(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 517 535 B9

(12) # CORRECTED EUROPEAN PATENT SPECIFICATION

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

(48) Corrigendum issued on:
30.04.2025 Bulletin 2025/18

(45) Date of publication and mention of the grant of the patent:
24.05.2017 Bulletin 2017/21

(21) Application number: **10798097.1**

(22) Date of filing: **22.12.2010**

(51) International Patent Classification (IPC):
H05B 33/08 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H05B 45/14; H05B 45/3725; H05B 45/375; H05B 45/44

(86) International application number:
PCT/EP2010/070587

(87) International publication number:
WO 2011/076898 (30.06.2011 Gazette 2011/26)

(54) **Circuit for operating light emitting diodes (LEDs)**

Schaltkreis zum Betreiben von Leuchtdioden (LED)

Circuit pour le fonctionnement de diodes électroluminescentes (DEL)

(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: **23.12.2009 EP 09180513**
20.01.2010 EP 10151196

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

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Description

[0001] The present invention relates to a circuit arrangement for operating light emitting diodes and to a method for achieving this purpose.

[0002] Conventional light emitting diodes (LEDs) emit light within a limited spectral range. Examples are spectra of a blue, a green, a yellow and a red light emitting diode. Modules are known in which light emitting diodes of different colours, e.g. blue and yellow (two LEDs) or red, green and blue (RGB) are combined in such a way that their light is mixed, for example, by means of a diffusion screen and that the mixed light appears white or that the spectrum of the light resulting therefrom extends over the whole visible range.

[0003] Although this light appears fundamentally "white" there are troughs within the spectrum of this emitted light. These troughs have a disadvantageous effect in that, for example, objects with colours in the range of these gaps are rendered with a very matt appearance. The quality of the colour rendering, which is expressed using the colour rendering index or CRI photometric variable, is accordingly dependent on these gaps.

[0004] The colour rendering index expresses how close the colour rendering of an artificial lighting means comes to the broadly distributed continuous spectrum of natural sunlight. As is generally known, this cannot be expressed solely by the colour temperature because the colour temperature does not indicate whether there may be gaps in the spectrum of an artificial lighting means.

[0005] These spectral gaps thus arise when RGB light emitting diodes are connected to each other. However, these troughs are also found when so-called white light emitting diodes are used. These are light emitting diodes which are combined with photoluminescent material (fluorescence stain, luminescent material). The light from the LED chip in a first spectrum is partially converted into a second spectrum by the phosphorous layer or colour conversion layer formed thereby. The mixture of the first and second spectrum then produces the spectrum of white light.

[0006] With the aid of a colour conversion layer, shortwave light such as, for example, blue light can be converted into longwave light, for example, in the yellow or red wavelength range.

[0007] However, between the actual (e.g. blue) spectrum of the lighting means chip and the second (yellow or red) shifted spectrum of the conversion layer there is also conventionally a spectral gap or at least a spectral trough so that the quality of the colour rendering or the colour rendering index is reduced as a result.

[0008] Document WO 2007/141741 A1 discloses a current supply circuitry for at least one LED, comprising at least one inductive reactance connected as a storage choke in series with the LED, a free running current path, connected parallel to the series connection of the LED and the storage choke. A switch is used for switching between a charging and a discharging process occurring in the storage choke. The current supply circuitry comprises control means arranged to change the current supplied to the LED from a continuous conduction mode to a discontinuous conduction mode at an adjustable dimming level of the LED.

[0009] The object of the present invention is to provide an improved control circuit and control method for operating for light emitting diodes.

[0010] This object is achieved by a device and a method having the features of the independent claims.

[0011] A first aspect of the invention relates to a driving circuit for provision of an operating current for at least one lighting means, such as e.g. a light emitting diode, the driving circuit comprising a switched converter having a switch controlled by a control circuitry, wherein a choke is charged when the control circuitry control the switch in its conducting state and the choke is de-charged when the control circuits controls the switch in its non-conducting state, wherein by supplying an external signal or an internal feedback signal to the control circuitry, the control circuitry is designed to adapt the clocking of the switch in order to adapt the operating mode of the switched converter.

[0012] The operating mode of the driving circuit arrangement and therefore of the switched converter can be selected out of three, so called continuos conduction mode, the so called borderline or critical conduction mode or the discontinuos conduction mode, or a combination of them.

[0013] The switched converter may be a DC/DC converter.

[0014] The switched converter may be a buck converter, a boost converter, a fly-back converter, a buck-boost converter or a switched power factor correction circuit.

[0015] The external signal may be at least one of a dimming signal, a color control signal and a color temperature signal.

[0016] The feedback signal may be at least one of a power consumption signal, a lighting means current signal or a load characteristic signal representing at least one electrical parameter of the lighting means load driven by the driving circuit.

