



(11) **EP 2 612 540 B9**

(12) **CORRECTED EUROPEAN PATENT SPECIFICATION**

(15) Correction information:  
**Corrected version no 1 (W1 B1)**  
**Corrections, see**  
**Claims EN 15**

(51) Int Cl.:  
**H05B 33/08 (2006.01)**

(86) International application number:  
**PCT/US2011/047364**

(48) Corrigendum issued on:  
**23.03.2016 Bulletin 2016/12**

(87) International publication number:  
**WO 2012/030496 (08.03.2012 Gazette 2012/10)**

(45) Date of publication and mention  
of the grant of the patent:  
**30.09.2015 Bulletin 2015/40**

(21) Application number: **11745679.8**

(22) Date of filing: **11.08.2011**

(54) **SOLID STATE LIGHT SOURCE DRIVING AND DIMMING USING AN AC VOLTAGE SOURCE**

**ANSTEUERUNG UND VERDUNKELUNG EINER FESTKÖRPER-LICHTQUELLE MIT EINER WECHSELSPANNUNGSQUELLE**

**EXCITATION D'UNE SOURCE LUMINEUSE À SEMI-CONDUCTEURS ET GRADATION DE LA LUMIÈRE FAISANT APPEL À UNE SOURCE DE TENSION CA**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

• **BETTS, David**  
**Peabody**  
**Massachusetts 01960 (US)**

(30) Priority: **02.09.2010 US 874292**

(74) Representative: **Viering, Jentschura & Partner mbB**  
**Patent- und Rechtsanwälte**  
**Am Brauhaus 8**  
**01099 Dresden (DE)**

(43) Date of publication of application:  
**10.07.2013 Bulletin 2013/28**

(73) Proprietor: **Osram Sylvania Inc.**  
**Danvers, MA 01923 (US)**

(56) References cited:  
**EP-A1- 1 608 206 EP-A1- 2 048 917**  
**DE-U1-202008 004 910**

(72) Inventors:  
• **ALEXANDROVICH, Benjamin**  
**Brookline**  
**Massachusetts 02446 (US)**

**EP 2 612 540 B9**

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

**Description**

## TECHNICAL FIELD

**[0001]** The present application relates to driving and dimming solid state light sources using an AC voltage source, and more particularly, to driving multiple solid state light source strings using an AC voltage source.

## BACKGROUND

**[0002]** Conventional driving systems for solid state light sources, such as but not limited to light emitting diodes (LEDs), typically utilize DC/DC converter circuits to generate a constant DC current to drive the LEDs. Power to a DC/DC converter is typically supplied from an AC voltage source. EP2048917 A1 discloses an LED airfield lighting system whereby the lighting units are feed by a constant alternating current and each unit comprises an AC/DC converter.

## SUMMARY

**[0003]** Conventional driving systems for solid state light sources, such as those described above, while typically offering stable drive current, unnecessarily increase electronic component count. This may degrade the efficiency of power transfer to the LEDs. In addition, these conventional driving systems are typically ill-suited to supply power to a plurality of LED strings, since there is no guarantee that the individual channels will remain isolated and/or grounded (non-floating) during operation.

**[0004]** In an embodiment, there is provided a solid state light source driving and dimming system according to claim 1.

**[0005]** Various additional embodiments are provided according to the dependent claims

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0006]** The foregoing and other objects, features and advantages disclosed herein will be apparent from the following description of particular embodiments disclosed herein, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles disclosed herein.

FIG. 1 is a circuit diagram of one exemplary LED driver system consistent with one embodiment of the present disclosure.

FIG. 2 is a circuit diagram of another exemplary LED driver system consistent with one embodiment of the present disclosure.

FIG. 3 is a circuit diagram of another exemplary LED driver system consistent with one embodiment of the present disclosure.

FIG. 4 is a circuit diagram of another exemplary LED driver system consistent with one embodiment of the present disclosure.

FIG. 5 is a circuit diagram of another exemplary LED driver system consistent with one embodiment of the present disclosure.

## DETAILED DESCRIPTION

**[0007]** Embodiments described herein concern driving and dimming solid state light sources, such as but not limited to light emitting diode (LED) strings. Solid state light sources may include, in addition to LEDs and among other things, organic LEDs (OLEDs), as well as other LED-based light sources. The drive current for an LED string may be derived, for example, from a conventional AC power source and/or an instant start ballast conventionally used to drive one or more linear fluorescent lamps. Thus, embodiments disclosed herein may be used as a direct retrofit to replace conventional fluorescent lamps with LED-based lighting, and in some embodiments, the need for DC/DC converter circuitry may be eliminated. PWM dimming techniques may be employed to control the brightness and/or color of individual LED strings. Advantageously, embodiments disclosed herein may offer reduced component count which may translate to increased power factor efficiency and significant cost savings over conventional LED driving systems.

**[0008]** FIG. 1 is a circuit diagram of a solid state light source driver system 100 according to embodiments described herein. In FIG. 1, the solid state light sources are a string of LEDs. The solid state light source driver system 100 includes an AC voltage source 102, current source circuitry 104, rectifier circuitry 110, and an LED string 112. The AC voltage source 102 is configured to generate an AC voltage, for example but not limited to, a sinusoidal AC voltage. Alternatively or additionally, the AC voltage source 102 may be a ballast source associated with a gas discharge lamp fixture, and may thus be configured to supply voltage in the range of 600 VAC operating at 20 to 200 KHz, depending on the type of gas discharge lamp conventionally used. Of course, these are only examples of the types of voltage sources that may be utilized herein, and those skilled in the art will recognize that other voltage sources may be used without departing from the scope of embodiments described herein. Since the drive current required by a typical LED string is much less that may be generated by the AC voltage source 102, embodiments may also include the current source circuitry 104 coupled to one or more voltage rails of the AC voltage source 102 and configured to generate a current from the AC voltage source 102. In this example, the current source circuitry 104 may include a ballast capacitor  $C_b$  that is configured to generate a constant AC current and is coupled to the positive voltage rail of the AC voltage source 102 and in series with the LED string 112, which is the load. The capacitance value of

the ballast capacitor  $C_b$  may be selected based on the operating frequency of the AC voltage source 102, and may be generally given by the equation  $C_b = I / 2\pi f V$ , where  $I$  is the output current of the ballast capacitor  $C_b$ ,  $V$  is the voltage of the AC voltage source 102, and  $f$  is the frequency of the AC voltage source 102.

**[0009]** The rectifier circuitry 110 may be coupled to the current source circuitry 104 and configured to rectify and filter the AC current generated by the current source circuitry 104. In some embodiments, and as shown in FIG. 1, the rectifier circuitry 110 may include full wave bridge circuitry (FWB) that includes four diodes arranged to rectify the AC current into a full wave rectified AC current. This arrangement is also known as a full wave rectifier, and may be referred to herein as either a full wave bridge, FWB or full wave rectifier. A filter capacitor  $C_f$  may be provided to filter the rectified AC current and generate a DC or quasi-DC current. The LED string 112 may be coupled to the rectifier circuitry 110. In some embodiments, the LED string 112 may include a plurality of LED and/or other solid state light source devices configured to emit light. The LED string 112 may be driven by the DC current generated by the rectifier circuitry 110. While the filter capacitor  $C_f$  may smooth the rectified DC current into a DC or quasi-DC signal, such smoothed signal may still produce significant DC variations in relation to the peak-to-trough values of the AC current. Thus, to reduce or eliminate perceptible flicker due to the incomplete smoothing effect of the filter capacitor  $C_f$ , the capacitance value of  $C_f$  may be selected to have a large enough time constant, based on, for example but not limited to, the operating frequency of the AC voltage source 102 and required supply LED current. In FIG. 1, the ballast capacitor  $C_b$  may be much smaller than the filter capacitor  $C_f$ , for example, by orders of magnitude. The LED string 112 may be coupled to a ground 116, which may include, for example, a system MAINS ground and/or common (earth) ground. Coupling the LED string 112 to the ground 116 may reduce or eliminate the LED string 112 from being in a "floating" state, which may reduce or eliminate electro-magnetic interference emanated by the LED string 112.

**[0010]** The solid state light source driver system 100 shown in FIG. 1 may also be configured for pulse width modulated (PWM) dimming to provide dimming control over the LED string 112. To that end, the solid state light source driver system 100 in some embodiments, includes shunt circuitry 106 and dimming circuitry that includes a switch 108 and a PWM signal source 114. In such embodiments, the shunt circuitry 106 may include two diodes D1 and D2 coupled to respective rails of the AC voltage source 102 and forward biased into the switch 108. The shunt circuitry 106 is configured to shunt the AC voltage source 102 depending on the conduction state of the switch 108, as will be described below. The switch 109 may be operably coupled to the shunt circuitry 106 and the FWB circuitry in the rectifier circuitry 110. In operation, the PWM signal source 114 is configured to

generate a PWM signal to control the conduction state of the switch 108. When the PWM signal is ON (high), the switch 108 may close, thus creating a conduction path through the switch 108. During the positive half wave of a signal from the AC voltage source 102, current may flow through the diode D1, through the switch 108, through a lower left diode of the FWB circuitry, and back to the AC voltage source 102. During the negative half wave of the signal from the AC voltage source 102, current may flow through the diode D2, through the switch 108, through the upper left diode of FWB circuitry, and back to the AC voltage source 102. Thus, when the switch 108 is conducting, the AC voltage source 102 may be shunted to interrupt current flow to the LED string 112.

