

(19)



(11)

**EP 2 519 079 B1**

(12)

**EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:  
**22.11.2017 Bulletin 2017/47**

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

(21) Application number: **12159970.8**

(22) Date of filing: **16.03.2012**

(54) **Solid light-emitting element lighting device and illumination fixture using the same**

Feste LED-Beleuchtungsanordnung und Beleuchtungsbefestigung damit

Dispositif d'éclairage à éléments électroluminescents solides et accessoire d'éclairage l'utilisant

(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**

(30) Priority: **18.03.2011 JP 2011060866**

(43) Date of publication of application:  
**31.10.2012 Bulletin 2012/44**

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**Description**

[Field of the Invention]

5 **[0001]** The present invention relates to a solid light-emitting element lighting device and to an illumination fixture using the same.

[Background Art]

10 **[0002]** Conventionally, an LED lighting device for supplying lighting power to an LED illumination module is provided (for example, refer to JPT 2006-511078 and paragraphs [0015] to [0017] and Fig. 7 to Fig. 9). As shown in Fig. 7, the LED lighting device includes: a control switch Q3 for being turned on and off in accordance with a dual signal including a low-frequency burst of high-frequency pulse, the control switch Q3 being connected to an LED illumination module 104 in series; an inductor L2 for accumulating energy when the control switch Q3 is turned on, the inductor similarly  
15 being connected to the LED illumination module 104 in series; and a diode D2 for regenerating the energy accumulated in the inductor L2 to the LED illumination module 104 at the turning-off of the control switch Q3. The above-mentioned dual signal is an AND output of a high-frequency drive pulse and a low-frequency PWM signal to the control switch Q3, an average current flowing to the LED illumination module 104 is varied by changing a duty ratio of the PWM signal, and thus a light intensity outputted from the LED illumination module 104 is changed (so-called burst dimming).

20 **[0003]** US 2007/0188112 A1 shows a solid light-emitting element lighting device comprising: a series circuit of an inductor and a switching element that are connected between output terminals of a direct-current power source via a load; a diode for regenerating, during turning-off of the switching element, energy accumulated during turning-on of the switching element in the inductor to the load; and a control circuit part for controlling on and off of the switching element. The control circuit part includes a drive signal generation part for generating the drive signal whose pulse width varies  
25 in accordance with an amplitude of a load current.

**[0004]** In order to prevent an excessive current flowing through the load, the device according to US 2007/0188112 A1 further contains a blocking means that blocks a PWM signal so that the drive signal is low if the current flowing through the load exceeds a preset value when the PWM signal is high. The current through the load is determined by measuring a shunt voltage that is subtracted from the high level voltage of the PWM signal and the difference is compared  
30 with a preset voltage value.

**[0005]** WO 2010/046065 A1 proposes a lighting device for an LED module. A series circuit of an inductor and a switching element that are connected between output terminals of a direct-current power source via the LED module. A diode for regenerating, during turning-off of the switching element, energy accumulated during turning-on of the switching element in the inductor to the LED module is provided. A capacitor is connected parallel with the LED module  
35 to minimize ripples of the current flowing through the LED module. The switching element is preferably switched when the current through the switching element is zero to avoid losses.

[Disclosure of the Invention]

40 [Problems to be solved by the Invention]

**[0006]** In the LED lighting device shown in above-mentioned JPT 2006-511078, the high-frequency drive pulse to the control switch Q3 is the AND output including the low-frequency PWM signal, and when an edge of the above-mentioned PWM signal is inputted during the turning-on of the control switch Q3, the drive pulse to the control switch Q3 becomes  
45 Low. Specifically, the on-period of the control switch Q3 is changed due to the variation of the low-frequency PWM signal, and accordingly an LED current, that is, an optical output of the LED illumination module 104 varies. On the other hand, during the off-period of the control switch Q3, the regeneration current of the inductor L2 flows to the LED illumination module 104 via the diode D2; however, even when the above-mentioned PWM signal varies, the LED current does not change during the period. That is, despite the variation of the PWM signal, the optical output of the LED module 104  
50 does not change.

**[0007]** Fig. 8 is a time chart of the case where the control switch Q3 is operated in a critical mode (a mode in which the control switch Q3 is switched from being turned off to being turned on at timing when the current flowing to the inductor L2 becomes zero). As shown in Fig. 8, in the case where the PWM signal changed from the solid line to the broken line, that is, in the case where the on-period of the PWM signal becomes long, a load current I1 of the LED  
55 illumination module 104 will increase by one cycle of the drive signal (the broken line in Fig. 8). In addition, since the larger a difference between an input voltage and an output voltage is, the more a slope of the current at the turning-on of the control switch Q3 becomes steep, in the case of obtaining the same output, the on-period will be short, and thus the off-period of the control switch Q3 is lengthened by the shortened on-period to extend the regeneration period (refer

to the drive signal in Fig. 8).

**[0008]** Accordingly, since the optical output does not vary during the off-period of the control switch Q3 even in the case of trying to smoothly change a dimming level, for example, by sweeping the duty of the above-mentioned PWM signal, the optical output to the duty variation will be stepwise as shown in Fig. 9. Then, the optical output difference of the one step is equivalent to the optical output of the one cycle of the high-frequency drive pulse for the control switch Q3, and accordingly the stepwise variation of the optical output can be watched. Specifically, since a variation rate of the optical output at the sweeping is large under a low light flux state, the stepwise variation will be more apparent.

**[0009]** As described above, in the case where the difference between the input voltage and the output voltage is large, the ratio of the period where the optical output does not vary in the sweeping of the PWM signal is large, and consequently there causes a problem that the optical output appears to vary in a stepwise fashion.

**[0010]** The present invention is achieved in consideration of the above-mentioned problems, and a purpose of the present invention is to provide a solid light-emitting element lighting device and an illumination fixture using the same that are able to smoothly change the optical output in the sweeping of the PWM signal for dimming.

[Means adapted to solve the Problems]

**[0011]** A solid light-emitting element lighting device of the present invention includes the features of claim 1.

**[0012]** In the solid light-emitting element lighting device, it is preferred that the control circuit part includes a zero current detection circuit for detection that a current flowing to the inductor becomes zero, and switches the switching element from being turned off to being turned on in synchronization with detection timing of the zero current detection circuit.

**[0013]** Additionally, in the solid light-emitting element lighting device, it is preferred that the control circuit part switches the switching element to be turned on before the current flowing to the inductor during the turning-off of the switching element becomes zero.

**[0014]** Moreover, in the solid light-emitting element lighting device, it is preferred that the direct-current power source includes an AC-DC converter or a DC-DC converter to which a detection result of the load voltage is feed backed and that controls an output voltage to be a voltage proportional to the detection result, and includes a voltage detection part for detecting the load voltage and feed backing the load voltage to the direct-current power source.

**[0015]** Furthermore, in the solid light-emitting element lighting device, it is preferred that the direct-current power source includes the AC-DC converter, and a frequency of the PWM signal is set to 600Hz or multiples of 600Hz.