[0017] The load characteristic signal may represent the number and/or the topology of at least two LEDs driven by the driving circuit.

[0018] The control circuitry may be an integrated circuit such as e.g. an ASIC or a microcontroller or a hybrid thereof.

[0019] A further aspect of the invention relates to a method for dimming at least one LED using a switched converter for supplying the at least one LED with electrical power, wherein the dimming selectively is performed via at least two dimming modes out of the three following dimming modes:

- a first dimming mode, in which the at least one LED is dimmed by controlling the switch such that the current through the choke has an essentially triangular shape, wherein the dimming is achieved by adjusting the time period for allowing the choke current to rise to a peak value by switching on a switch of the switched converter, wherein the fall of the choke current, caused by switching off the switch of the switched converter at the peak, is stopped by switching on the switch of the switched converter at the latest when the falling choke current reaches a non-zero value,

- a second dimming mode, in which the at least one LED is dimmed by controlling the switch such that the current through the choke has an essentially triangular shape, wherein the dimming is achieved by adjusting the time period for allowing the choke current to rise to a peak value by switching on a switch of the switched converter, wherein the choke current is allowed to drop to zero and made to raise again as soon as the zero value has been reached, and
- a third dimming mode, in which, in addition or alternatively to the adjustment of the time period for allowing the current to rise to a peak value, the duration of a non-zero time period between the falling choke current reaching zero and the switching-on of the switch of the switched converter in order to cause the choke current to raise again is adjusted.

The first and second dimming mode, respectively, may be selected depending on the value of a external signal or an internal feedback signal of the switched converter.

[0020] The external signal may be at least one of a dimming signal, a color control signal and a color temperature signal.

[0021] The feedback signal may be at least one of a power consumption signal, a lighting means current signal or a load characteristic signal representing at least one electrical parameter of the lighting means load driven by the driving circuit.

[0022] The invention will be explained in more detail hereinunder with the aid of the enclosed drawings in which:

Fig. 1 shows a further exemplified embodiment of a circuit arrangement in accordance with the present invention,

Fig. 2 shows signal curves for a continuous conduction mode of a switched regulator.

Fig. 3 shows signal curves for a critical conduction (borderline) mode of a switched regulator

Fig. 4 shows signal curves for a discontinuous conduction mode of a switched regulator

Fig. 5 shows a switched power factor correction circuit (PFC), and

Fig. 6 shows a buck converter used as a current source of one or more LEDs.

[0023] Fig. 1 shows a first exemplified embodiment of a circuit arrangement 130 for controlling the light emitting diode 34 in accordance with the invention. The circuit arrangement 130 has a switched converter which is formed by the choke L1, the capacitor C1, the free-wheeling diode D1, the switch S1 and the light emitting diodes 34.

[0024] The switch S1 is controlled by a control circuitry, such as an IC (microcontroller, ASIC, hybrid thereof etc.).

[0025] In this example the switched converter is formed as a buck converter, however, other topologies such as a boost converter (see figure 5), a flyback converter, a PFC or even a buck-boost converter can also be used. A plurality of resistors ("shunts") is provided in order to monitor the currents and voltages in the switched converter and at the light emitting diodes 34. The resistor Rs thus serves to monitor the current through the switch S1 during the switch-on period of the switch S1, wherein the current is represented by the voltage U_s across the shunt R_s.

[0026] The current iF flows through the load, i.e. the LEDs.

[0027] The current i_L flows through the choke L1.

[0028] The two voltage dividers R3/ R4 and R1/ R2 serve to monitor the voltage U_{LED} across the light emitting diodes 34. However, in an alternative embodiment the light emitting diodes 34 can also be connected in series with the choke L1. The switch S1 of the switched converter is controlled by the control circuit IC. The control circuit IC can be supplied externally and/or internally with desired values which specify the time-averaged desired current through the light emitting diodes. In addition, internal feedback signals can be supplied to the control circuit IC from the supply voltage, the switched regulator and/or the load circuit comprising one or more LEDs.

[0029] The control circuit IC can be supplied with a colour locus correction command as an external desired value. This colour locus correction command can selectively trigger the amplitude spread and possibly also specify the extent of the amplitude spread. The colour locus correction command therefore specifies an adaptation of the spectrum.

[0030] The circuit arrangement 130 is an advantageous embodiment to achieve control of the light emitting diodes 34 in accordance with the invention with the smallest possible losses.

