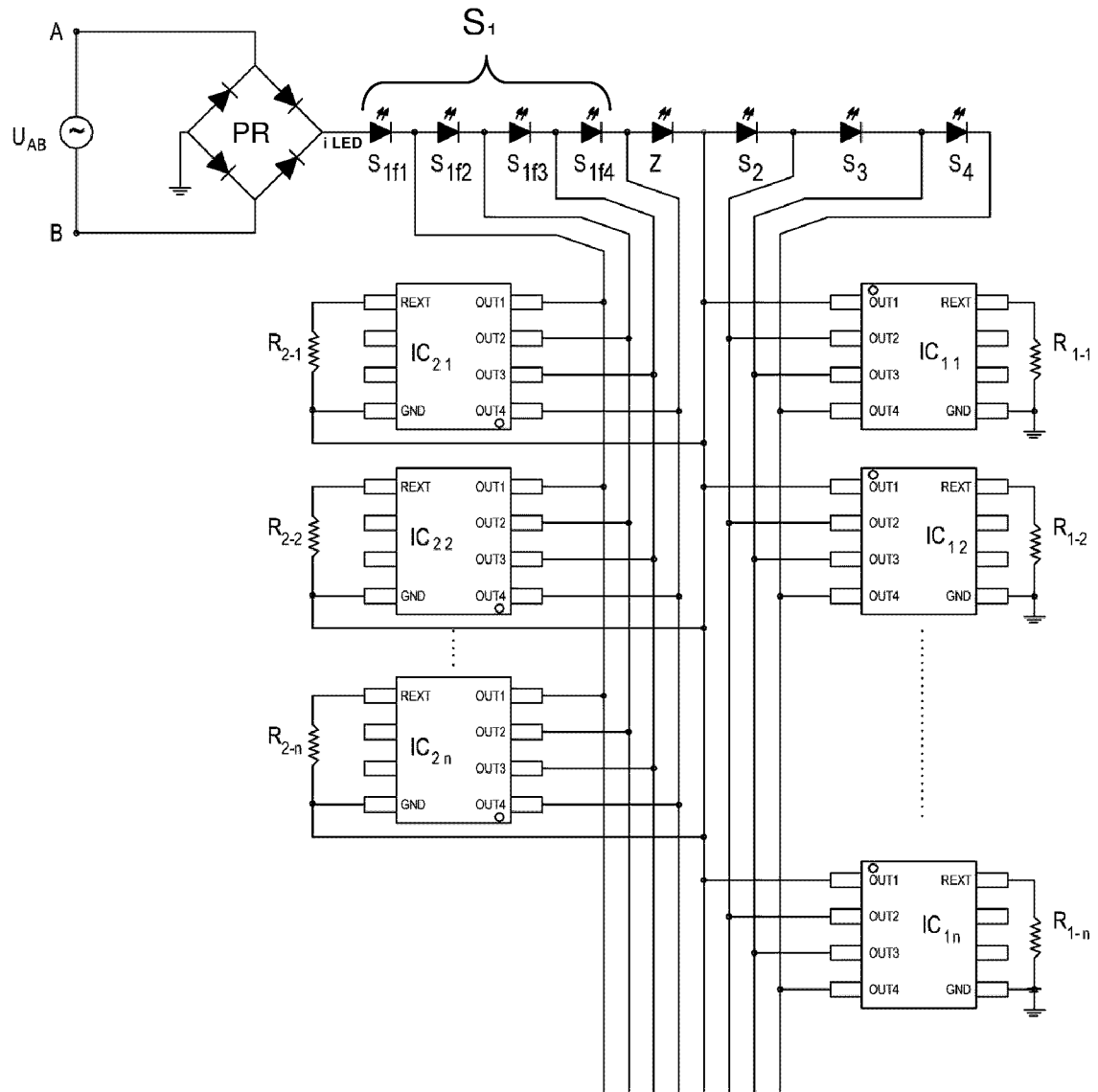


Fig. 8

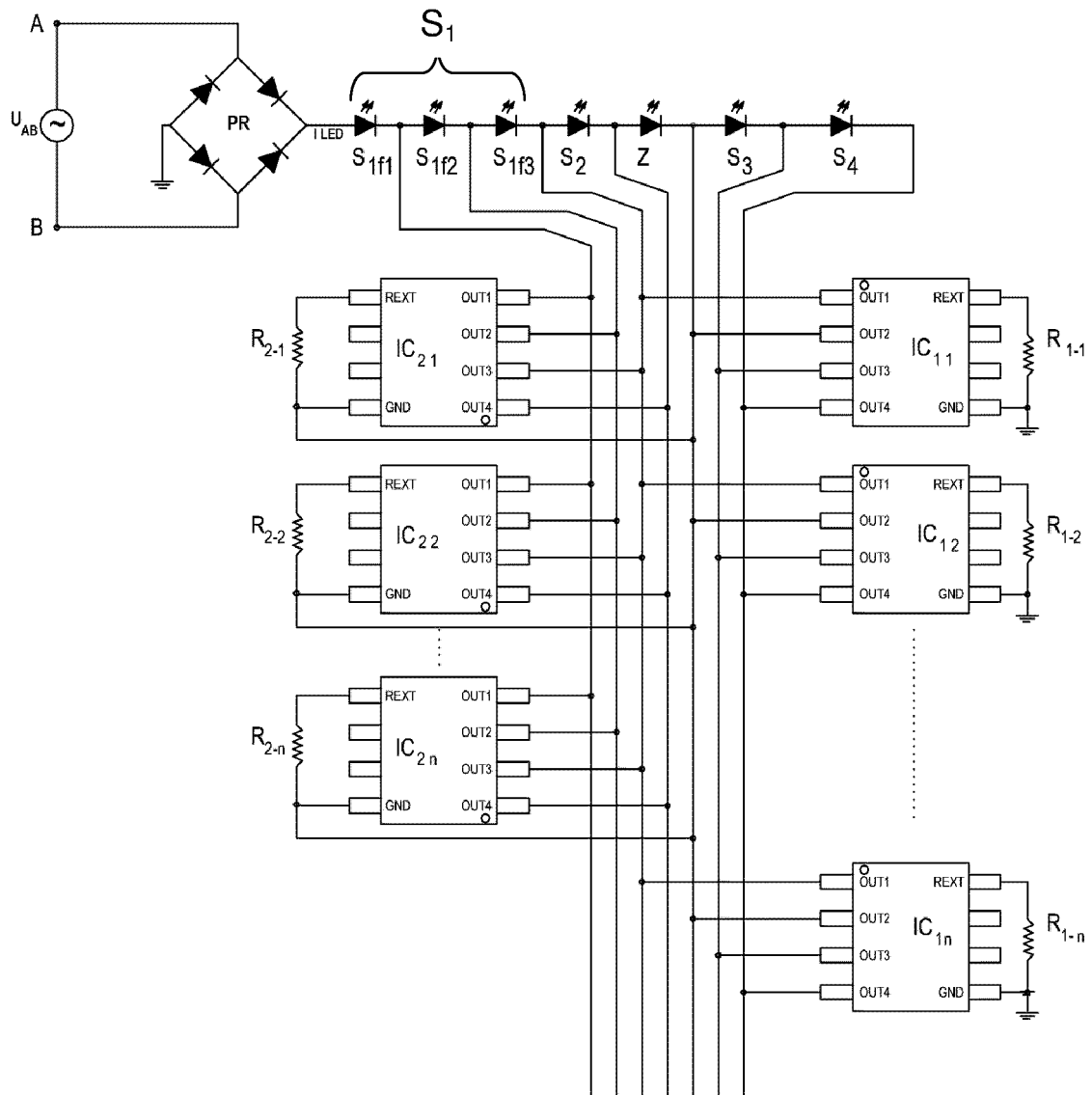