**[0016]** An illumination fixture of the present invention includes: the solid light-emitting element lighting device according to any one of claims 1 to 5; and a solid light-emitting element to which lighting power is supplied from the solid light-emitting element lighting device.

[Effect of the Invention]

**[0017]** An effect to provide a solid light-emitting element lighting device and an illumination fixture using the same that are able to smoothly change the optical output in the sweeping of the PWM signal for dimming can be obtained.

[Brief Description of the Drawings]

**[0018]**

[Fig. 1] Fig. 1 is a schematic circuit diagram showing an example LED lighting device.

[Fig. 2] Fig. 2 is a time chart for explaining an operation of the above-mentioned device.

[Fig. 3] Fig. 3 is a graph for explaining the operation of the above-mentioned device.

[Fig. 4] Fig. 4 is a schematic circuit diagram showing another example of the above-mentioned LED lighting device.

[Fig. 5] Fig. 5 is a schematic circuit diagram showing an LED lighting device according an embodiment of the invention.

[Fig. 6] Fig. 6 is a schematic circuit diagram showing another example of the above-mentioned LED lighting device.

[Fig. 7] Fig. 7 is a schematic circuit diagram showing a conventional LED lighting device.

[Fig. 8] Fig. 8 is a time chart for explaining an operation of the above-mentioned device.

[Fig. 9] Fig. 9 is a graph for explaining the operation of the above-mentioned device.

[Best Mode for Carrying Out the Invention]

**[0019]** On the basis of drawings, embodiments of an illumination fixture using a LED lighting device will be explained below.

First Example

5 **[0020]** Fig. 1 is a schematic circuit view showing an LED lighting device (a solid light-light emitting device lighting device) according to a first example. The LED lighting device includes: a step-down chopper circuit part 2 for stepping down an output voltage of a direct-current power source 1 to a direct current of a desired voltage value; and a control circuit part 3 for controlling a switching element Q1 to be turned on and off, the switching element Q1 described later constituting the step-down chopper circuit part 2. In addition, an illumination fixture according to the present example includes: the LED lighting device; and a LED module (a solid light-emitting element, a load) 4 to which lighting power is supplied from the LED lighting device. Meanwhile, in the present embodiment, the LED module 4 includes three LEDs (light-emitting diodes); however, the number of LEDs is not limited to the present example and may be one, two, four or more.

10 **[0021]** The step-down chopper circuit part 2 includes: a series circuit of an inductor L1 and the switching element Q1, the series circuit being connected between output terminals of the direct-current power source 1 via the LED module 4; and a diode D1 for regenerating energy during the turning-off of the switching element Q1, the energy being accumulated in the inductor L1 during the turning-on of the switching element Q1.

15 **[0022]** The control circuit part 3 includes: a starter 32 for outputting a start-up signal to generate a drive pulse during stopping of oscillation at regular intervals; a zero current detection circuit 31 for detecting that a current flowing to a secondary wiring N2 of the inductor L1 becomes zero; and a drive pulse generation part 34 for generating the drive pulse to turn on and off the switching element Q1. In addition, the control circuit part 3 includes: a drive circuit 33 for driving the switching element Q1 in response to the drive pulse from the drive pulse generation part 34; a comparator 35 for outputting a reset signal to the drive pulse generation part 34 when a current flowing to the switching element Q1 reaches a reference value.

20 **[0023]** In the present example, the drive pulse generation part 34 includes a RS flip-flop; to a set terminal of the RS flip-flop, an OR output of a detection signal of the zero current detection circuit 31 and the start-up signal of the starter 32 is inputted via an OR circuit 36, and an output of the drive pulse generation part 34 becomes High when the set signal is inputted. In addition, the output of the drive pulse generation part 34 becomes Low when the reset signal is inputted from the comparator 35, and thus a high-frequency drive pulse where the High and Low are alternately repeated is outputted from the drive pulse generation part 34.

25 **[0024]** Additionally, to the drive circuit 33, an AND output of the high-frequency drive pulse inputted from the drive pulse generation part 34 and the lower-frequency PWM signal than the drive pulse is inputted via an AND circuit 37, and the drive circuit 33 controls the switching element Q1 to be turned on and off in accordance with the AND output. Here, the above-mentioned drive pulse changes the pulse width on the basis of amplitude of a load current flowing to the LED module 4, and the above-mentioned PWM signal changes the on-duty on the basis of a dimming level. Meanwhile, a resistance R1 in Fig. 1 is a resistance for current detection to detect the current flowing to the switching element Q1.

30 **[0025]** Next, an operation of the LED lighting device will be explained. When the reset signal is inputted to the drive pulse generation part 34 due to an output signal from the starter 32 or the zero current detection circuit 31 during a period where the above-mentioned PWM signal is High, the output of the drive pulse generation part 34 becomes High, the switching element Q1 is turned on via the drive circuit 33, and thus a current flows to light the LED module 4. On this occasion, a temporal change of the load current I1 flowing to the switching element Q1 is shown as follows.

35 [Expression 1]

$$I_1 = \frac{V_{out} - V_1}{L_1} t \quad \dots \dots (1)$$

40 where in expression 1, Vout represents the output voltage of the direct-current source 1, V1 represents the load voltage of the LED module 4, t represents an elapsed time, L1 represents an impedance of the inductor, and a starting time of the turning-on of the switching element Q1 is t = 0.

45 **[0026]** When a voltage between both ends of the resistance R1 (that is, I1 × R1) reaches a reference voltage Vref, the output of the comparator 35 is inverted, the reset signal is inputted to the drive pulse generation part 34, the output of the drive pulse generation part 34 becomes Low, and thus the switching element Q1 is turned off. When the switching element Q1 is turned off, the energy accumulated in the inductor L1 is regenerated to the LED module 4, and thus the LED module 4 is lighted by the regeneration current. On this occasion, the temporal change of the current I2 flowing to the inductor L1 is represented as follows.

50 [Expression 2]

$$I2 = -\frac{V1}{L1}(t - Ton) + Idp \quad \dots \dots \dots (2)$$

5 where in expression 2, Ton represents the on-period of the switching element Q1 and Idp represents a peak current flowing to the inductor L1.

10 **[0027]** And, when the current I2 flowing to the inductor L1 during the turning-off of the switching element Q1 becomes zero, thereby inverting the current due to a function of the inductor L1, the electric charge charged in the switching element Q1 is discharged. As the result, the voltage between the drain and source of the switching element Q1 is decreased, and the voltage of the inductor L1 is inverted. The zero current detection circuit 31 detects the voltage inverting and outputs the set signal to the drive pulse generation part 34, and thereby the switching element Q1 is turned on again at near zero of the current I2 flowing to the inductor L1. Then, the chopper operation is realized by repeating a series of the operations. Here, in the present example, the switching element Q1 is switched from being turned off to being turned on at timing when the current I2 flowing to the inductor L1 becomes zero, and the mode is referred to as a critical mode.