**[0011]** When the PWM signal is OFF, the switch 108 may open, thus decoupling the shunt circuitry 106 and the switch 108 from the AC voltage source 102. In that case, during a positive half wave of a signal from the AC voltage source 102, current flows through the upper right diode of the full wave rectifier FWB, through the LED string 112, through the lower left diode of the FWB and back to the AC voltage source 102. During a negative half wave of the signal from the AC voltage source 102, current flows through the lower right diode of the FWB, through the LED string 112, through the upper left diode of the FWB and back to the AC voltage source 102. Decoupling the shunt circuitry 106, such that there no power loss on the elements in the shunt circuitry 106, when power is delivered to the LED string 112, may offer significant efficiency and power factor enhancements and may further operate to increase a signal to noise ratio of power delivered to the LED string 112.

**[0012]** In some embodiments, the filter capacitor  $C_f$  may have a capacitance value that enables the filter capacitor  $C_f$  to still deliver energy to the LED strings 112 when the AC voltage source 102 is shunted, but also to de-energize quickly enough to allow for adequate dimming control using the duty cycle of the PWM signal generated by the PWM signal source 114. Thus, for example, the filter capacitor  $C_f$  may have a value that allows it to drain energy to the LED string 112 within a few percent of the ON time of the switch 108. The PWM signal source 114 may be coupled to the ground 116, which may include, for example, a system MAINS ground and/or common (earth) ground. Coupling the PWM signal source 114 to the ground 116 may reduce or eliminate the PWM signal source 114 from being in a "floating" state, which may reduce or eliminate harmonic noise in the switch 108 and shunt circuitry 106 and enable finer control over the LED string 112. While the switch 108 is depicted as a generalized switching circuit, those skilled in the art will recognize that the switch 108 may include a FET switch, BJT switch or other electronic circuit capable of switching conduction states. As is known, the PWM signal generated by the PWM signal source 114 may have a controllable duty cycle to control the brightness and/or color of the LED string 112. For example, assuming a 50% duty cycle, drive current is delivered to LED string 112 during

the OFF time of the switch 108 and interrupted during the ON time of the switch 108. To control the overall brightness in the LED string 112, the duty cycle of the PWM signal may be adjusted. For example, the duty cycle may range from 0% (the switch 108 is always open) to 100% (the switch 108 is always closed) to control the overall brightness (luminosity) and/or color of the LED string 112.

**[0013]** FIG. 2 shows a solid state light source driver system 200 according to embodiments described herein. The solid state light source driver system 200 is configured to drive a plurality of LED strings 112A, 112B, ..., 112n from a single AC voltage source 102, and includes a plurality of LED driver circuits 201A, 201B, ..., 201n. An AC voltage source 102 is coupled to each of the LED driver circuits 201A, 201B, ..., 201n, each of which, in whole or in part, may represent an LED channel, and the LED driver circuits 201A, 201B, ..., 201n, each as a whole or in part thereof, may be referred to herein as a "channel", and vice versa. Each of the LED driver circuits 201A, 201B, ..., 201n have a similar topology and operate in a similar manner as the circuit shown in FIG. 1, except as described below. Each LED driver circuit 201A, 201B, ..., 201n may include respective current source circuitry 104A, 104B, ..., 104n, a respective switch 108A, 108B, ..., 108n, respective PWM signal source circuitry 114A, 114B, ..., 114n, respective rectifier circuitry 110A, 110B, ..., 110n and a respective LED string 112A, 112B, ..., 112n. Here, the designation A, B, ..., N in connection with reference numerals should be interpreted as a repetition of like components. The description and operation of these components are described above with reference to FIG. 1.

**[0014]** Each LED driver circuit 201A, 201B, ..., 201n may also include respective shunt circuitry 206A, 206B, ..., 206n. Each respective shunt circuitry 106A, 106B, ..., 106n may include three diodes D1, D2 and D3, where the diodes D1 and D3 are coupled to the negative rail of the AC voltage source 102 and forward biased into the respective switch 108, and the diode D2 is coupled to the positive rail of the AC voltage source 102 and forward biased into the respective switch 108. The shunt circuitry 206A, 206B, ..., 206n is configured to independently shunt the AC voltage source 102 depending on the conduction state of the respective switch 108A, 108B, ..., 108n, as will be described below. Embodiments may also include a return diode (Dc) 218 that is shared by each of the driver circuits 201A, 201B, ..., 201n and coupled to each respective shunt circuitry 206A, 206B, ..., 206n and switch 108A, 108B, ..., 108n. Each switch 108A, 108B, ..., 108n may be operably coupled to respective shunt circuitry 106A, 106B, ..., 106n and the return diode 218.

**[0015]** In operation, each respective PWM signal source circuitry 114A, 114B, ..., 114n is configured to generate a PWM signal to control the conduction state of a respective switch 108A, 108B, ... 108n. Using the driver circuit 201A as an example, when the PWM signal

is ON (high), the switch 108A may conduct, thus closing the switch 108A. During the positive half wave of a signal from the AC voltage source 102, current may flow through the diode D2, through the switch 108A, through the return diode 218, and back to the AC voltage source 102. During the negative half wave of a signal from the AC source 102, current may flow through the diode D3, through the switch 108A, through the diode D1, and back to the AC voltage source 102. Thus, when the switch 108A is conducting, the AC voltage source 102 may be shunted to interrupt current flow to the LED string 112A. When the PWM signal is OFF (low), the switch 108A may open, thus decoupling the shunt circuitry 206A from the AC voltage source 102. In that case, current flows through the rectifier circuitry 110A to power the LED string 112A, as described above in regards to FIG. 1. Decoupling the shunt circuitry 206A, such that there is no power loss on the elements in the shunt circuitry 206A when power is delivered to the LED string 112A, may offer significant power factor enhancements and may further operate to increase a signal to noise ratio of power delivered to the LED string 112A. Each of the other driver circuits 201B, ..., 201n may, and in some embodiments do, operate in a similar manner.

**[0016]** Each LED string 112A, 112B, ..., 112n may include one or more individual LED devices. Each string may be arranged by color, for example but not limited to a red, green, blue (RGB) topology in which the LED string 112A may include one or more red LEDs, the LED string 112B may include one or more green LEDs, and the LED string 112n may include one or more blue LEDs. Of course, this is only an example and other color arrangements are equally contemplated herein, for example, RGW (red, green, white), RGBY (red, green, blue, yellow), infrared, etc., without departing from the scope of the embodiments described herein. By controlling the brightness in each LED string 112A, 112B, ..., 112n, the overall brightness and/or perceived color of the collection of the LED strings 112A, 112B, ..., 112n may be controlled. Thus, in such embodiments, each PWM signal source 114A, 114B, ..., 114n may be independently controlled with its own duty cycle to independently control each LED string 112A, 112B, ..., 112n. To that end, the return diode 218 may operate to reduce or eliminate crosstalk between each driver circuit 201A, 201B, ..., 201n, i.e., reduce or eliminate the effect of varying current between LED strings 112A, 112B, ..., 112n.

**[0017]** In embodiments as shown in FIG. 2, the PWM signal source circuitry 114B may be coupled to a ground 116, which may include, for example, a system MAINS ground and/or common (earth) ground. Coupling the PWM signal source circuitry 114B to the ground 116 may reduce or eliminate the PWM signal source circuitry 114B from being in a "floating" state, which may reduce or eliminate harmonic noise in the respective switch 108B and the respective shunt circuitry 206B and enable finer control over the LED string 112B. However, in such embodiments, each LED string 112A, 112B, ..., 112n may not

be coupled to a ground (due to potential shorting issues), and thus, the LED strings 112A, 112B, ..., 112n may be in a floating condition which could introduce noise and/or other non-controllable factors into the solid state light source driving system 200.

**[0018]** FIG. 3 shows a solid state light source driver system 300 according to embodiments described herein, which are configured to drive a plurality of LED strings 112A, 112B, ..., 112n from a single AC voltage source, similar to the embodiment of FIG. 2. Here, a plurality of LED driver circuits 301A, 301B, ..., 301n are each coupled to an AC voltage source 102. Each of the LED driver circuits 301A, 301B, ..., 301n have a similar topology and operate in a similar manner as the system 100 shown in FIG. 1, except as described below. Each LED driver circuit 301A, 301B, ..., 301n may include respective current source circuitry 104A, 104B, ..., 104n, a respective switch 108A, 108B, ..., 108n, respective PWM signal source circuitry 114A, 114B, ..., 114n, respective shunt circuitry 206A, 206B, ..., 206n, and respective LED strings 112A, 112B, ..., 112n. Here, the designation A, B, ..., N in connection with reference numerals should be interpreted as a repetition of like components. The description and operation of these components are described above with reference to FIGS. 1 and 2.