[0031] During operation of the light emitting diodes 34 with almost constant amplitude, at least for a certain time duration of the time period T, it is possible to cause the circuit arrangement 130 to be operated in the so-called continuous conduction mode. The circuit arrangement 130 is controlled in such a way that the current i_L through the choke L1 never falls to zero but maintains a value which is constant on average (this is called the continuous conduction mode as the current i_L is never allowed to drop to zero). In order to achieve such operation, the choke L1 is magnetised in a first phase by switching on the switch S1. The current i_L through the choke L1 can be monitored in this phase by means of the resistor Rs. If a certain current value (upper limit value) is achieved, the switch S1 is opened. Owing to the magnetisation of the choke L1 the current i_L is now driven further through the free-wheeling diode D1 and the light emitting diodes 34. The current i_L through the choke L1 thus slowly falls. Owing to the flow of current through the free-wheeling diode D1 and the light emitting diodes 34 the capacitor C1 is also charged. The reduction in the demagnetisation and in the current i_L through the choke L1 can be monitored by the two voltage dividers R3/ R4 and R1/ R2. If the current i_L reaches a certain lower limit value, the switch S1 is switched on and the choke L1 is magnetised. While the free-wheeling diode D1 now blocks the current flow, the capacitor C1 is discharged via the light emitting diodes 34. The circuit arrangement 130 is thus operated in the high-frequency range.

[0032] The circuit arrangement 130, however, can also be operated in the so-called borderline (or critical mode), in which the current is allowed to drop to zero, but caused to raise again immediately when reaching the zero value. The borderline mode operation produces an operating current 100 in accordance with Figure 3. The choke L1 is magnetised, starting from complete demagnetisation, by closing the switch S1 until the maximum value ΔI has been achieved. The switch S1 is now opened and the choke L1 demagnetised, which leads to a fall in the operating current. By means of a measurement at the two voltage dividers R3/R4 and R1/R2 or at least at the voltage divider R1/R2 the time when the zero point of the operating current is achieved can be determined. As soon as it is detected (or it can be deduced), by means of a direct or indirect measurement variable, that the zero point of the choke current i_L has been reached, the switch S1 can be closed and the choke L1 can be magnetised again.

[0033] The circuit arrangement 130 can, for example, also be operated in an operating mode in accordance with Fig. 2. The choke L1 is magnetised, starting from complete demagnetisation, by closing the switch S1 until the maximum value ΔI has been achieved. The switch S1 is now opened and the choke L1 is demagnetised but only until an internally set lower limit value just below the maximum value ΔI is achieved. If this value has been achieved, the switch S1 is switched on, such that a hysteresis control is achieved. The circuit arrangement 130 is now operated in a so-called continuous conduction mode CCM until the time duration T_{nom} has elapsed. Now, during the time duration T_f the switch S1 is permanently open and the choke L1 is demagnetised, which leads to a fall in the choke current i_L. By means of a measurement at the two voltage dividers R3/R4 and R1/R2 or at least at the voltage divider R1/R2 the time when the zero point of the choke current i_L is reached can be determined (not shown in Fig. 2). As soon as the reaching of the zero point of the operating current has been detected (see Fig. 3) or the time duration t_{off} has elapsed (see Fig. 4), the switch S1 can be closed and the choke L1 can be magnetised. In the operating mode according to Fig. 2 the switch S1 has two different switching frequencies, during the time duration T_{nom} it is controlled with a higher clock frequency in comparison to the time durations T_r, T_f and T_{off}.

[0034] Thus by supplying an external signal such as, for example, a colour locus correction command, the operating mode of the circuit arrangement 130 and therefore of the switched converter can be selected and adapted. Operation in the so-called continuous conduction mode, in the so-called borderline or critical mode, the discontinuous mode (in which the current remains at zero for a time period larger than zero) or even a combination of the three operating modes can be selected for example.

[0035] It will now be explained how, according to an aspect of the invention, a switched converter (buck converter, boost converter, PFC converter, flyback converter, etc.) selectively operates in at least two different operation modes, which different operation modes e.g. can be different dimming modes.

[0036] The at least two different operation modes can be selected e.g. from:

- The continuous conduction mode,
- The border line mode, and
- The discontinuous conduction mode.

[0037] The different dimming modes can e.g. be used to have a first dimming range up to a defined threshold value, and a second dimming range in which the switch converter is in a different operation mode than in the first dimming range. Optionally also a third dimming range can be provided in which the switch converter is operated in a third operation mode (which is different both to the first and second operation mode).

[0038] Figure 2 shows different signal curves when a switched converter is operated in the so-called continuous conduction mode CCM.

[0039] As can be seen from figure 2, in the continuous conduction mode, when a control circuitry switches on the switch S1, which can be seen from the depicted gate signal in figure 2, both the current i_F through the light emitting diode 34 as well as the current i_L through the magnetizing choke L1 will increase. Also the voltage Us across the shunt Rs increases essentially linearly, representing the increasing current through the switch S1.

