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## (54) Led lighting module with variable colour temperature.

(57) The present invention refers to a LED lighting module that comprises a primary chain of LED devices and secondary chains of LED devices.

The primary chain of LED devices is connected in series to a current generator, adapted to provide a supply current to the lighting module.

The secondary chains of LED devices are connected in parallel to one another and in series to said current generator and to said primary chains of LED devices.

The primary chain and one the first and second secondary chains form different lighting units with different colour temperatures.

The lighting module comprises one or more electronic switches, through which it is possible to alternatively turn on/off one of the lighting units in order to change the colour temperature of the light emitted by the lighting module.

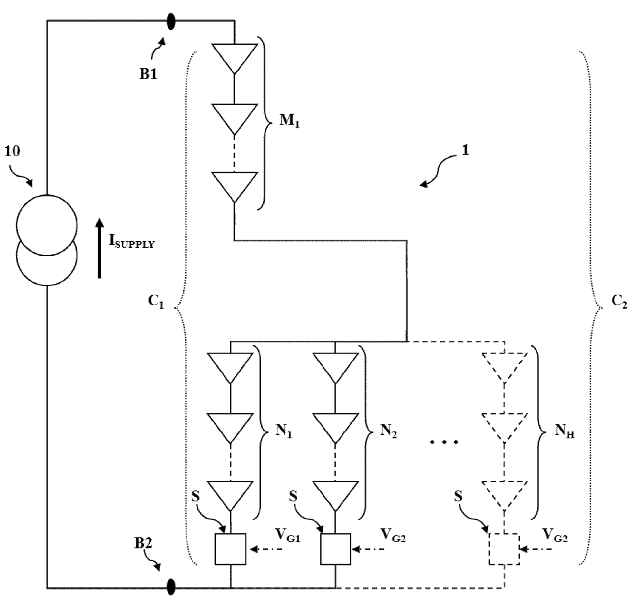


FIG. 1

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## Description

**[0001]** The present invention refers to a lighting module, in particular a LED (Light Emitting Diode) lighting module.

**[0002]** As is known, the chromatic properties of a light source are generally described by using certain characteristic measuring parameters, including colour temperature, colour rendering index and chromatic quality.

**[0003]** The colour temperature of a light source is a quantity (measured in K) indicative of the temperature a black body should have in order that the light radiation emitted by the latter appears chromatically as close as possible to the light radiation emitted by the source itself. The colour rendering index of a light source is a quantity indicative of the capacity of said light source to illuminate a series of normalized colour samples in relation to the capacity of a black body to illuminate the same series of colour samples.

**[0004]** In general, the colour rendering index (Ra) is indicated by a maximum number of 100 (perfect colour rendering capacity). By way of example, the colour rendering capacity of a filament light source (incandescent bulb) is typically 98-99, therefore very close to that of a black body.

**[0005]** The chromatic quality of a light source is represented by the distance between the chromatic coordinates of a light source and the coordinates of a black body, at the same colour temperature, in the CIE 1931 chromaticity diagram. The greater the distance of the black body from the chromatic coordinates, the lower the chromatic quality of the light source.

**[0006]** In lighting systems for private and public use, lighting devices or bodies which comprise LED lighting modules able to emit white light are widely used.

**[0007]** The most traditional lighting modules use LED devices with phosphor conversion system, typically characterised by an emission spectrum with peaks in the blue and yellow wavelengths.

**[0008]** As is known, the colour rendering index (below 90) of these lighting modules is wholly unsatisfactory, in particular as regards their use in interior lighting devices/systems.

**[0009]** LED lighting modules have been developed that are able to emit white light by varying the colour temperature of the light radiation emitted.

**[0010]** Often these lighting modules use phosphor LED devices characterised by an emission spectrum with emission peaks in the wavelengths typical of blue/violet and yellow, coupled with LED devices, typically of AlInGaP (Aluminium Indium Gallium Phosphide) type able to emit red-amber light.

**[0011]** The colour temperature of the light radiation emitted can be varied by appropriately modifying the ratio between the light flux generated by the phosphor LED devices and the light flux generated by the red/amber LED devices.

**[0012]** The lighting modules of this type have some drawbacks.

**[0013]** In phosphor LED devices, the light flux generated varies with the drive current in a different manner from the red/amber LED devices.

**[0014]** The two types of LED devices (phosphor white LEDs and red/amber LEDs) furthermore behave differently when a variation in temperature occurs.

**[0015]** To remedy these difficulties, it is common practice to differentiate regulation of the drive current for the different types of LED devices.