**[0019]** Embodiments may also include first and second return diodes (Dc and Dc1) 218 and 320 that are shared by each of the LED driver circuits 301A, 301B, ..., 301n. The first return diode 218 may be coupled to each respective shunt circuitry 206A, 206B, ..., 206n and each respective switch 108A, 108B, ..., 108n. The second return diode 320 may be coupled to each respective LED string 112A, 112B, ..., 112n and each respective rectifier circuitry 310A, 310B, ..., 310n. Each switch 108A, 108B, ..., 108n may be operably coupled to the respective shunt circuitry 206A, 206B, ..., 206n and the first return diode 218. The rectifier circuitry 310A, 310B, ..., 310n may include three diodes D4, D5 and D6 instead of the FWB topology that comprises four diodes as shown in FIGS. 1 and 2.

**[0020]** In operation, each respective PWM signal source circuitry 114A, 114B, ..., 114n is configured to generate a PWM signal to control the conduction state of a respective switch 108A, 108B, ... 108n. Using the LED driver circuit 301A as an example, when the PWM signal is ON (high), the switch 108A may close, creating a conduction path through the switch 108A. During the positive half wave of a signal from the AC voltage source 102, current may flow through the diode D2, through the switch 108A, through the first return diode 218, and back to the AC voltage source 102. During the negative half wave of a signal from the AC voltage source 102, current may flow through the diode D3, through the switch 108A, through the diode D1, and back to the AC voltage source 102. Thus, when the switch 108A is conducting, the AC voltage source 102 may be shunted to interrupt current flow to the LED string 112A. When the PWM signal is OFF (low), the switch 108A may open, thus decoupling

the shunt circuitry 106A from the AC voltage source 102. In that case, during the positive half wave of a signal from the AC voltage source 102, current may flow through the diode D5, through the LED string 112A, through the second return diode 320, and back to the AC voltage source 102. During the negative half wave of a signal from the AC voltage source 102, current may flow through the diode D6, through the LED string 112A, through the diode D4, and back to the AC voltage source 102. As with previously described embodiments, decoupling the shunt circuitry 206A, such that there is no power loss on the elements in the shunt circuitry 206A, when power is delivered to the LED string 112A, may offer significant power factor enhancements and may further operate to increase a signal to noise ratio of power delivered to the LED string 112A. Each of the other LED driver circuits 301B, ..., 301n may operate in a similar manner.

**[0021]** As with the previous described embodiments, each LED string 112A, 112B, ..., 112n may include one or more individual LED devices. Each LED string 112A, 112B, ..., 112n may be arranged by color, for example a red, green, blue (RGB) topology in which the LED string 112A may include one or more red LEDs, the LED string 112B may include one or more green LEDs, and the LED string 112n may include one or more blue LEDs. Of course, this is only an example, and other color arrangements are equally contemplated herein, for example, RGW (red, green, white), RGBY (red, green, blue, yellow), infrared, etc., without departing from the scope of embodiments described herein. By controlling the brightness in each LED string 112A, 112B, ..., 112n, the overall brightness and/or perceived color of the collection of LED strings 112A, 112B, ..., 112n may be controlled. Thus, in such embodiments, each PWM signal source circuitry 114A, 114B, ..., 114n may be independently controlled with its own duty cycle to independently control each LED string 112A, 112B, ..., 112n. To that end, the first and second return diodes 218 and 320 may operate to reduce or eliminate crosstalk between each LED driver circuit 301A, 301B, ..., 301n, i.e., reduce or eliminate the effect of varying current between the LED strings 112A, 112B, ..., 112n.

**[0022]** Advantageously, in such embodiments, elimination of one of the diodes in each of the respective rectifier circuitry 310A, 310B, ..., 310n may enable the rectifier circuitry 310A, 310B, ..., 310n and the LED string 112A, 112B, ..., 112n in each LED driver circuit 301A, 301B, ..., 301n to be coupled to a ground 116. Such an arrangement may reduce or eliminate noise and/or reduce electro-magnetic interference emanated by the LED string 112A, 112B, ..., 112n and other non-controllable factors into the system 300. However, in this arrangement, the PWM signal source circuitry 114A, 114B, ..., 114n may not be coupled to a ground due to potential shorting issues, and thus, the PWM signal source circuitry 114A, 114B, ..., 114n may be in a floating condition, which could introduce noise and/or other non-controllable factors into the system 300.

**[0023]** FIG. 4 shows a solid state light source driver system 400 according to embodiments described herein. The driver system 400 is configured to drive a plurality of solid state lights source strings, here LED strings 112A, 112B, ..., 112n, from a single AC voltage source, similar to the embodiments shown in FIGs. 2 and 3. The driver system 400 includes a plurality of LED driver circuits 401A, 401B, ..., 401n and an AC voltage source 102 coupled to each of the LED driver circuits 401A, 401B, ..., 401n. Each of the LED driver circuits 401A, 401B, ..., 401n have a similar topology and operate in a similar manner as other LED driver circuits described throughout the specification. Each LED driver circuit 401A, 401B, ..., 401n may include respective current source circuitry 104A, 104B, ..., 104n, a respective switch 108A, 108B, ..., 108n, respective PWM signal source circuitry 114A, 114B, ..., 114n, respective shunt circuitry 106A, 106B, ..., 106n, and respective LED strings 112A, 112B, ..., 112n. Here, the designation A, B, ..., N in connection with reference numerals should be interpreted as a repetition of like components. The description and operation of these components are described above with reference to FIGs 1-3.

**[0024]** Each LED driver circuit 401A, 401B, ..., 401n in this embodiment may also include respective isolation circuitry 403A, 403B, ..., 403n coupled to the negative voltage rail of the AC voltage source 102. In some embodiments, the isolation circuitry 403A, 403B, ..., 403n may include a capacitor Cb2. The capacitance value of the capacitor Cb2 may be the same or approximately the same as the ballast capacitor Cb1 (element 104 in FIG. 1) to reduce or eliminate uneven loading of the AC voltage source 102. The isolation circuitry 403A, 403B, ..., 403n is configured to isolate each LED channel from other LED channels. Thus, advantageously, the isolation circuitry 403A, 403B, ..., 403n may reduce or eliminate crosstalk between the channels to enable more precise control over each channel. Also advantageously, the isolation circuitry 403A, 403B, ..., 403n enables each LED driver circuit 401A, 401B, ..., 401n to be coupled to a ground 116, thus eliminating a floating condition in any of the LED driver circuit 401A, 401B, ..., 401n. In other words, the isolation circuitry 403A, 403B, ..., 403n may enable both the PWM signal source circuitry 114A, 114B, ..., 114n and the LED strings 112A, 112B, ..., 112n to be coupled to the ground 116.

**[0025]** As with the embodiments described previously, each LED string 112A, 112B, ..., 112n may include one or more individual LED devices. Each string may be arranged by color, for example a red, green, blue (RGB) topology in which the LED string 112A may include one or more red LEDs, the LED string 112B may include one or more green LEDs, and the LED string 112n may include one or more blue LEDs. Of course, this is only an example and other color arrangements are equally contemplated herein, for example, RGW (red, green, white), RGBY (red, green, blue, yellow), infrared, etc., without departing from the scope of embodiments described

herein. By controlling the brightness in each LED string 112A, 112B, ..., 112n, the overall brightness and/or perceived color of the collection of the LED strings 112A, 112B, ..., 112n may be controlled. Thus, in such embodiments, each PWM signal source circuitry 114A, 114B, ..., 114n may be independently controlled with its own duty cycle to independently control each LED string 112A, 112B, ..., 112n. To that end, the respective ballast capacitor Cb1 in each respective current source circuitry 104A, 104B, ..., 104n, and the respective isolation capacitor Cb2 in each respective isolation circuitry 403A, 403B, ..., 403n, may operate to reduce or eliminate crosstalk between each LED driver circuit 401A, 401B, ..., 401n, i.e., reduce or eliminate the effect of varying current between LED strings 112A, 112B, ..., 112n.

**[0026]** FIG. 5 shows a solid state light source driver system 500 according to embodiments described herein. The driver system 500 shown in FIG. 5 is configured to drive a plurality of solid state light sources, here LED strings, from a single AC voltage source, similar to the embodiments of FIGs. 2, 3 and 4. The driver system 500 includes a plurality of LED driver circuits 501A, 501B, ..., 501n and an AC voltage source 102 coupled to each of the LED driver circuits 501A, 501B, ..., 501n. Each of the LED driver circuits 501A, 501B, ..., 501n have a similar topology and operate in a similar manner as those described throughout. Each LED driver circuit 501A, 501B, ..., 501n may include respective current source circuitry 104A, 104B, ..., 104n, a respective switch 108A, 108B, ..., 108n, respective PWM signal source circuitry 114A, 114B, ..., 114n, respective shunt circuitry 106A, 106B, ..., 106n, respective rectifier circuitry 110A, 110B, ..., 110n and respective LED strings 112A, 112B, ..., 112n. Here, the designation A, B, ..., N in connection with reference numerals should be interpreted as a repetition of like components. The description and operation of these components are described above with reference to FIGs. 1-4.