[0040] As soon as e.g. the current through the choke i_L or the current through the switch reaches an upper threshold value, the control circuitry switches off the switch S1. After this switching off at the peak of the choke current i_L, the choke L1 linearly demagnetizes which can be seen from the linearly falling choke current i_L. As soon as the choke current reaches a lower threshold value, the lower threshold being larger than zero, the switch S1 is switched on again leading to the shown hysteresis controller behaviour of figure 2.

[0041] Note that the current through the load (LEDs) is not exactly following the choke current i_L, as the storage capacitor C1 has a filtering effect.

[0042] The power supplied to the LED load is a function of the time average value of the choke current. Obviously, by increasing the time period t_{off} during which the switch is in the non-conducting state, the average value of the choke current i_L can be reduced, leading to a downwards dimming (reduced power) of the LED load.

[0043] Figure 3 shows the so-called borderline or critical conduction mode, in which the non-conducting period of the switch S1, the time period t_{off} as well as the switching-on time period t_{on} have been increased such that the current i_L is allowed to drop to zero during the non-conducting time period t_{off}, the switch S1 is switched on (put in the conducting state) by the control circuitry as soon as it has reached the zero value.

[0044] Figure 4 now illustrates the already mentioned third operation mode for a switch converter, the so-called discontinuous conduction mode. The choke current i_L is again be allowed to drop to zero. However, the switch S1 is not immediately switched on upon the choke current i_L reaching the zero value. Rather, the non conducting time period t_{off} is extended such that there is a non zero time period during which the choke current I_L remains at zero. In this operation mode a dimming can be achieved e.g. by increasing the t_{off} value and thus the time period in which the choke current i_L is zero.

[0045] Figure 5 shows an actively switched power factor correction circuit PFC, which according to the invention can selectively operate in a least two different modes, when assessed by the respective waveform of the choke current i_L.

[0046] The power circuitry is depicted as a micro controller μc, although e.g. also an ASIC or a hybrid version of a microcontroller and an ASIC can be used.

[0047] Internal feedback signals from the switched controller can be fed back to the control circuitry. Typical examples are the sensed input voltage of the switched converter, a zero crossing detection signal for detecting the zero crossing of the choke current i_L, a signal indicating the current through the switch S1 and furthermore, feedback signals from the load such as e.g. the lighting means (LED) voltage, the lighting means (LED) current and the load characteristics, i.e. a signal indicating e.g. the number and the topology of several connected LEDs driven as a load.

[0048] Also external control signals, such as e.g. dimming signals can be fed to the control circuitry.

[0049] According to one aspect of the invention, the control circuitry as shown in figures 5 or 6 for a switched lighting means converter can operate selectively in different operation modes, i.e. the continuous conduction mode of figure 2, the borderline (critical) conduction mode of figure 3 or the discontinuous conduction mode of figure 4.

[0050] The control circuitry will select the best-suited operation mode according to any of the internal and/or external feedback signals, examples of which are given above.

[0051] Figure 6 shows a buck converter used as a current source of one or more LEDs driven as a load. Again, different internal feedback signals (e.g. input or supply voltage, zero crossing detection, switch current, load characteristic, power consumption representing parameters) and external signals (e.g. external dimming control signals) can be fed to the depicted control circuitry.

[0052] The adaptive setting of the operation mode of the switched lighting means converter according to the invention has several advantages, which will be explained now.

[0053] An advantage is that without changing the dimensions of the hardware elements, such as for example the choke L1 and the storage capacitor C1, varying loads, such as for example different topologies or different numbers of driven LEDs can be operated by the switched conducting means converter, all by having reasonable switching times and frequencies for the choke current i_L and thus the LED current i_F.

[0054] Just as an illustrative example, a choke L1 with a maximum allowed current of 0.55 A can be used in the continuous conduction mode (CCM) for a LED current iF up to 500 mA (average value), wherein the t_{on}-time period duration for the switch S1 primarily depends on the amplitude (RMS value) of the supply voltage V_{in} and the voltage across the LEDs U_{LED}. If it is desired (indicated e.g. via an external or internal dimming command) to reduce the average value of the LED current iF, obviously the t_{on}-time period has to be reduced, especially when also U_{LED} is small. This reduction of Ton-time period for the switch S1 will thus lead to very high switching frequencies. The choke current i_L will eventually be allowed to drop to zero, which corresponds to a dimming of the LEDs, in which the LED current iF time average basis is only 50% of the allowed maximum LED current iF. Thus, this illustrative example the dimming value of 50% leads to a change of the previous continuous conduction mode to the borderline mode.