Fig. 9

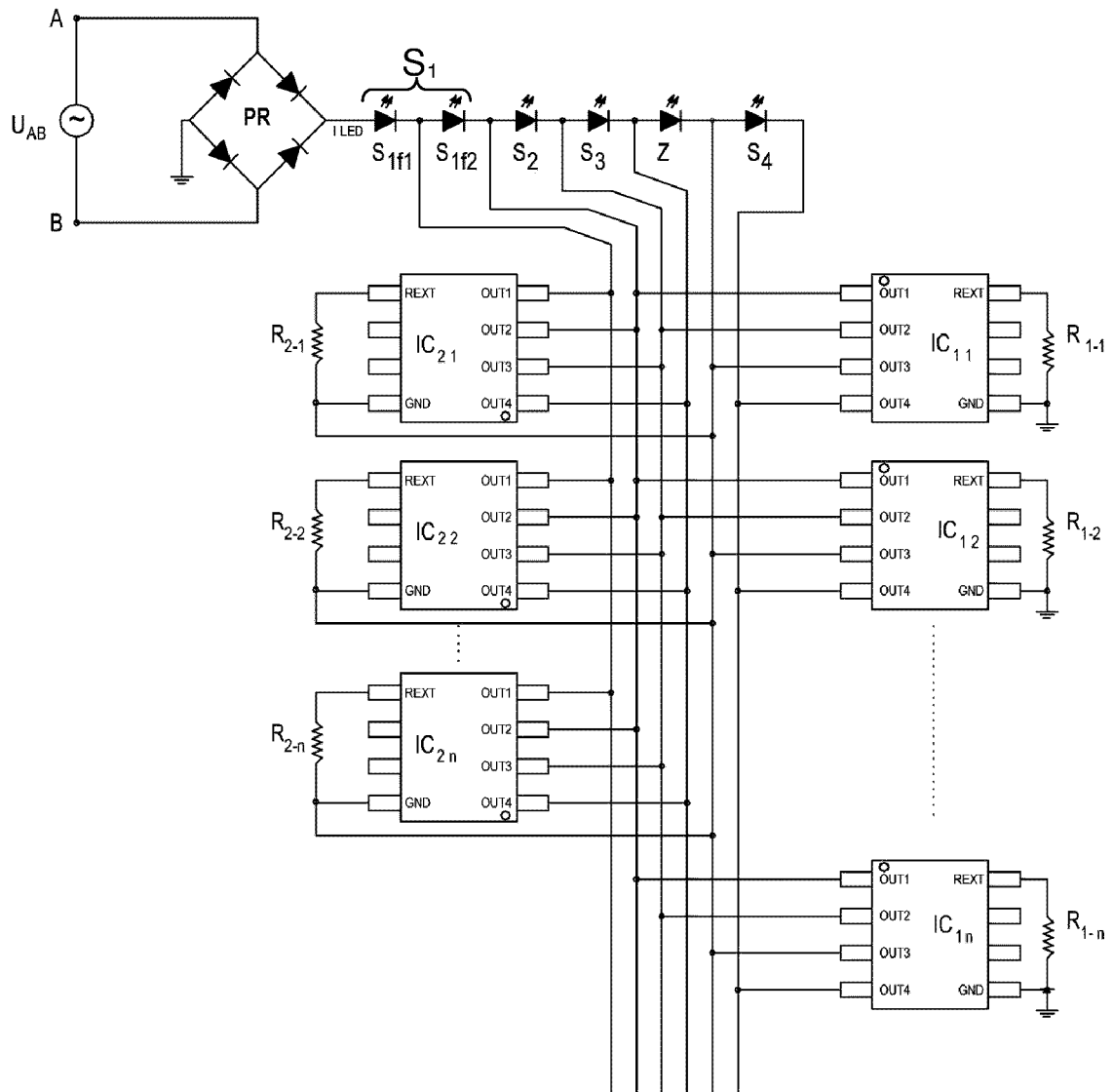


Fig. 10

REFERENCES CITED IN THE DESCRIPTION

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