**[0027]** The driver system 500 may also include an isolation transformer 503 coupled between the AC voltage source 102 and each of the LED driver circuits 501A, 501B, ..., 501n. The isolation transformer 503 may be configured to supply each LED driver circuit 501A, 501B, ..., 501n with an AC voltage and to isolate each LED driver circuit 501A, 501B, ..., 501n from other driver circuits. The isolation transformer 503 may be, and in some embodiments is, a known isolation transformers of any type; such transformers are generally configured with a primary winding and a plurality of isolated secondary windings. The turn ration between the primary and secondary side may determine the voltage delivered by the isolation transformer 503. Thus, advantageously, the isolation transformer 503 may reduce or eliminate crosstalk between the channels to enable more precise control over each channel. Also advantageously, the isolation transformer 503 may enable each LED driver circuit 501A, 501B, ..., 501n to be coupled to a ground 116, thus eliminating a floating condition in any of the LED driver

circuits 501A, 501B, ..., 501n. In other words, the isolation transformer 503 may enable both the PWM signal source circuitry 114A, 114B, ..., 114n and the LED strings 112A, 112B, ... 112n to be coupled to the ground 116.

**[0028]** As with other embodiments, each LED string 112A, 112B, ..., 112n may include one or more individual LED devices. Each string may be arranged by color, for example a red, green, blue (RGB) topology in which the LED string 112A may include one or more red LEDs, the LED string 112B may include one or more green LEDs, and the LED string 112n may include one or more blue LEDs. Of course, this is only an example and other color arrangements are equally contemplated herein, for example, RGW (red, green, white), RGBY (red, green, blue, yellow), infrared, etc., without departing from the scope of embodiments described herein. By controlling the brightness in each LED string 112A, 112B, ..., 112n, the overall brightness and/or perceived color of the collection of LED strings 112A, 112B, ..., 112n may be controlled. Thus, in such embodiments, each PWM signal source circuitry 114A, 114B, ..., 114n may be independently controlled with its own duty cycle to independently control each LED string 112A, 112B, ..., 112n.

**[0029]** In any of the embodiments described herein, a feedback controller (not shown in any of FIGs. 1-5) may be utilized to provide feedback current control over the LED strings 112 and/or 112A, 112B, ..., 112n. For example, each LED driver circuit may include a feedback sense resistor coupled to the LED strings to generate a current feedback signal to a feedback controller. Alternatively, a photodetector may be disposed near the LED strings to receive light and generate a feedback signal proportional to the light of the LED strings. A feedback controller may be utilized to compare the feedback signal to user-defined and/or preset values to generate control signals to control the duty cycle of the PWM signal generated by the PWM signal source circuitry. Known feedback controllers, in accordance with the teachings of the present disclosure, may be used to control the duty cycle of power delivered to each LED string.

**[0030]** As used in any embodiment herein, "circuit" or "circuitry" may comprise, for example, singly or in any combination, hardwired circuitry, programmable circuitry, state machine circuitry, and/or firmware that stores instructions executed by programmable circuitry. In at least one embodiment, the circuits and/or circuitry described herein may collectively or individually comprise one or more integrated circuits. An "integrated circuit" may include a digital, analog or mixed-signal semiconductor device and/or microelectronic device, such as, for example, but not limited to, a semiconductor integrated circuit chip.

**[0031]** Unless otherwise stated, use of the word "substantially" may be construed to include a precise relationship, condition, arrangement, orientation, and/or other characteristic, and deviations thereof as understood by one of ordinary skill in the art, to the extent that such deviations do not materially affect the disclosed methods

and systems.

**[0032]** Throughout the entirety of the present disclosure, use of the articles "a" or "an" to modify a noun may be understood to be used for convenience and to include one, or more than one, of the modified noun, unless otherwise specifically stated.

**[0033]** Elements, components, modules, and/or parts thereof that are described and/or otherwise portrayed through the figures to communicate with, be associated with, and/or be based on, something else, may be understood to so communicate, be associated with, and or be based on in a direct and/or indirect manner, unless otherwise stipulated herein.

**[0034]** Although the methods and systems have been described relative to a specific embodiment thereof, they are not so limited. Obviously many modifications and variations may become apparent in light of the above teachings. Many additional changes in the details, materials, and arrangement of parts, herein described and illustrated, may be made by those skilled in the art.

## Claims

1. A solid state light source driving and dimming system, comprising:

a plurality of solid state light source driver circuits configured to be coupled to an AC voltage source (102), each driver circuit comprising:

a constant current circuitry (104) coupled to the AC voltage source, wherein the constant current circuitry is configured to generate a constant AC current from the AC voltage source;  
 rectifier circuitry (110) coupled to the constant current circuitry and configured to generate a DC current to drive at least one solid state light source;  
 shunt circuitry (106) coupled to a negative voltage rail and a positive voltage rail of the AC voltage source;  
 switch circuitry (108) coupled to the shunt circuitry; and  
 pulse width modulation (PWM) circuitry (114) configured to generate a PWM signal to control a conduction state of the switch circuitry to either open or closed; **characterised in that**

when the switch circuitry conduction state is closed, a conduction path exists between the AC voltage source and the shunt circuitry through the switch circuitry to discontinue the DC current, and when the switch circuitry conduction state is open, the shunt circuitry is electrically decoupled from the AC voltage source.

2. The solid state light source driving and dimming system of claim 1, wherein the constant current circuitry comprises a ballast capacitor coupled to the positive rail of the AC voltage source.
3. The solid state light source driving and dimming system of claim 1, wherein the shunt circuitry comprises:
- a first diode coupled to the positive voltage rail and in forward bias toward the switch; and  
a second diode coupled to the negative voltage rail and in forward bias toward the switch;  
wherein when the switch is closed, the AC voltage source is shunted through the first and second diodes to discontinue the DC current to the at least one solid state light source.
4. The solid state light source driving and dimming system of claim 1, wherein the shunt circuitry comprises:
- a first diode coupled to the negative voltage rail and in forward bias toward the positive voltage rail;  
a second diode coupled to the first diode and the positive voltage rail and in forward bias toward the switch; and  
a third diode coupled to the negative voltage rail and in forward bias toward the switch; wherein when the switch is closed, the AC voltage source is shunted through the first, second and third diodes to discontinue the DC current to the at least one solid state light source.
5. The solid state light source driving and dimming system of claim 1, wherein the rectifier circuitry comprises full wave bridge rectifier circuitry configured to generate a full wave rectified AC current from the AC current and a filtering capacitor in parallel with the at least one solid state light source; and wherein the filtering capacitor is configured to filter the full wave rectified AC current into the DC current to drive the at least one solid state light source.
6. The solid state light source driving and dimming system of claim 1, wherein the rectifier circuitry comprises three diodes configured to generate a rectified AC current from the AC current and a filtering capacitor in parallel with the at least one solid state light source; and wherein the filtering capacitor is configured to filter the rectified AC current into the DC current to drive the at least one solid state light source.
7. The solid state light source driving and dimming system of claim 1, further comprising:
- a return diode shared by the driver circuits, wherein the return diode is coupled to the switch and the shunt circuitry and in forward bias toward the negative voltage rail;  
wherein when the switch is closed, the return diode provides a current path from the positive voltage rail, through the shunt circuitry and the switch and to the negative voltage rail.
8. The solid state light source driving and dimming system of claim 1, further comprising:
- first and second return diodes shared by the driver circuits, wherein the first return diode is coupled to the switch and the shunt circuitry and in forward bias toward the negative voltage rail, and the second return diode is coupled to the rectifier circuitry and the solid state light source and in forward bias toward the negative voltage rail;  
wherein when the switch is closed, the first return diode provides a current path from the positive voltage rail, through the shunt circuitry and the switch and to the negative voltage rail, and wherein when the switch is opened, the second return diode provides a current path from the solid state light source to the negative voltage rail.
9. The solid state light source driving and dimming system of claim 1,  
wherein the switch circuitry and the PWM circuitry are coupled to a common ground, or  
wherein the rectifier circuitry and the at least one solid state light source are coupled to a common ground, or  
wherein the switch circuitry, the PWM circuitry, the rectifier circuitry and the at least one solid state light source are coupled to a common ground.
10. The solid state light source driving and dimming system of claim 1, wherein each driver circuit further comprises isolation circuitry coupled to a negative voltage rail of the AC current source and configured to electrically isolate each driver circuit from each other.
11. The solid state light source driving and dimming system of claim 1, further comprising:
- an isolation transformer having a primary winding and a plurality of secondary windings, wherein the primary winding is coupled to the AC voltage source and each driver circuit is coupled to a respective secondary winding, and wherein the isolation transformer is configured to electrically isolate each driver circuit from each other.
12. The solid state light source driving and dimming system of any one of claims 1, 4 and 9, wherein each driver circuit further comprising isolation circuitry

coupled to the AC voltage source and configured to electrically isolate each driver circuit from each other;

13. The solid state light source driving and dimming system of claim 12, wherein the isolation circuitry comprises a capacitor coupled to the negative voltage rail and the constant current circuitry comprises a capacitor coupled to the positive voltage rail, any wherein the capacitance of the isolation circuitry and the constant current circuitry are approximately equal.