[0055] According to the invention, if the feedback signals or the external signals (dimming signals) require a further dimming e.g. going below of the 50% value, according to the invention the switched converter will change from the borderline conduction mode to the discontinuous conduction mode depicted in figure 4. In order to further reduce the power supplied to the LEDs, the t_{off} time period will be further increased in order to further reduce the average LED current i_F, all by having a t_{on} time period that is not too small, i.e. below a certain lower threshold value representing the minimum value possible e.g. with the clocking of the control circuitry.

[0056] Thus, according to the invention the control circuitry will use an operation mode for the switched lighting means converter depending on the load, the current requirements of the load etc. in order to have a flexible use of the same hardware for different scenarios and for a wide dimming range.

[0057] As explained in figure 5, the switched converter may be a switched PFC, which generates, as a first converter stage of at least two converter stages, a DC voltage typically out of a rectified AC voltage, such as e.g. mains voltage. As second converter stage may be provided, which may be a DC/DC or DC/AC (e.g. half bridge or full bridge converter) stage supplying the lighting means and optionally also selectively operating in different operation modes, depending on external signal and/or internal feedback signal.

Claims

1. Method for dimming at least one LED using a switched converter for supplying the at least one LED with electrical power, the switched converter comprising a switch (S1) for charging a choke (L1) when the switch (S1) is conducting and discharging the choke (L1) when the switch (S1) is non-conducting,

   - wherein the dimming selectively is performed via a combination of at least two dimming modes in a first and a second dimming range:
   - a borderline mode, in which the at least one LED is dimmed by controlling the switch (S1) such that the current through the choke has an essentially triangular shape,
   - wherein the dimming is achieved by adjusting the time period for allowing the choke (L1) current to rise to a peak value by switching on a switch of the switched converter,
   - wherein the fall of the choke current, caused by switching off the switch (S1) of the switched converter at the peak, is stopped by switching on the switch (S1) of the switched converter at the latest when the falling choke current reaches zero, and
   - a discontinuous conduction mode, in which, in addition or alternatively to the adjustment of the time period for allowing the current to rise to a peak value, a non-zero time period between the falling choke current reaching zero and the switching-on of the switch (S1) of the switched converter in order to cause the choke current to raise again is adjusted.

2. Method according to claim 1, wherein the borderline mode and the discontinuous conduction mode, respectively, are selected depending on the value of a external signal or an internal feedback signal of the switched converter.

3. Method according to claim 2, wherein the external signal is at least one of a dimming signal, a color control signal and a color temperature signal.

4. Method according to claim 2, wherein the feedback signal is at least one of a power consumption signal, a lighting means current signal or a load characteristic signal representing at least one electrical parameter of the lighting means load driven by the driving circuit.

Patentansprüche

1. Verfahren zum Dimmen von mindestens einer LED unter Verwendung eines geschalteten Wandlers zur Versorgung der mindestens einen LED mit elektrischer Leistung, wobei der geschaltete Wandler einen Schalter (S1) umfasst, um eine Drosselspule (L1) zu laden, wenn der Schalter (S1) leitet, und die Drosselspule (L1) zu entladen, wenn der Schalter (S1) nicht leitet,

   - wobei das Dimmen selektiv mit Hilfe einer Kombination von mindestens zwei Dimmmodi in einem ersten und einem zweiten Dimmmodus durchgeführt wird:
   - einem Borderline-Modus, in dem die mindestens eine LED durch Steuern des Schalters (1i) gedimmt wird, so dass der Strom durch die Drosselspule eine im Wesentlichen dreieckige Form aufweist,
   - wobei das Dimmen durch Einstellen des Zeitraums erzielt wird, der ermöglicht, dass der Strom der Drosselspule (L1) zu einem Spitzenwert ansteigt, indem ein Schalter des geschalteten Wandlers eingeschaltet, und
   - wobei der Abfall des Drosselspulenstroms, verursacht durch das Abschalten des Schalters (S1) des geschalteten Wandlers an der Spitze, durch Schaltern des Schalters (S1) des geschalteten Wandlers spätestens dann, wenn, der abfallende Drosselspulenstrom Null erreicht, gestoppt wird, und
   - einem unterbrochenen Modus, in dem, zusätzlich oder alternativ zur Einstellung des Zeitraums, um zu ermöglichen, dass der Strom zu einem Spitzenwert ansteigt, ein von Null verschiedener Zeitraum zwischen dem abfallenden Drosselspulenstrom, der Null erreicht, und dem Einschalten des Schalters (S1) des geschalteten Wandlers, um zu verursachen, dass der Drosselspulenstrom erneut angehoben wird, eingestellt wird.

2. Verfahren nach Anspruch 1, wobei der Borderline-Modus und der unterbrochene Leitungsmodus abhängig von dem Wert eines externen Signals oder

eines internen Feedback-Signals des geschalteten Wandlers ausgewählt werden.