15 **[0028]** On the other hand, when the above-mentioned PWM signal becomes Low, it is stopped to input the drive pulse to the drive circuit 33, and accordingly the oscillation is stopped during the period, that is, a state where the LED module 4 is lighted off is produced. Then, by varying the on-duty of the above-mentioned PWM signal, a ratio between a lighting-on state and the lighted-off state is changed, and consequently the output of the LED module 4 can be controlled.

20 **[0029]** Meanwhile, even if the above-mentioned PWM signal is varied during the off-period of the switching element Q1, the load current I1 flowing to the LED module 4 does not change. That is, even when the on-duty of the PWM signal is varied, the optical output of the LED module 4 does not change. Here, the on-period Ton and on-period Toff of the switching element Q1 are represented as follows in accordance with expression (1) and expression (2).

[Expression 3]

$$Ton = \frac{L1}{Vout - V1} Idp \quad \dots \dots \dots (3)$$

30 [Expression 4]

$$Toff = \frac{L1}{V1} Idp \quad \dots \dots \dots (4)$$

35 **[0030]** And, the on-duty Don of the switching element Q1 is represented as follows in accordance with expression (3) and expression (4).

[Expression 5]

$$Don = \frac{Ton}{Ton + Toff} = \frac{V1}{Vout} \quad \dots \dots \dots (5)$$

45 **[0031]** According to expression (5), it is found that the on-duty of the switching element Q1 is determined only by the output voltage Vout of the direct-current power source 1 and the load voltage V1 of the LED module 4.

**[0032]** Here, when the output voltage Vout of the direct-current power source 1 is defined as "Vout = K × V1", K = 1/Don is drawn from expression (5). Fig. 2 is a time chart for explaining the operation of the LED lighting device according to the present example, and shows a case of K = 1.2.

50 As will be understood in comparison with Fig. 8, since the off-period Toff of the switching element Q1 is very short in comparison with the on-period Ton, the load current I1 of the LED module 4 is slightly increased even when the PWM signal is varied, for example, from a solid line to a broken line. And accordingly the rapid change of the optical output can be suppressed.

55 **[0033]** Fig. 3 shows change of the optical output to the duty ratio of the PWM signal, and a solid line b in Fig. 3 shows the above-mentioned conventional LED lighting device, which corresponds to K = 10 in this case. A dashed line c in Fig. 3 corresponds to K = 1.1, the optical output substantially continuously changes in accordance with the variation of the duty ratio, and thus the stepwise changing of the optical output can be reduced even in the extraordinary deep dimming level. Additionally, a broken line d in Fig. 3 corresponds to K = 2.5, a period where the optical output is constant is

approximately 60% on this occasion; however, the optical output variation is slower in comparison with the case of  $K = 10$ . In this case, the optical output appears to change in a stepwise fashion when the LED module 4 is directly looked; however, the change was in a level where the change cannot be recognized on an irradiation surface of the light as a flicker. Meanwhile, when  $K > 2.5$  is satisfied, the change is recognized on the above-mentioned irradiation surface as the flicker, and accordingly it is preferable to set the output voltage  $V_{out}$  of the direct-current power source 1 to be two and half times larger than the load voltage  $V_1$  of the LED module 4 or less. Additionally, in order to realize the step-down chopper operation, the lower limit of the output voltage  $V_{out}$  requires  $K > 1$ , it is preferable to satisfy  $1 < K \leq 2.5$ . Moreover, considering the variation of the load voltage  $V_1$  due to a temperature characteristic of the LED and the like, it is more preferable to satisfy  $1.2 \leq K \leq 2.5$ .

**[0034]** Next, Fig. 4 is a schematic circuit diagram showing another example of the LED lighting device according to the present embodiment. In the example shown in Fig. 1, a drive pulse of the drive pulse generation part 34 and an AND output of the PWM signal are outputted to the drive circuit 33 with use of the AND circuit 37; however, in the present example, a voltage superimposing the PWM signal on the voltage of the resistance  $R_1$  is compared with the reference voltage  $V_{ref}$ , and the reset signal is outputted to the drive pulse generation part 34 in the case of exceeding the reference voltage  $V_{ref}$ . Meanwhile, other configurations are the same as those of Fig. 1, and accordingly the same numerals are given to the same components to omit the explanations.

**[0035]** According to the present configuration, a signal of the reference voltage  $V_{ref}$  or more is inputted to the comparator 35 when the PWM signal is Low, and thus the reset signal continues to be inputted to the drive pulse generation part 34. Accordingly, on this occasion, the drive pulse is not inputted to the drive circuit 33, and the switching element  $Q_1$  is kept to be off. On the other hand, when the PWM signal is High, the output of the drive pulse generation part 34 becomes High due to the inputting of the output signal from the starter 32 or the zero current detection circuit 31 to turn on the switching element  $Q_1$  via the drive circuit 33, in the same manner as that of the LED lighting device shown in Fig. 1. Then, when the load current  $I_1$  flowing to the switching element  $Q_1$  increases and the signal inputted to the comparator 35 via the resistance  $R_2$  becomes the reference voltage  $V_{ref}$  or more, the comparator 35 outputs the reset signal, and accordingly the output of the drive pulse generation part 34 becomes Low to turn off the switching element  $Q_1$ . Specifically, when the PWM signal is High, the switching element  $Q_1$  is controlled to be on and off due to the drive pulse from the drive pulse generation part 34 in the same manner as that of the LED lighting device shown in Fig. 1. In addition, according to the configuration, a universal IC for PFC (MC33262 manufactured by the ON Semiconductor Co., Ltd. and L6562 manufactured by STMicroelectronics Co., Ltd.) can be used as the control circuit part 3, and consequently the number of parts can be reduced.

**[0036]** Thus, according to the present example, by setting the output voltage  $V_{out}$  of the direct-current power source 1 to be larger than the load voltage  $V_1$  of the LED module 4 and to be 2.5 times as large as the load voltage  $V_1$  or less, the off period  $T_{off}$  where the optical output does not vary due to the change of the duty ratio of the above-mentioned PWM signal can be shortened, and consequently the optical output can be smoothly changed in the sweeping of the PWM signal. In addition, by switching the switching element  $Q_1$  to be turned on in synchronization with detection timing of the zero current detection circuit 31, the on/off control of the switching element  $Q_1$  can be certainly performed. Moreover, an illumination fixture able to smoothly change the optical output in the sweeping of the PWM signal can be provided by using the LED lighting device according to the present embodiment.