14. The solid state light source driving and dimming system of claim 1 or 9, further comprising:

an isolation transformer having a primary winding coupled to the AC voltage source and a plurality of secondary windings, wherein the isolation transformer is configured to electrically isolate each respective secondary winding from each other;

wherein the plurality of solid state light source driver circuits configured to be coupled to a respective secondary winding,

wherein

the constant current circuitry is coupled to a secondary winding;

the shunt circuitry coupled to a negative and positive voltage rails of the secondary winding; wherein when the switch circuitry is open, the shunt circuitry is electrically decoupled from the secondary winding.

15. The solid state light source driving and dimming system of claim 14, wherein the shunt circuitry comprises:

a first diode coupled to the negative voltage rail and in forward bias toward the positive voltage rail;

a second diode coupled to the first diode and the positive voltage rail and in forward bias toward the switch; and

a third diode coupled to the negative voltage rail and in forward bias toward the switch; wherein when the switch is closed the secondary winding is shunted through the first, second and third diodes to discontinue the DC current to the at least one solid state light source.

## Patentansprüche

1. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle aufweisend:

eine Mehrzahl von Festkörper-Lichtquellen-Treiberschaltungen, die konfiguriert ist, um mit

einer Wechselstrom-Spannungsquelle (102) verbunden zu werden, wobei jede Treiberschaltung aufweist:

eine Konstantstrom-Schaltung (104), welche mit der Wechselstrom-Spannungsquelle verbunden ist, wobei die Konstantstrom-Schaltung konfiguriert ist, einen konstanten Wechselstrom von der Wechselstrom-Spannungsquelle zu erzeugen;

eine Gleichrichterschaltung (110), welche mit der Konstantstrom-Schaltung verbunden ist und konfiguriert ist, einen Gleichstrom zu erzeugen, um mindestens eine Festkörper-Lichtquelle zu betreiben;

eine Parallelschaltung (106), die mit einer negativen Spannungsschiene und einer positiven Spannungsschiene der Wechselstrom-Spannungsquelle verbunden ist;

eine Schalterschaltung (108), die mit der Parallelschaltung verbunden ist; und

eine Pulsweitenmodulations- (PWM) Schaltung (114), die konfiguriert ist ein PWM-Signal zu erzeugen, um einen Leitzustand der Schalterschaltung (108) entweder zu offen oder zu geschlossen zu steuern, **dadurch gekennzeichnet, dass**

wenn der Leitzustand der Schalterschaltung geschlossen ist, zwischen der Wechselstrom-Spannungsquelle und der Parallelschaltung durch die Schalterschaltung ein Leitungspfad existiert, um den Gleichstrom zu unterbrechen, und wenn der Leitzustand der Schalterschaltung offen ist, die Parallelschaltung von der Wechselstrom-Spannungsquelle elektrisch entkoppelt ist.

2. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, wobei die Konstantstrom-Schaltung einen Vorschaltgerät-Kondensator aufweist, welcher mit der positiven Schiene der Wechselstrom-Spannungsquelle verbunden ist.

3. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, wobei die Parallelschaltung aufweist:

eine erste Diode, welche mit der positiven Spannungsschiene verbunden ist und sich in Vorwärtsspannung zu dem Schalter hin befindet; und

eine zweite Diode, welche mit der negativen Spannungsschiene verbunden ist und sich in Vorwärtsspannung zu dem Schalter hin befindet, wobei, wenn der Schalter geschlossen ist, die Wechselstrom-Spannungsquelle durch die erste und die zweite Diode parallel geschaltet wird, um den Gleichstrom zu der mindestens ei-

nen Festkörper-Lichtquelle zu unterbrechen.

4. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, wobei die Parallelschaltung aufweist:

eine erste Diode, welche mit der negativen Spannungsschiene verbunden ist und sich in Vorwärtsspannung zu der positiven Spannungsschiene hin befindet;

eine zweite Diode, welche mit der ersten Diode und der positiven Spannungsschiene verbunden ist und sich in Vorwärtsspannung zu dem Schalter hin befindet; und

eine dritte Diode, welche mit der negativen Spannungsschiene verbunden ist und sich in Vorwärtsspannung zu dem Schalter hin befindet, wobei, wenn der Schalter geschlossen ist, die Wechselstrom-Spannungsquelle durch die erste, die zweite und die dritte Diode parallel geschaltet wird, um den Gleichstrom zu der mindestens einen Festkörper-Lichtquelle zu unterbrechen.

5. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, wobei die Gleichrichterschaltung eine Vollwellen-Brückengleichrichterschaltung aufweist, die konfiguriert ist, einen vollwellengleichgerichteten Wechselstrom von dem Wechselstrom zu erzeugen, und einen Filterkondensator, welcher parallel zu der mindestens einen Festkörper-Lichtquelle geschaltet ist; und wobei der Filterkondensator konfiguriert ist, den vollwellengleichgerichteten Wechselstrom in den Gleichstrom zu filtern, um die mindestens eine Festkörper-Lichtquelle zu betreiben.

6. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, wobei die Gleichrichterschaltung drei Dioden aufweist, die konfiguriert sind, einen gleichgerichteten Wechselstrom von dem Wechselstrom zu erzeugen, und einen Filterkondensator, welcher parallel zu der mindestens einen Festkörper-Lichtquelle geschaltet ist; und wobei der Filterkondensator konfiguriert ist, den gleichgerichteten Wechselstrom in den Gleichstrom zu filtern, um die mindestens eine Festkörper-Lichtquelle zu betreiben.

7. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, ferner aufweisend:

eine Rücklaufdiode, die von den Treiberschaltungen gemeinsam genutzt wird, wobei die Rücklaufdiode mit dem Schalter und der Parallelschaltung verbunden ist und sich in Vorwärtsspannung zu der negativen Spannungsschiene

hin befindet;

wobei, wenn der Schalter geschlossen wird, die Rücklaufdiode einen Leitungspfad von der positiven Spannungsschiene durch die Parallelschaltung und den Schalter und zu der negativen Spannungsschiene bereitstellt.

8. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, ferner aufweisend:

eine erste und eine zweite Rücklaufdiode, die von den Treiberschaltungen gemeinsam genutzt werden, wobei die erste Rücklaufdiode mit dem Schalter und der Parallelschaltung verbunden ist und sich in Vorwärtsspannung zu der negativen Spannungsschiene hin befindet, und die zweite Rücklaufdiode mit der Gleichrichterschaltung und der Festkörper-Lichtquelle verbunden ist und sich in Vorwärtsspannung zu der negativen Spannungsschiene hin befindet; wobei, wenn der Schalter geschlossen ist, die erste Rücklaufdiode einen Strompfad von der positiven Spannungsschiene durch die Parallelschaltung und den Schalter zu der negativen Spannungsschiene bereitstellt, und wobei, wenn der Schalter geöffnet ist, die zweite Rücklaufdiode einen Strompfad von der Festkörper-Lichtquelle zu der negativen Spannungsschiene bereitstellt.

9. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, wobei die Schalterschaltung und die PWM-Schaltung an eine gemeinsame Masse gekoppelt sind, oder

wobei die Gleichrichterschaltung und die mindestens eine Festkörper-Lichtquelle an eine gemeinsame Masse gekoppelt sind, oder

wobei die Schalterschaltung, die PWM-Schaltung, die Gleichrichterschaltung und die mindestens eine Festkörper-Lichtquelle an eine gemeinsame Masse gekoppelt sind.

10. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, wobei jede Treiberschaltung ferner eine Isolationsschaltung aufweist, die mit einer negativen Spannungsschiene der Wechselstromquelle verbunden ist und konfiguriert ist, jede Treiberschaltung von jeder anderen elektrisch zu isolieren.

11. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1, ferner aufweisend:

einen Trenntransformator, der eine Primärwicklung und eine Mehrzahl von Sekundärwicklungen

gen aufweist, wobei die Primärwicklung mit der Wechselstrom-Spannungsquelle verbunden ist und jede Treiberschaltung mit einer jeweiligen Sekundärwicklung verbunden ist, und wobei der Trenntransformator konfiguriert ist, jede Treiberschaltung von jeder anderen elektrisch zu isolieren.

12. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß irgendeinem der Ansprüche 1, 4 und 9, wobei jede Treiberschaltung ferner eine Isolationsschaltung aufweist, die mit der Wechselstrom-Spannungsquelle verbunden ist und konfiguriert ist, jede Treiberschaltung von jeder anderen elektrisch zu isolieren.

13. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 12, wobei die Isolationsschaltung einen Kondensator aufweist, der mit der negativen Spannungsschiene verbunden ist und die Konstantstrom-Schaltung einen Kondensator aufweist, der mit der positiven Spannungsschiene verbunden ist, und wobei die Kapazität der Isolationsschaltung und der Konstantstrom-Schaltung ungefähr gleich ist.

14. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 1 oder 9, ferner aufweisend:

einen Trenntransformator, der eine Primärwicklung, die mit der Wechselstrom-Spannungsquelle verbunden ist, und eine Mehrzahl von Sekundärwicklungen aufweist, wobei der Trenntransformator konfiguriert ist, jede jeweilige Sekundärwicklung von jeder anderen elektrisch zu isolieren;  
wobei die Mehrzahl von Festkörper-Lichtquellen-Treiberschaltungen konfiguriert ist, mit einer jeweiligen Sekundärwicklung verbunden zu werden,  
wobei  
die Konstantstrom-Schaltung mit einer Sekundärwicklung verbunden ist;  
die Parallelschaltung mit einer negativen und einer positiven Spannungsschiene der Sekundärwicklung verbunden ist;  
wobei, wenn die Schalterschaltung offen ist, die Parallelschaltung von der Sekundärwicklung elektrisch entkoppelt ist.