3. Verfahren nach Anspruch 2, wobei das externe Signal mindestens eines aus einem Dimmsignal, einem Farbsteuerungssignal und einem Farbtemperatursignal ist.

4. Verfahren nach Anspruch 2, wobei das Feedback-Signal mindestens eines aus einem Leistungsverbrauchssignal, einem Beleuchtungsmittel-Stromsignal oder eines Lasteigenschaftssignal ist, das mindestens einen elektrischen Parameter der Beleuchtungsmittellast darstellt, das von der Treiberschaltung betrieben wird.

Revendications

1. Procédé pour la gradation d'au moins une DEL en utilisant un convertisseur commuté pour fournir une énergie électrique à ladite au moins une DEL, le convertisseur commuté comprenant un commutateur (S1) pour charger une inductance de lissage (L1) lorsque le commutateur (S1) conduit et décharger l'inductance de lissage (L1) lorsque le commutateur (S1) ne conduit pas,

- dans lequel la gradation est effectuée de manière sélective par l'intermédiaire d'une combinaison d'au moins deux modes de gradation dans une première et une deuxième plage de gradation ;
- un mode de limite, dans lequel la gradation de ladite au moins une DEL est effectuée en commandant le commutateur (S1) de sorte que le courant à travers l'inductance de lissage ait une forme essentiellement triangulaire,
- dans lequel la gradation est obtenue en ajustant la période de temps pour permettre au courant de l'inductance de lissage (L1) d'augmenter à une valeur crête en fermant un commutateur du convertisseur commuté,
- dans lequel la diminution du courant de l'inductance de lissage, provoquée par l'ouverture du commutateur (S1) du convertisseur commuté au niveau du pic, est arrêtée en fermant le commutateur (S1) du convertisseur commuté au plus tard lorsque le courant décroissant de l'inductance de lissage atteint zéro, et
- un mode de conduction discontinue, dans lequel, en plus de ou alternativement à l'ajustement de la période de temps pour permettre au courant d'augmenter à une valeur crête, une période de temps non nulle entre l'instant auquel le courant décroissant de l'inductance de lissage atteint zéro et la fermeture du commutateur (S1) du convertisseur commuté afin d'amener le courant de l'inductance de lissage à augmenter de nouveau est ajustée.

2. Procédé selon la revendication 1, dans lequel le mode de limite et le mode de conduction discontinue, respectivement, sont sélectionnés en fonction de la valeur d'un signal externe ou d'un signal de rétroaction interne du convertisseur commuté.

3. Procédé selon la revendication 2, dans lequel le signal externe est au moins l'un d'un signal de gradation, d'un signal de commande de couleur et d'un signal de température de couleur.

4. Procédé selon la revendication 2, dans lequel le signal de rétroaction est au moins l'un d'un signal de consommation d'énergie, d'un signal de courant de moyens d'éclairage ou d'un signal de caractéristique de charge représentant au moins un paramètre électrique de la charge des moyens d'éclairage commandée par le circuit de commande.