**[0037]** Here, in the present example, the switching element  $Q_1$  is controlled in the critical mode; however, the switching element  $Q_1$  may be controlled in a sequential mode for switching the switching element  $Q_1$  to be turned on, for example, before the current  $I_2$  flowing to the inductor  $L_1$  in the turning-off of the switching element  $Q_1$  becomes zero ( $I_2 > 0$ ). Also in this case, by setting the output voltage  $V_{out}$  of the direct-current power source 1 to be larger than the load voltage  $V_1$  of the LED module 4 and to be 2.5 times as large as the load voltage  $V_1$  or less, the optical output can be smoothly changed in the sweeping of the PWM signal, and additionally the on/off control of the switching element  $Q_1$  can be certainly performed. Meanwhile, in the case where the switching element  $Q_1$  is controlled in a non-sequential mode (an operation mode having a period where the current  $I_2$  flowing to the inductor  $L_1$  becomes zero), the off-period of the switching element  $Q_1$  becomes long, and accordingly the operation mode is disadvantageous with respect to the above-mentioned critical mode and sequential mode, but has an advantage that the change of the optical output can be smooth.

(Embodiment of the invention)

**[0038]** An embodiment of an illumination fixture using the LED lighting device will be explained on the basis of Figs. 5 and 6. The present embodiment is different from the first example in that the direct-current power source 1 includes an AC-DC converter and further the load voltage  $V_1$  of the LED module 4 is feed backed to the AC-DC converter. Meanwhile, other configurations are the same as those of the first embodiment, and accordingly explanations of the same components will be omitted by adding the same reference numerals.

**[0039]** The LED lighting device according to the present embodiment includes: the step-down chopper circuit part 2, the control circuit part 3, and a voltage detection part 6 for detecting the load voltage  $V_1$  of the LED module 4 and feed

backing the load voltage V1 to the direct-current power source 1.

**[0040]** The direct-current power source 1 includes the AC-DC converter for converting an alternating-current output of a commercial alternating-current power source 5 into a direct-current voltage of a desired voltage value, and includes: an error amplifier 12 for comparing the load voltage V1 of the LED module 4 with the output voltage Vout and amplifying and outputting the error, and a control circuit 11 for controlling the switching element Q2 to be turned on and off in accordance with an output value of the error amplifier 12.

**[0041]** Here, in the present embodiment, the voltage detection part 6 detects the load voltage V1 of the LED module 4 and feed backs the load voltage V1 to the direct-current power source 1, and in the direct-current power source 1, the feedback controls is performed so that the output voltage Vout can be K times larger than the feed backed load voltage V1. Accordingly, in the same manner as that of the first example when  $1 < K < 2.5$  is set, the off period Toff where the optical output does not vary due to the change of the duty ratio of the PWM signal can be shortened, and consequently the optical output can be smoothly changed in the sweeping of the PWM signal. In addition, as in the present embodiment, when the load voltage V1 is feed backed to the direct-current power source 1, a relationship between the output voltage Vout of the direct-current power source 1 and the load voltage V1 of the LED module 4 can be retained to be constant even in the case where the load voltage V1 varies, and consequently, the optical output variation more close to a linear-shape with respect to the PWM signal can be realized. Meanwhile, the on-duty of the switching element Q1 is  $1/K$ , and the more the K is close to 1, the more the illumination variation becomes smooth.

**[0042]** Meanwhile, in the case of using the AC-DC converter as in the present embodiment, ripples of 100Hz/120Hz appear in the output voltage Vout due to a capacity of an electrolytic capacitor C1 and the like, and thus the flicker of the optical output of the LED module 4 may occur due to interference between the ripples and a frequency of the PWM signal. In order to avoid the interference, it is preferable to set the frequency of the PWM signal to 600Hz or multiples of 600Hz, and consequently the interference of the ripples can be suppressed in both cases of 100Hz and 120Hz to allow obtaining substantially constant optical output where the flicker is suppressed.

**[0043]** In addition, Fig. 6 is a schematic circuit diagram showing another example of the LED lighting device according to the present embodiment, the illustrations of the AC-DC converter and the voltage detection part 6 in Fig. 5 are omitted. In the example shown in Fig. 6, an electrolytic capacitor C2 is connected in parallel with the LED module 4, the ripples of the current flowing to the LED module 4 can be reduced by the electrolytic capacitor C2, and consequently the flicker of the optical output can be suppressed. Moreover, the illumination fixture able to smoothly change the optical output in the sweeping of the PWM signal can be provided by using the LED lighting device according to the present embodiment.

**[0044]** Here, in the present embodiment, the direct-current power source 1 includes the AC-DC converter but may include a DC-DC converter. Additionally, in the present embodiment, the step-down chopper circuit part 2 is provided on a low-voltage side of the direct-current power source 1; however, the step-down chopper circuit part 2 may be provided on a high-voltage side of the direct-current power source 1. Moreover, in the above-mentioned first and second embodiments, the LED lighting device employing the LED as loads is explained as an example; however, the load is desired to be the solid light-emitting element, for example, may be an organic EL. Furthermore, in the above-mentioned first and second embodiments, the on/off of the switching element Q1 is controlled in accordance with the drive pulse in the on-period of the PWM signal (refer to Fig. 2); however, the on/off of the switching element Q1 may be controlled in accordance with the drive pulse in the off-period of the PWM signal. Meanwhile, in this case, it is required to set the length of the off-period of the PWM signal in accordance with the dimming level.

[Description of Reference Numerals]

#### **[0045]**

- 1 Direct-current power source
- 3 Control circuit part
- 4 LED module (Solid light-emitting element and loads)
- 34 Drive pulse generation part
- D1 Diode
- L1 Inductor
- Q1 Switching element

#### **Claims**

1. A solid light-emitting element lighting device comprising:

a direct-current power source (1), and a series circuit of an inductor (L1) and a switching element (Q1) that

are connected between output terminals of the direct-current power source (1) via a load (4);  
 a diode (D1) for regenerating, during turning-off of the switching element (Q1) energy accumulated during  
 turning-on of the switching element (Q1) in the inductor (L1) to the load (4);  
 and a control circuit part (3) for controlling on and off of the switching element (Q1), wherein  
 5 the control circuit part (3) includes a drive signal generation part (34) for generating a drive signal whose pulse  
 width varies in accordance with an amplitude of a load current (I1), and controls the on and off of the switching  
 element (Q1) according to the drive signal in an on-period or an off-period of a PWM signal whose on-duty  
 varies in accordance with a dimming level, the PWM signal being a lower frequency than the drive signal ; and  
 10 a voltage detection part (6) for detecting the load voltage (V1) applied to the load (4) and  
 feeding back the load voltage (V1) to the direct-current power source (1) is provided;  
**characterized in that** the direct-current power source (1) includes an AC-DC converter or a DC-DC converter  
 to which the detected load voltage (V1) is fed back and that controls the output voltage (Vout) to be K times  
 larger than the detected load voltage (V1) according to

$$V_{out} = K \times V1$$

, and that the direct-current power source (1) is adapted to set the output voltage (Vout) to be larger than the  
 load voltage (V1) and to be 2.5 times as large as the load voltage (V1) or less according to  $1 < K \leq 2.5$ ;  
 20 wherein the the on-duty (Don) of the switching element (Q1) is

$$Don = \frac{V1}{Vout}$$

2. The solid light-emitting element lighting device according to claim 1, wherein  
 the control circuit part (3) includes a zero current detection circuit (31) for detection that a current flowing to the  
 inductor (L1) becomes zero, and switches the switching element (Q1) from being turned off to being turned on in  
 synchronization with detection timing of the zero current detection circuit (31).  
 30
3. The solid light-emitting element lighting device according to claim 1, wherein  
 the control circuit part (3) switches the switching element (Q1) to be turned on before a current flowing to the inductor  
 (L1) during the turning-off of the switching element (Q1) becomes zero.
- 35 4. The solid light-emitting element lighting device according to any one of claims 1 to 3, wherein  
 the direct-current power source (1) includes the AC-DC converter, and a frequency of the PWM signal is set to  
 600Hz or multiples of 600Hz.
- 40 5. An illumination fixture comprising: the solid light-emitting element lighting device according to any one of claims 1  
 to 4; and a solid light-emitting element to which lighting power is supplied from the solid light-emitting element lighting  
 device.