15. System zum Betreiben und Dimmen einer Festkörper-Lichtquelle gemäß Anspruch 14, wobei die Parallelschaltung aufweist:

eine erste Diode, welche mit der negativen Spannungsschiene verbunden ist und sich in Vorwärtsspannung zu der positiven Span-

nungsschiene hin befindet;

eine zweite Diode, welche mit der ersten Diode und der positiven Spannungsschiene verbunden ist und sich in Vorwärtsspannung zu dem Schalter hin befindet; und

eine dritte Diode, welche mit der negativen Spannungsschiene verbunden ist und sich in Vorwärtsspannung zu dem Schalter hin befindet, wobei, wenn der Schalter geschlossen wird, die Sekundärwicklung durch die erste, die zweite und die dritte Diode parallel geschaltet wird, um den Gleichstrom zu der mindestens einen Festkörper-Lichtquelle zu unterbrechen.

## Revendications

1. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs, comprenant :

une pluralité de circuits d'excitation de sources lumineuses à semi-conducteurs configurée pour être couplée à une source de tension C.A. (102), chaque circuit d'excitation comprenant :

des circuits de courant constant (104) couplés à la source de tension C.A., dans lequel les circuits de courant constant sont configurés pour générer un courant C.A. constant à partir de la source de tension C.A.;  
des circuits de redressement (110) couplés aux circuits de courant constant et configurés pour générer un courant C.C. afin d'exciter au moins une source lumineuse à semi-conducteurs ;  
des circuits de dérivation (106) couplés à un rail de tension négative et un rail de tension positive de la source de tension C.A.;  
des circuits de commutation (108) couplés aux circuits de dérivation ; et  
des circuits de modulation en largeur d'impulsion (PWM) (114) configurés pour générer un signal PWM afin de commander un état de conduction des circuits de commutation sur l'état ouvert ou l'état fermé ; **caractérisé en ce que** lorsque les circuits de commutation sont dans l'état de conduction fermé, un chemin de conduction existe entre la source de tension C.A. et les circuits de dérivation à travers les circuits de commutation pour interrompre le courant C.C., et quand les circuits de commutation sont dans l'état de conduction ouvert, les circuits de dérivation sont électriquement découplés de la source de tension C.A.

2. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication

- 1, dans lequel les circuits de courant constant comprennent un condensateur ballast couplé au rail positif de la source de tension C.A.
3. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, dans lequel les circuits de dérivation comprennent :
- une première diode couplée au rail de tension positive et en polarisation directe vers le commutateur ; et
  - une seconde diode couplée au rail de tension négative et en polarisation directe vers le commutateur ;
  - dans lequel quand le commutateur est fermé, la source de tension C.A. est dérivée à travers les première et seconde diodes pour interrompre le courant C.C. allant à l'au moins une source lumineuse à semi-conducteurs.
4. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, dans lequel les circuits de dérivation comprennent :
- une première diode couplée au rail de tension négative et en polarisation directe vers le rail de tension positive ;
  - une deuxième diode couplée à la première diode et au rail de tension positive et en polarisation directe vers le commutateur ; et
  - une troisième diode couplée au rail de tension négative et en polarisation directe vers le commutateur ; dans lequel quand le commutateur est fermé, la source de tension C.A. est dérivée à travers les première, deuxième et troisième diodes pour interrompre le courant C.C. allant à l'au moins une source lumineuse à semi-conducteurs.
5. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, dans lequel les circuits de redressement comprennent des circuits de redressement en pont double alternance configurés pour générer un courant C.A. redressé double alternance à partir du courant C.A. et un condensateur de filtrage en parallèle à l'au moins une source lumineuse à semi-conducteurs ; et dans lequel le condensateur de filtrage est configuré pour filtrer le courant C.A. redressé double alternance pour produire le courant C.C. servant à exciter l'au moins une source lumineuse à semi-conducteurs.
6. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, dans lequel les circuits de dérivation comprennent
- trois diodes configurées pour générer un courant C.A. redressé à partir du courant C.A. et un condensateur de filtrage en parallèle à l'au moins une source lumineuse à semi-conducteurs ; et dans lequel le condensateur de filtrage est configuré pour filtrer le courant C.A. redressé pour produire le courant C.C. servant à exciter l'au moins une source lumineuse à semi-conducteurs.
7. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, comprenant en outre :
- une diode de retour partagée par les circuits d'excitation, dans lequel la diode de retour est couplée au commutateur et aux circuits de dérivation et en polarisation directe vers le rail de tension négative ; dans lequel quand le commutateur est fermé, la diode de retour fournit un trajet de courant depuis le rail de tension positive, à travers les circuits de dérivation et le commutateur et jusqu'au rail de tension négative.
8. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, comprenant en outre :
- des première et seconde diodes de retour partagées par les circuits d'excitation, dans lequel la première diode de retour est couplée au commutateur et aux circuits de dérivation et en polarisation directe vers le rail de tension négative, et la seconde diode de retour est couplée aux circuits de redressement et à la source lumineuse à semi-conducteurs et en polarisation directe vers le rail de tension négative ;
  - dans lequel quand le commutateur est fermé, la première diode de retour fournit un trajet de courant depuis le rail de tension positive, à travers les circuits de dérivation et le commutateur et jusqu'au rail de tension négative, et dans lequel quand le commutateur est ouvert, la seconde diode de retour fournit un trajet de courant depuis la source lumineuse à semi-conducteurs jusqu'au rail de tension négative.
9. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, dans lequel les circuits de commutation et les circuit de modulation PWM sont couplés à une masse commune, ou dans lequel les circuits de redressement et l'au moins une source lumineuse à semi-conducteurs sont couplés à une masse commune, ou dans lequel les circuits de commutation, les circuits de modulation PWM, les circuits de redressement et l'au moins une source lumineuse à semi-conduc-

teurs sont couplés à une masse commune.

10. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, dans lequel chaque circuit d'excitation comprend en outre des circuits d'isolation couplés à un rail de tension négative de la source de courant C.A. et configurés pour isoler électriquement chaque circuit d'excitation des autres circuits d'excitation.
11. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1, comprenant en outre :
- un transformateur d'isolation ayant un enroulement primaire et une pluralité d'enroulements secondaires, dans lequel l'enroulement primaire est couplé à la source de tension C.A. et chaque circuit pilote est couplé à un enroulement secondaire respectif, et dans lequel le transformateur d'isolation est configuré pour isoler électriquement chaque circuit d'excitation des autres circuits d'excitation.
12. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon l'une quelconque des revendications 1, 4 et 9, dans lequel chaque circuit d'excitation comprend en outre des circuits d'isolation couplés à la source de tension C.A. et configurés pour isoler électriquement chaque circuit d'excitation des autres circuits d'excitation.
13. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 12, dans lequel les circuits d'isolation comprennent un condensateur couplé au rail de tension négative et les circuits de courant constant comprennent un condensateur couplé au rail de tension positive, et dans lequel les capacités des circuits d'isolation et des circuits de courant constant sont approximativement égales.
14. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 1 ou 9, comprenant en outre :
- un transformateur d'isolation ayant un enroulement primaire couplé à la source de tension C.A. et une pluralité d'enroulements secondaires, dans lequel le transformateur d'isolation est configuré pour isoler électriquement chaque enroulement secondaire respectif des autres enroulements secondaires ;  
dans lequel la pluralité de circuits d'excitation de sources lumineuses à semi-conducteurs est configurée pour être couplée à un enroulement secondaire respectif,  
dans lequel

les circuits de courant constant sont couplés à un enroulement secondaire ;  
les circuits de dérivation sont couplés à des rails de tension négative et positive de l'enroulement secondaire ;  
dans lequel quand les circuits de commutation sont ouverts, les circuits de dérivation sont électriquement découplés de l'enroulement secondaire.

15. Système d'excitation et de gradation de sources lumineuses à semi-conducteurs selon la revendication 14, dans lequel les circuits de dérivation comprennent :

une première diode couplée au rail de tension négative et en polarisation directe vers le rail de tension positive ; et  
une deuxième diode couplée à la première diode et au rail de tension positive et en polarisation directe vers le commutateur ; et  
une troisième diode couplée au rail de tension négative et en polarisation directe vers le commutateur ; dans lequel quand le commutateur est fermé, l'enroulement secondaire est dérivé à travers les première, deuxième et troisième diodes pour interrompre le courant C.C. allant à l'au moins une source lumineuse à semi-conducteurs.