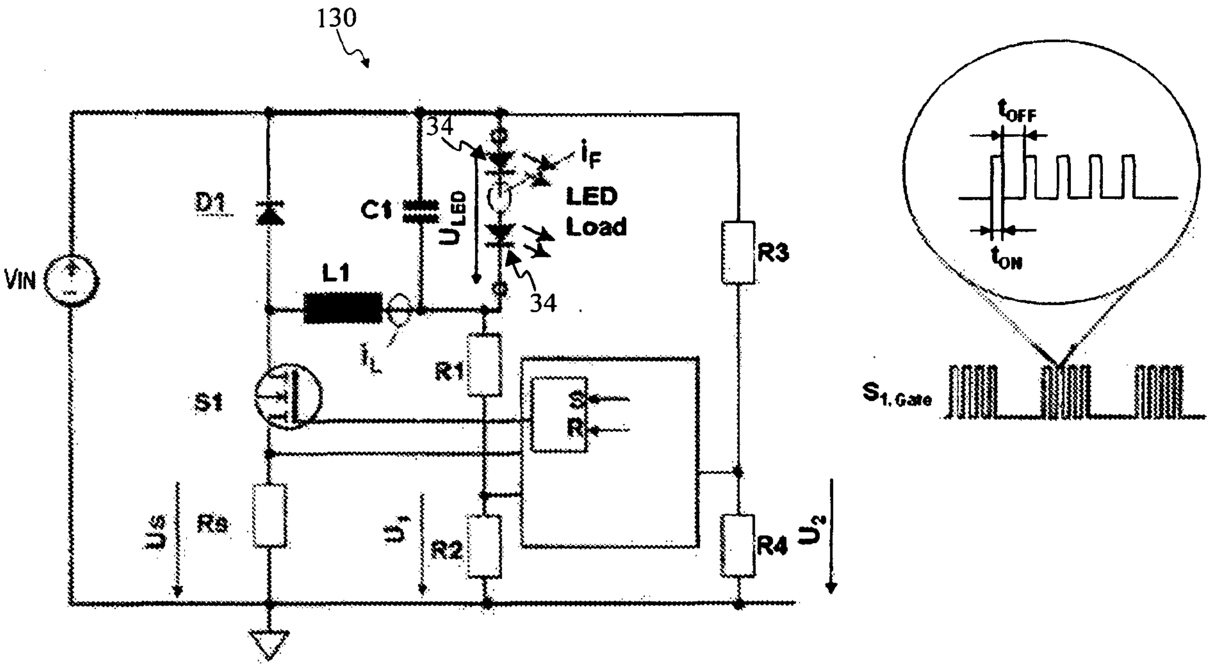

Figure 1

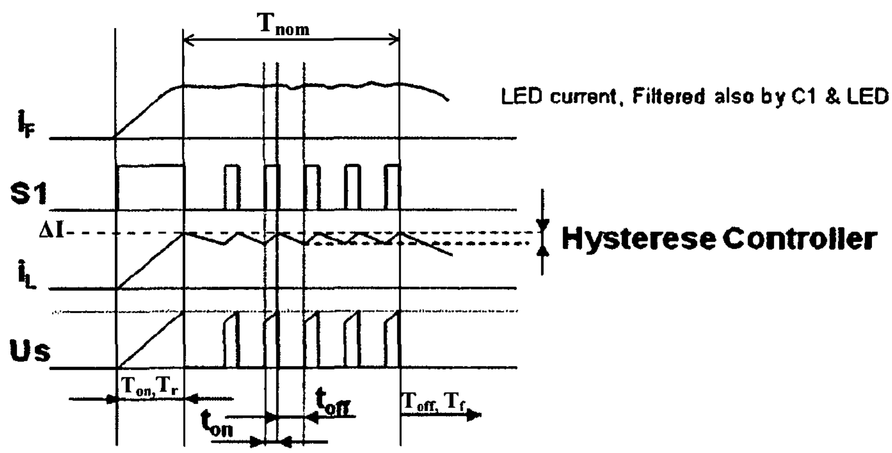

Figure 2

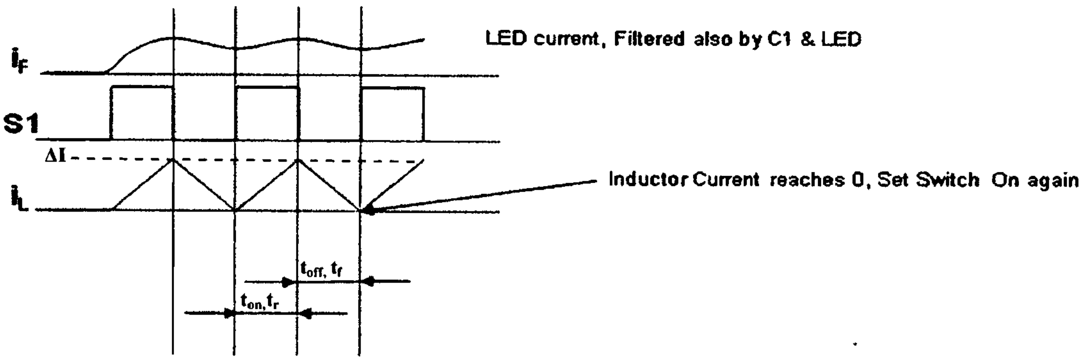

Figure 3

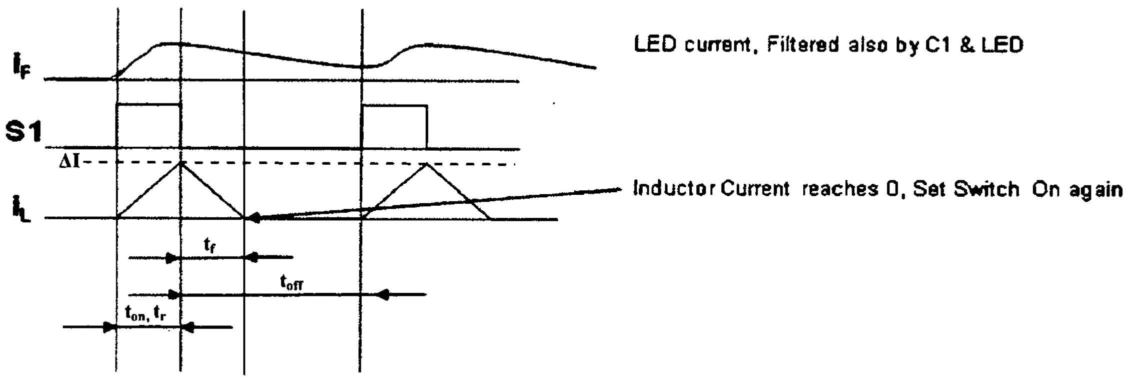