## Patentansprüche

1. Lichtemittierende Festkörperelement-Beleuchtungsvorrichtung, umfassend:

eine Gleichspannungsquelle (1) und eine Reihenschaltung eines Induktors (L1) und eines Schaltelements (Q1),  
 die über eine Last (4) zwischen Ausgangsanschlüsse der Gleichspannungsquelle (1) geschaltet sind;  
 50 eine Diode (D1) zum Regenerieren von während des Einschaltens des Schaltelements (Q1) in dem Induktor  
 (L1) angesammelter Energie zur Last (4) während des Ausschaltens des Schaltelements (Q1)  
 und einen Steuerschaltungsteil (3) zum Steuern des Ein- und Ausschaltens des Schaltelements (Q1), wobei  
 der Steuerschaltungsteil (3) einen Ansteuersignalerzeugungsteil (34) zum Erzeugen eines Ansteuersignals,  
 dessen Pulsbreite gemäß einer Amplitude eines Laststroms (I1) variiert, beinhaltet und das Ein- und Ausschalten  
 55 des Schaltelements (Q1) gemäß dem Ansteuersignal in einer Ein-Periode oder einer Aus-Periode eines PWM-  
 Signals steuert, dessen Einschaltdauer gemäß einem Dimming-Grad variiert, wobei das PWM-Signal eine  
 niedrigere Frequenz als das Ansteuersignal hat; und

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einen Spannungserkennungsteil (6) zum Erkennen der an die Last (4) angelegten Lastspannung (V1) und Zurückkoppeln der Lastspannung (V1) zur Gleichspannungsquelle (1) bereitgestellt ist;

**dadurch gekennzeichnet, dass** die Gleichspannungsquelle (1) einen AC-DC-Wandler oder einen DC-DC-Wandler beinhaltet, zu dem die erkannte Lastspannung (V1) zurückgekoppelt wird und der die Ausgangsspannung (Vout) regelt, so dass sie K-mal größer als die erkannte Lastspannung (V1) ist, gemäß

$$V_{out} = K \times V1$$

und so dass die Gleichspannungsquelle (1) dafür ausgelegt ist, die Ausgangsspannung (Vout) gemäß  $1 < K \leq 2,5$  so einzustellen, dass sie größer als die Lastspannung (V1) ist und 2,5-mal so groß wie die Lastspannung (V1) oder kleiner ist;

wobei die Einschaltdauer (Don) des Schaltelements (Q1) wie folgt ist:

$$D_{on} = \frac{V1}{V_{out}}$$

2. Lichtemittierende Festkörperelement-Beleuchtungsanordnung nach Anspruch 1, wobei der Steuerschaltungsteil (3) eine Nullstromerkennungsspannung (31) zur Erkennung, dass ein zum Induktor (L1) fließender Strom null wird, beinhaltet und das Schaltelement (Q1) in Synchronisation mit Erkennungszeitsteuerung der Nullstromerkennungsschaltung (31) von Ausschaltung auf Einschaltung umschaltet.
3. Lichtemittierende Festkörperelement-Beleuchtungsanordnung nach Anspruch 1, wobei der Steuerschaltungsteil (3) das Schaltelement (Q1) so schaltet, dass es eingeschaltet wird, bevor ein zum Induktor (L1) fließender Strom während des Ausschaltens des Schaltelements (Q1) null wird.
4. Lichtemittierende Festkörperelement-Beleuchtungsanordnung nach einem der Ansprüche 1 bis 3, wobei die Gleichspannungsquelle (1) den AC-DC-Wandler beinhaltet und eine Frequenz des PWM-Signals auf 600 Hz oder Vielfache von 600 Hz eingestellt ist.
5. Leuchtkörper, der Folgendes aufweist: die lichtemittierende Festkörperelement-Beleuchtungsanordnung nach einem der Ansprüche 1 bis 4 und ein lichtemittierendes Festkörperelement, an das von der lichtemittierenden Festkörperelement-Beleuchtungsanordnung Beleuchtungsleistung angelegt wird.

### Revendications

1. Dispositif d'éclairage à élément électroluminescent solide comprenant :

une source d'alimentation en courant continu (1), et un circuit série d'un inducteur (L1) et d'un élément de commutation (Q1) qui sont connectés entre des bornes de sortie de la source d'alimentation en courant continu (1) via une charge (4) ;

une diode (D1) pour réémettre, pendant l'arrêt de l'élément de commutation (Q1), l'énergie accumulée pendant la marche de l'élément de commutation (Q1) dans l'inducteur (L1) vers la charge (4) ;

et une partie de circuit de commande (3) pour commander la marche et l'arrêt de l'élément de commutation (Q1), dans lequel

la partie de circuit de commande (3) inclut une partie de génération de signal pilote (34) pour générer un signal pilote dont la largeur de pulsation varie en fonction d'une amplitude d'un courant de charge (I1), et commande la marche et l'arrêt de l'élément de commutation (Q1) en fonction du signal pilote dans une période on ou une période off d'un signal PWM dont l'état en service varie en fonction d'un niveau d'atténuation, le signal PWM étant d'une fréquence inférieure au pilote ; et

une partie de détection de tension (6) pour détecter la tension de charge (V1) appliquée à la charge (4) et réalimenter la tension de charge (V1) vers la source d'alimentation en courant continu (1) est fournie ;

**caractérisé en ce que** la source d'alimentation en courant continu (1) inclut un convertisseur CA-CC ou un convertisseur CC-CC vers lequel la tension de charge (V1) détectée est réalimentée et qui commande la tension

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de sortie ( $V_{out}$ ) pour être  $k$  fois plus grande que la tension de charge ( $V_1$ ) détectée selon  $V_{out} = k \times V_1$   
et **en ce que** la source d'alimentation en courant continu (1) est adaptée pour régler la tension de sortie ( $V_{out}$ )  
pour être plus grande que la tension de charge ( $V_1$ ) et pour être 2,5 fois aussi grande que la tension de charge  
( $V_1$ ) ou inférieure selon  $1 < K < 2,5$  ;

5 dans lequel le facteur de service ( $Don$ ) de l'élément de commutation ( $Q_1$ ) est  $Don = V_1/V_{out}$