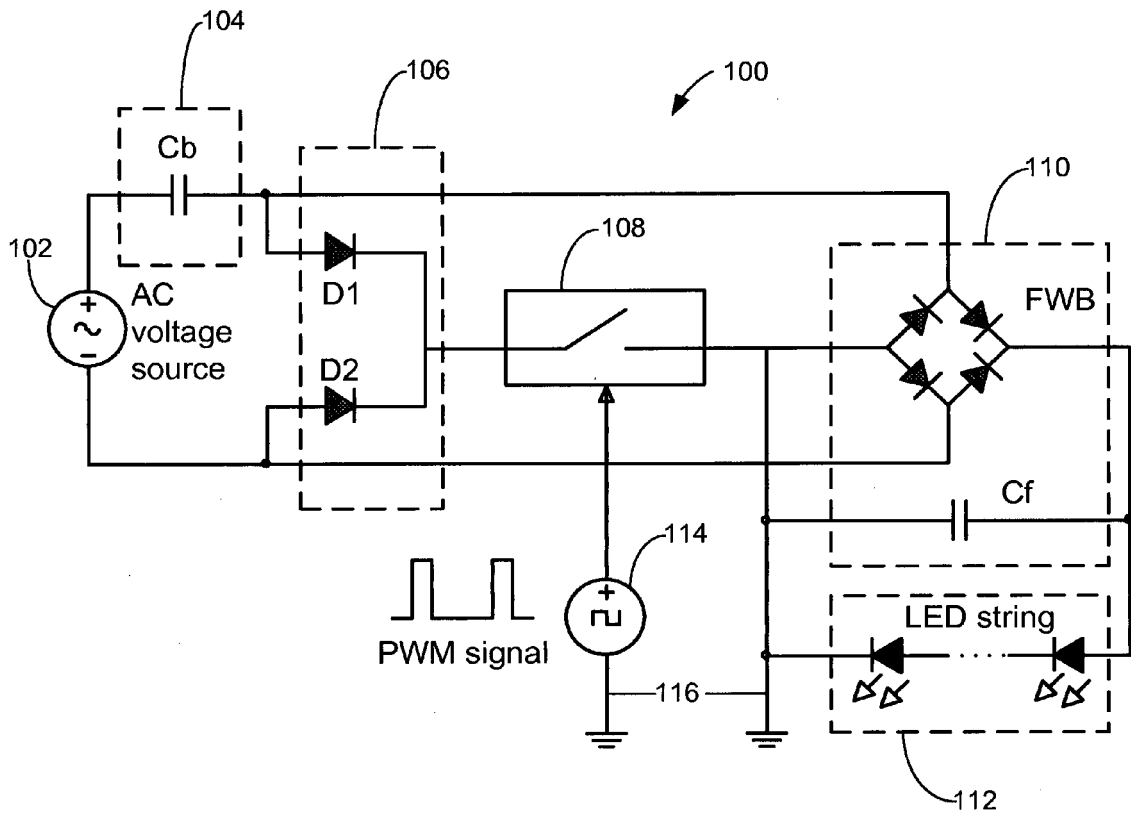


FIG. 1

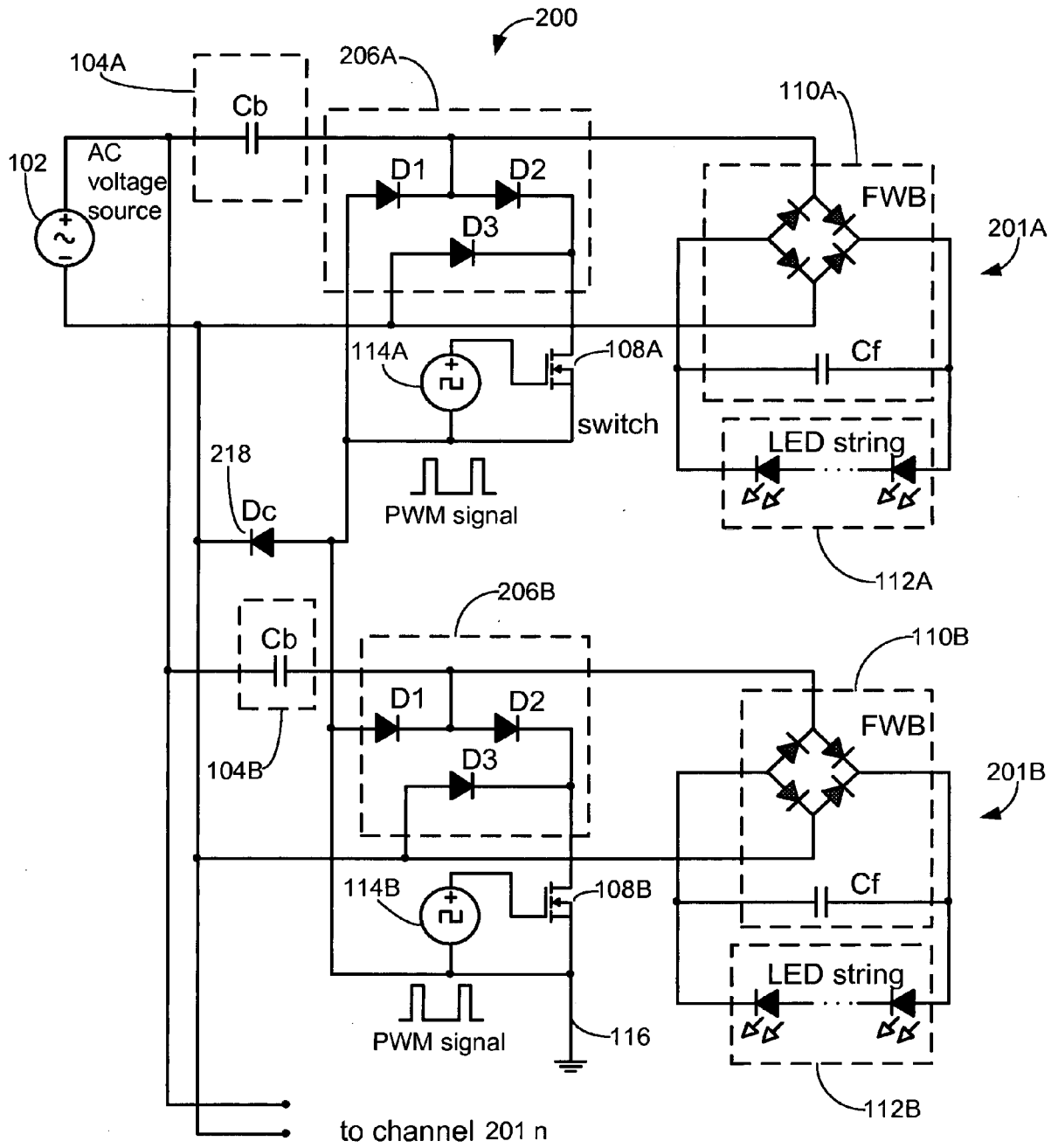


FIG. 2

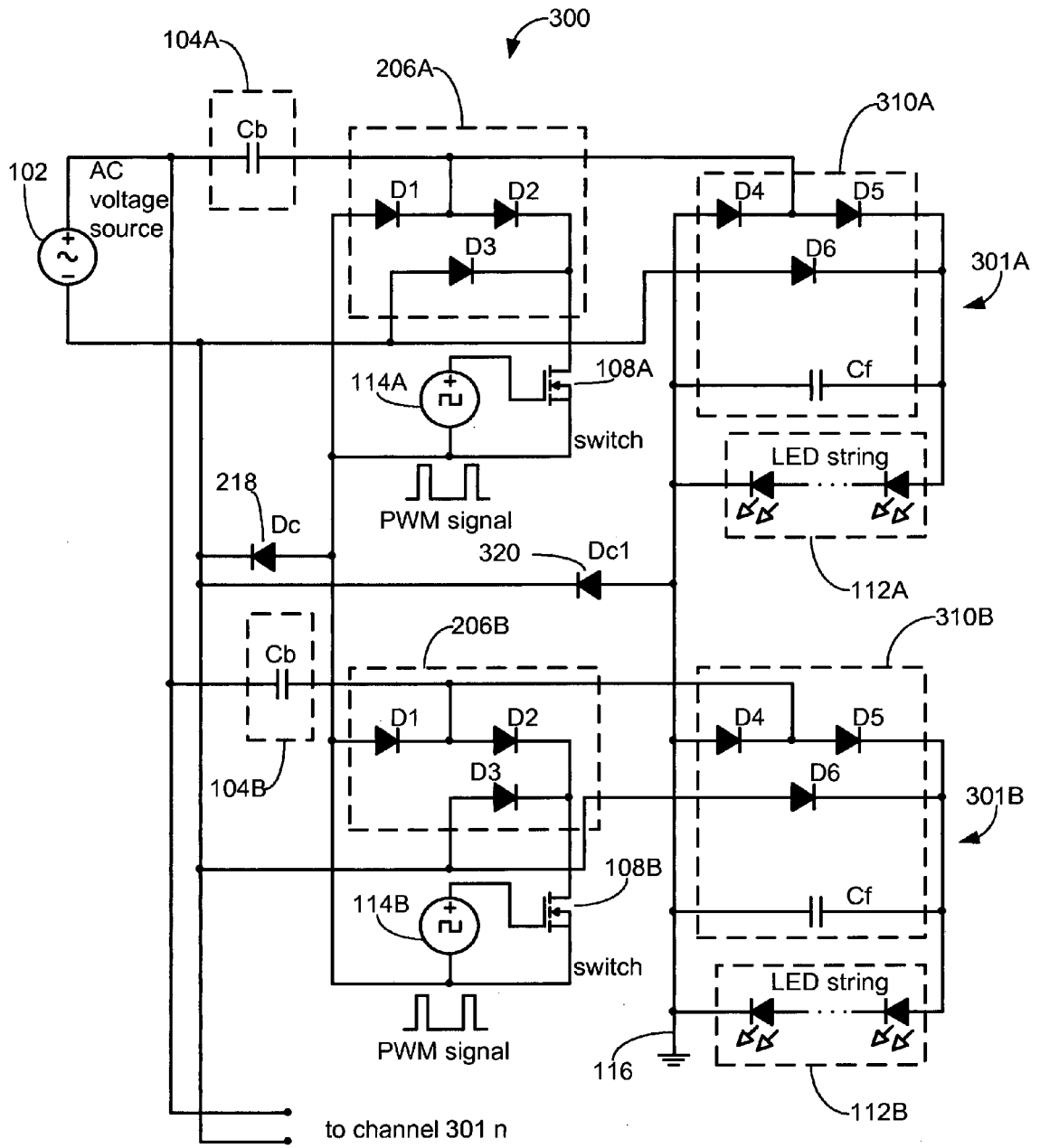


FIG. 3