Figure 4

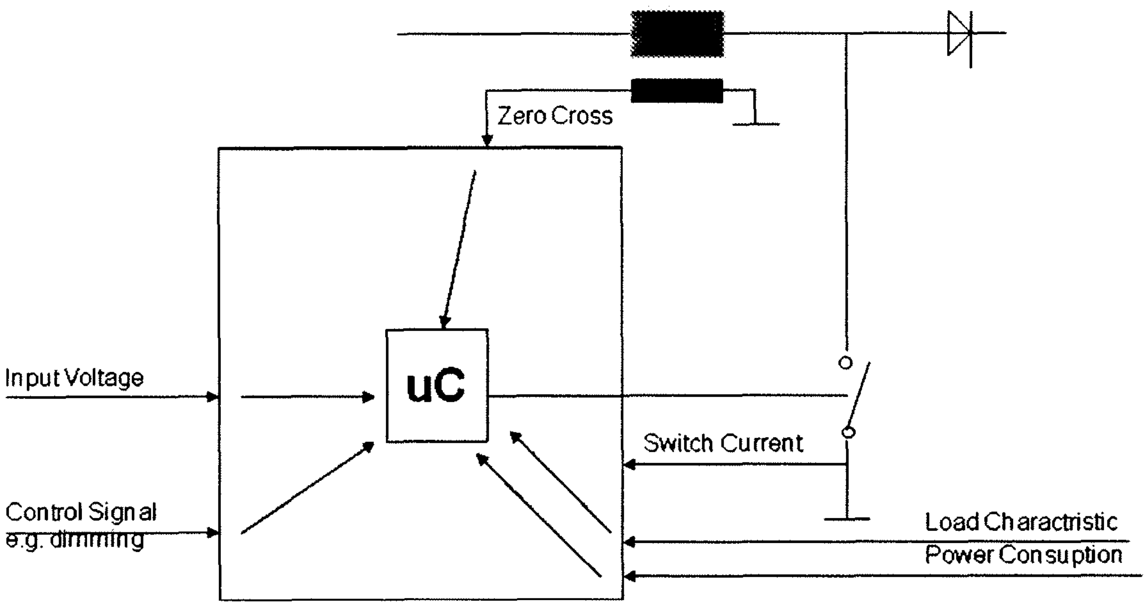

Figure 5

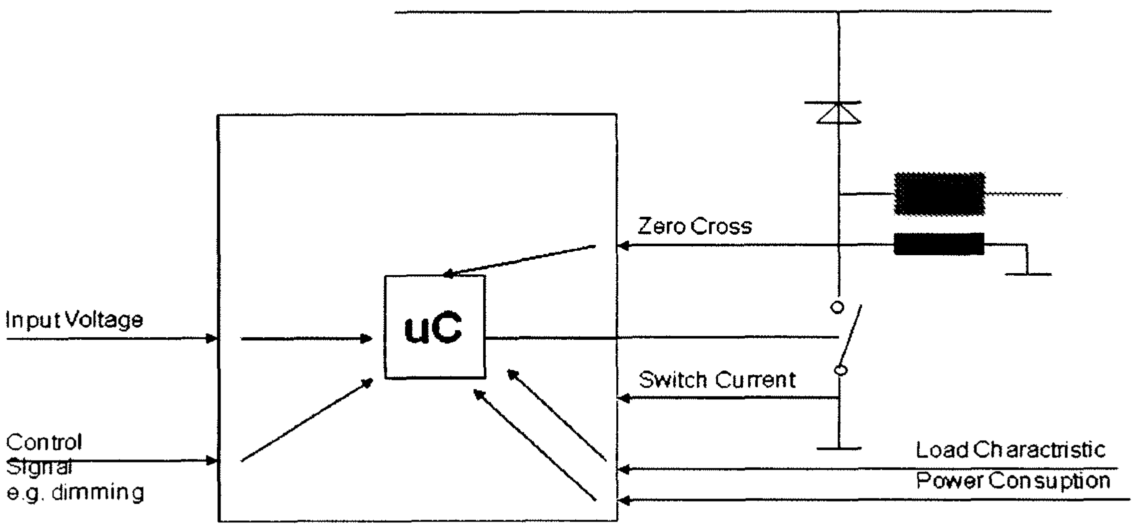

Figure 6

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO 2007141741 A1 **[0008]**