2. Dispositif d'éclairage à élément électroluminescent solide selon la revendication 1, dans lequel  
la partie de circuit de commande (3) inclut un circuit de détection de courant nul (31) pour détection qu'un courant  
s'écoulant vers l'inducteur ( $L_1$ ) devient nul, et commute l'élément de commutation ( $Q_1$ ) de l'état arrêt vers l'état  
10 marche en synchronisation avec le moment de détection du circuit de détection de courant nul (31).
3. Dispositif d'éclairage à élément électroluminescent solide selon la revendication 1, dans lequel  
la partie de circuit de commande (3) commute l'élément de commutation ( $Q_1$ ) pour être en marche avant qu'un  
courant s'écoulant vers l'inducteur ( $L_1$ ) pendant l'état arrêt de l'élément de commutation ( $Q_1$ ) devienne nul.  
15
4. Dispositif d'éclairage à élément électroluminescent solide selon l'une quelconque des revendications 1 à 3, dans  
lequel  
la source d'alimentation en courant continu (1) inclut un convertisseur CA-CC, et une fréquence du signal PWM est  
réglée à 600Hz ou des multiples de 600Hz.  
20
5. Applique d'éclairage comprenant : le dispositif d'éclairage à élément électroluminescent solide selon l'une quelcon-  
que des revendications 1 à 4 ; et un élément électroluminescent solide auquel la puissance d'éclairage est fournie  
depuis le dispositif d'éclairage à élément électroluminescent solide.  
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Figure 1