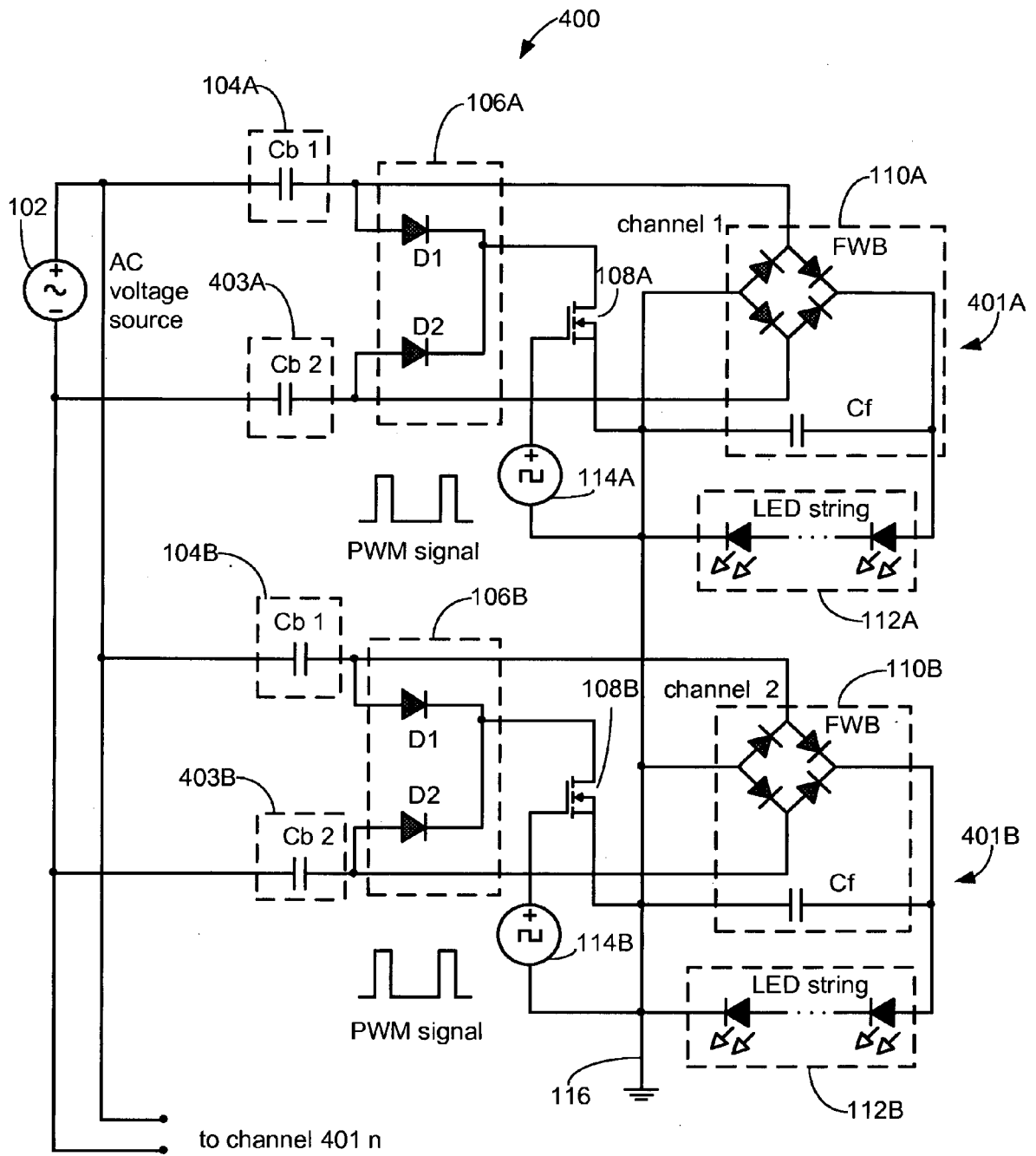


FIG. 4

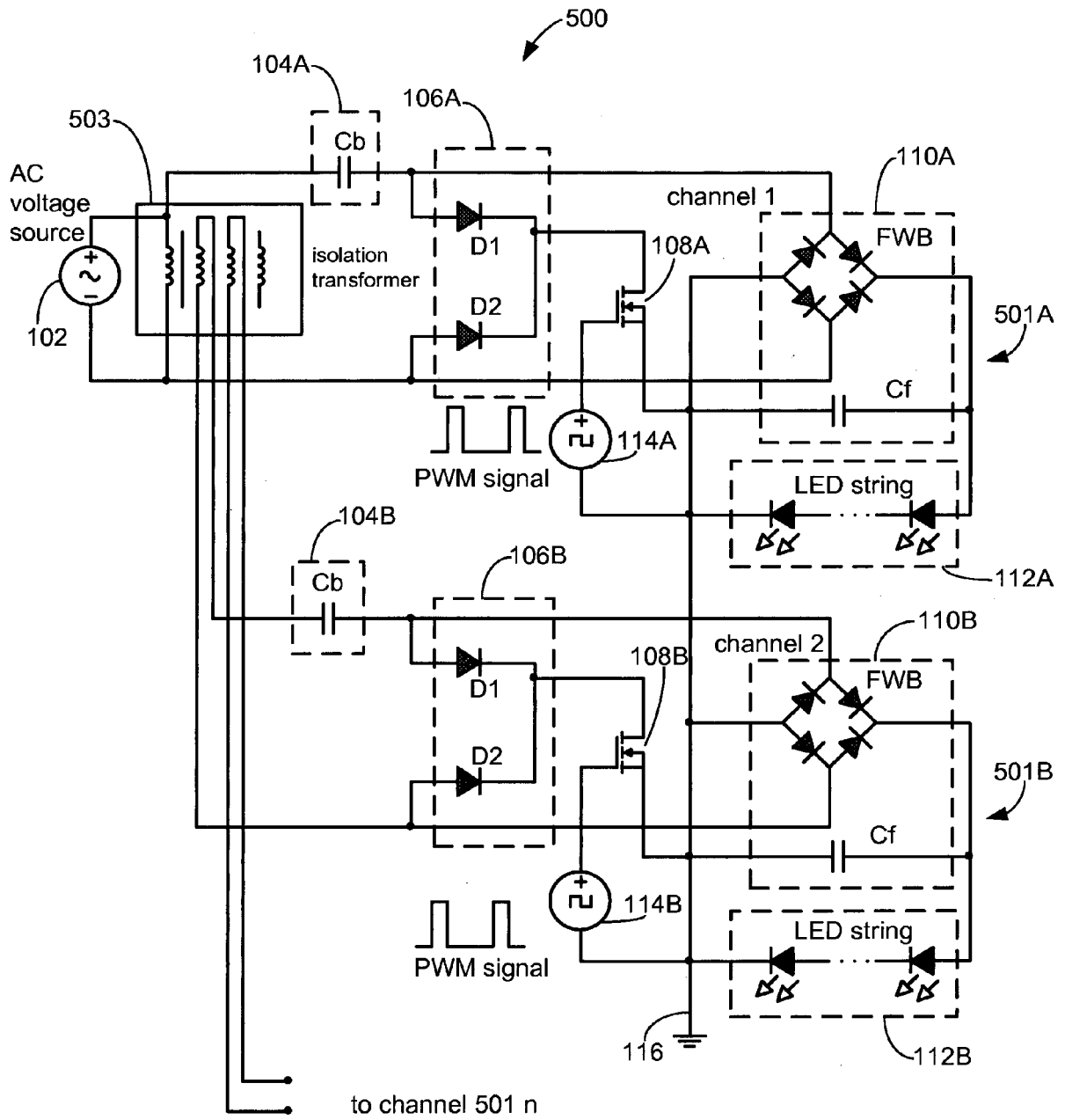


FIG. 5

**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- EP 2048917 A1 [0002]