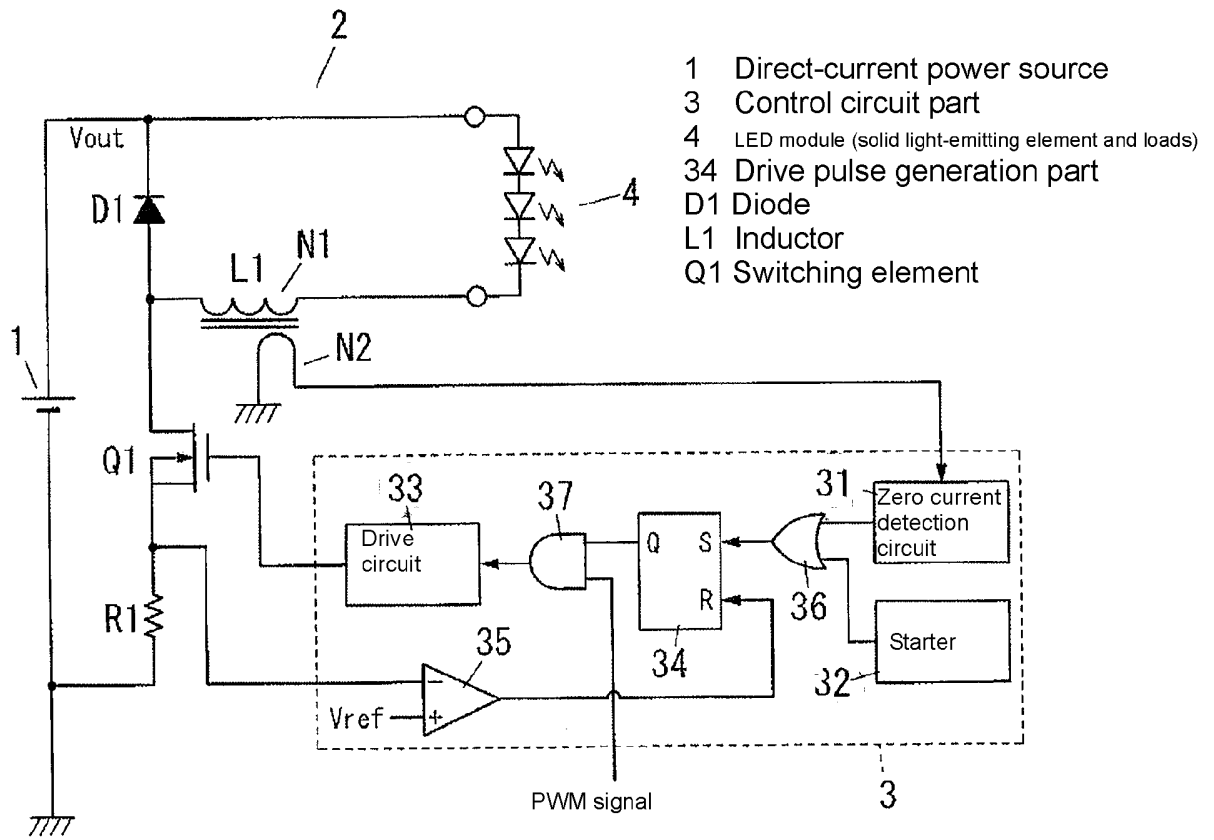


Figure 2

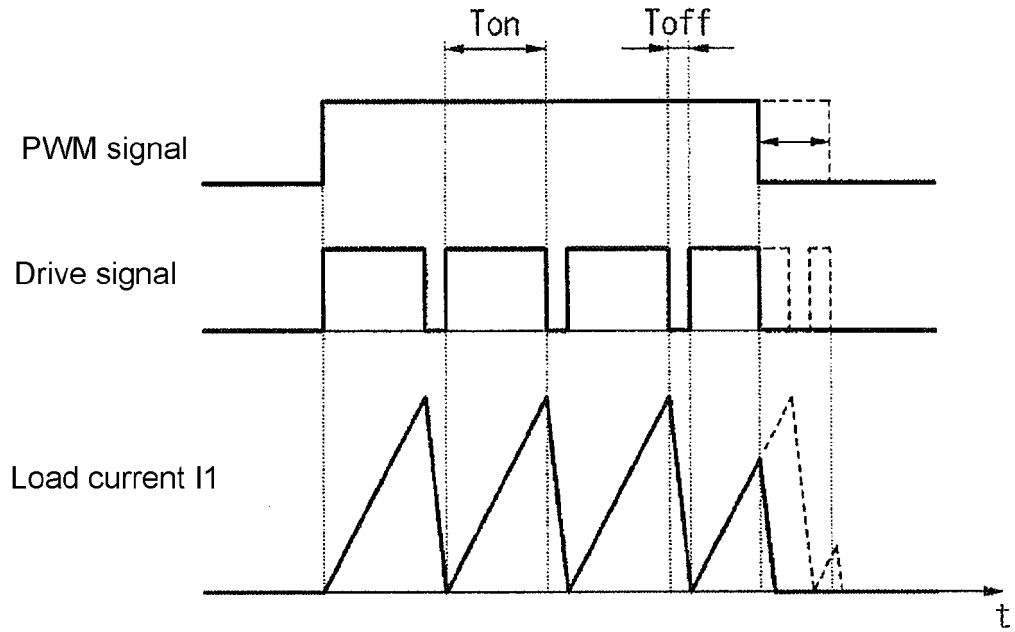


Figure 3

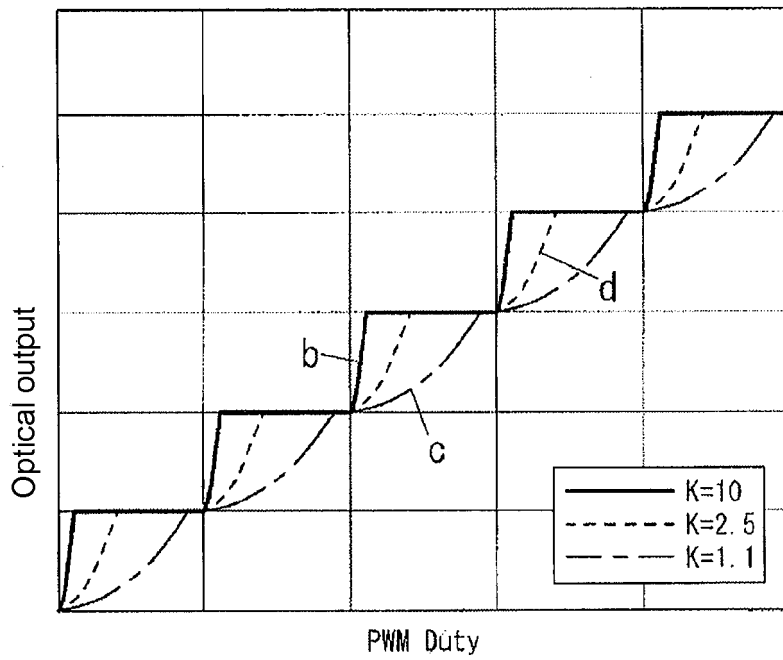


Figure 4

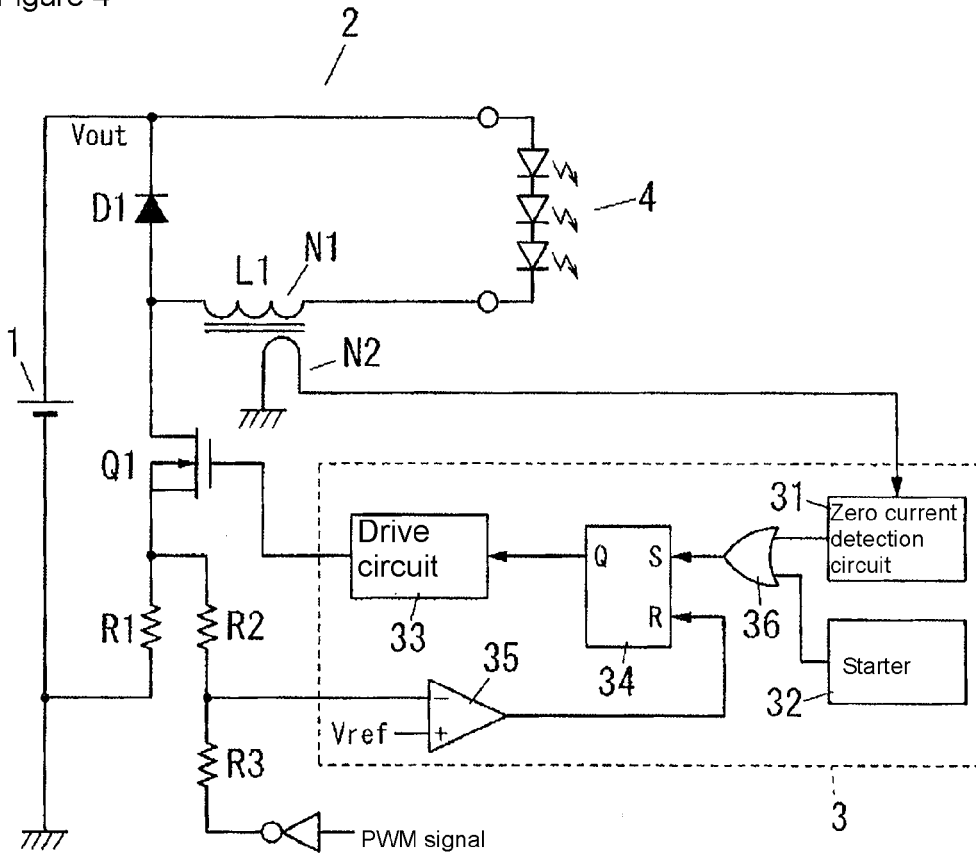


Figure 5

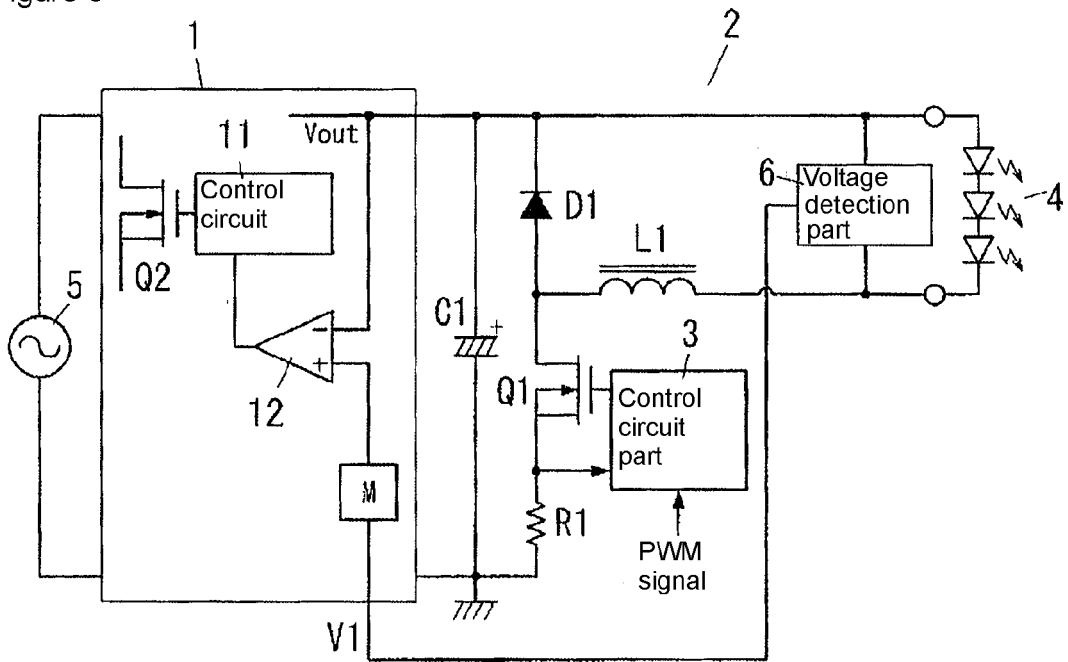


Figure 6

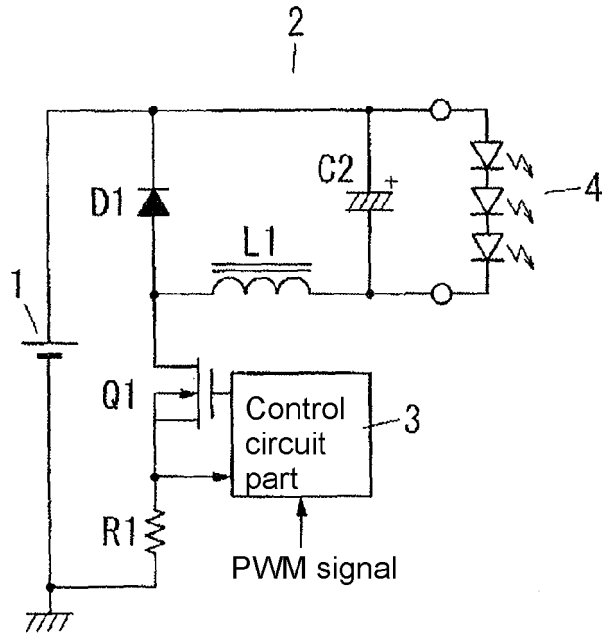


Figure 7

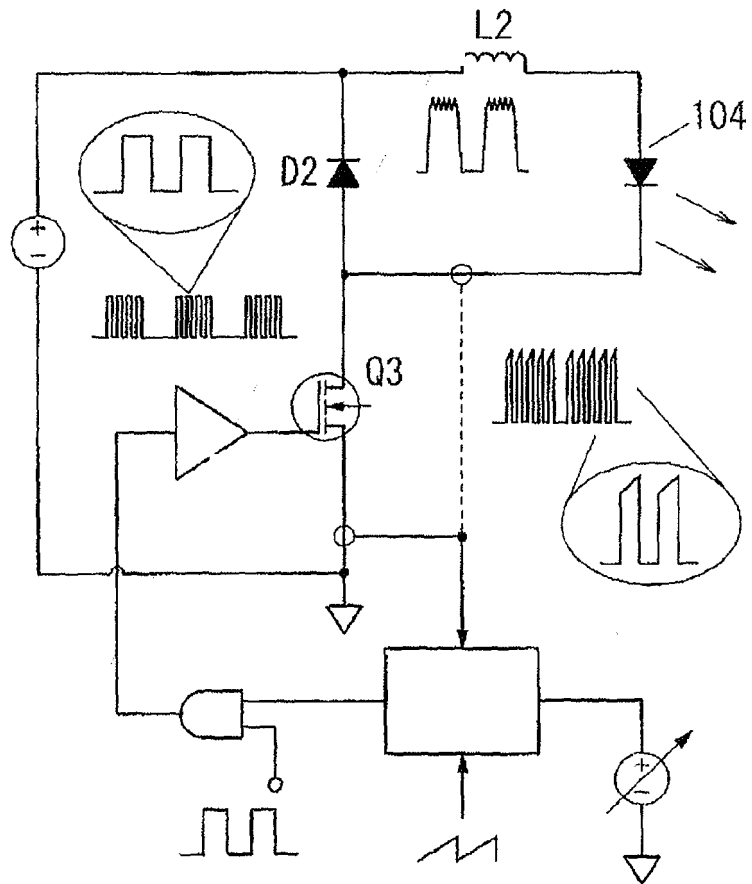


Figure 8

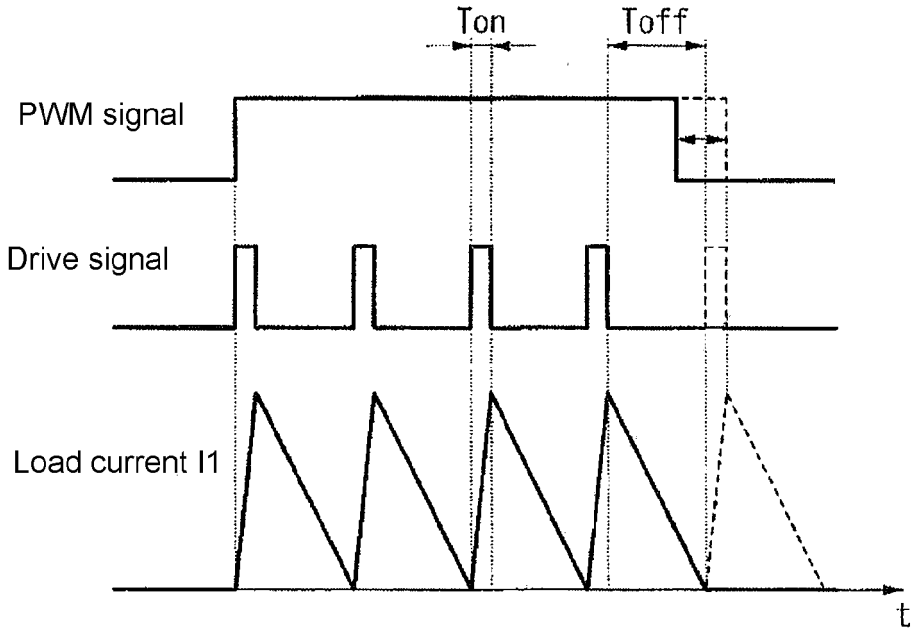
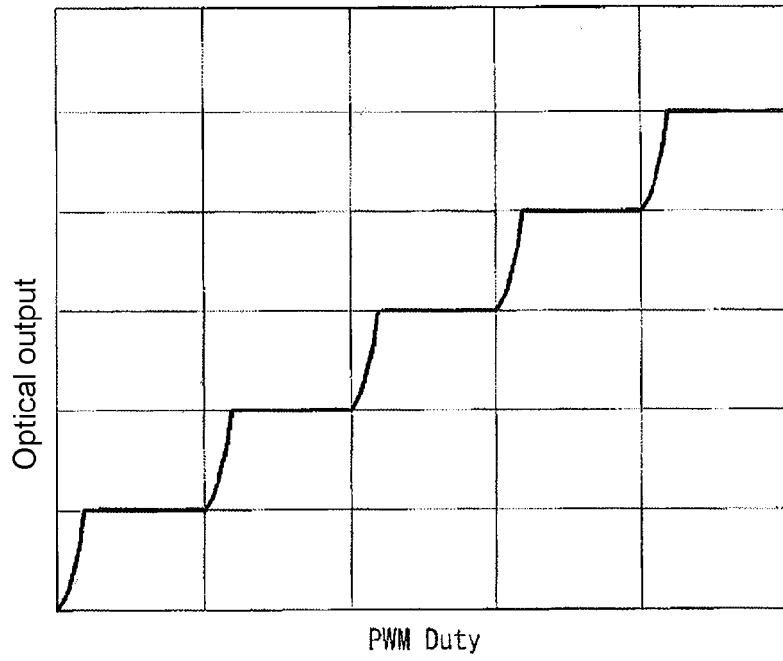


Figure 9



**REFERENCES CITED IN THE DESCRIPTION**

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