**[0016]** Experience has shown that this solution, albeit effective, significantly increases the overall costs for the industrial production of said lighting modules.

**[0017]** A further drawback arises from the fact that these lighting modules are characterised by a high colour rendering index only for a limited colour temperature interval (approximately 50°K). Outside this colour temperature range, the chromatic qualities of the light emitted deteriorate significantly, turning green for the highest colour temperatures and red for the lowest colour temperatures (figure 8).

**[0018]** Other lighting modules of known type use different types of phosphor LED devices, able to emit white light with different colour temperatures.

**[0019]** Also in this case, the colour temperature of the light emitted can be varied by appropriately modifying the ratio between the light flux generated by LED devices of different types. Unfortunately also these lighting modules have a series of drawbacks.

**[0020]** The number of LED devices used is relatively high, generally double that of a single CCT solution, with consequent increase in costs and overall dimensions.

**[0021]** Furthermore, for colour temperature values that are intermediate with respect to those characteristic of the LED devices used, the light flux of the light radiation emitted significantly increases (in practice it doubles).

**[0022]** The main aim of the present invention is to provide a LED lighting module, which overcomes the drawbacks described above.

**[0023]** In the context of this aim, one object of the present invention is to provide a LED lighting module which allows variation of the chromatic characteristics of the light radiation emitted, in particular the colour temperature, in a relatively simple and effective manner.

**[0024]** A further object of the present invention is to provide a LED lighting module, in which the colour temperature of the light radiation emitted can be varied within a relatively wide range. A further object of the present invention is to provide a LED lighting module, in which the colour temperature of the light radiation emitted can be varied, maintaining the colour rendering index and the light flux substantially unchanged.

**[0025]** A further object of the present invention is to provide a LED lighting module, which has a relatively simple and compact overall structure.

**[0026]** A further object of the present invention is to provide a LED lighting module, which has chromatic characteristics (colour temperature, colour rendering and chromatic coordinates) that are stable when the operating temperature varies.

**[0027]** Last but not least, a further object of the present invention is to provide a LED lighting module which is easy to produce industrially, at competitive costs.

**[0028]** This aim and these objects, in addition to other objects which will appear evident from the following description and the accompanying drawings, are achieved, according to the invention, by a LED lighting module, as claimed in claim 1 and related dependent claims, proposed below.

**[0029]** In a further aspect, the present invention relates to a lighting body or device as claimed in claim 10.

**[0030]** Further characteristics and advantages of the lighting module, according to the invention, will become clearer by referring to the description given below and the accompanying figures, provided for purely illustrative non-limiting purposes, in which:

- figure 1 schematically illustrates the structure of the lighting module, according to the invention; and
- figure 2 schematically illustrates the structure of a preferred embodiment of the lighting module, according to the invention; and
- figure 3 schematically illustrates the operation of the lighting module, according to the invention, in the embodiment of figure 2; and
- figures 4-8 illustrate some experimental measurements carried out on an example of the lighting module, according to the invention, according to the embodiment of figure 2.

**[0031]** With reference to the cited figures, the present invention refers to a LED lighting module 1, particularly suitable for use in lighting bodies or lighting devices in general.

**[0032]** The lighting module 1 is operatively combined with a current generator 10 able to provide a power supply current $I_{UPPLY}$ which is preferably constant over time.

**[0033]** Advantageously, the lighting module 1 comprises a pair of input terminals $B_1$, $B_2$ connected in parallel to the current generator 10.

**[0034]** The latter can be integrated with the lighting module 1 or, preferably, be comprised in a control stage or device (not illustrated) operatively combined with the lighting module.

**[0035]** The lighting module 1 comprises a primary chain $M_1$ of LED devices, which is electrically connected in series to the current generator 10.

**[0036]** The lighting module 1 comprises first and second secondary chains $N_1$, $N_2$, ..., $N_H$ of LED devices, which are electrically connected in parallel to one another and are electrically connected in series to the current generator 10 and to the primary chain $M_1$.

**[0037]** The lighting module 1 may comprise any positive integer number H of first and second secondary chains $N_1$, $N_2$, ..., $N_H$.

**[0038]** The whole set of secondary chains of LED devices may be grouped according to the needs. For example, the first secondary chains may comprise the sole secondary chain $N_1$ while the second secondary chains may comprise the secondary chains $N_2$, ..., $N_H$.

**[0039]** A different grouping of the secondary chains $N_1$, $N_2$, ..., $N_H$ is possible, according to the needs. For example, the group of the first secondary chains might comprise a plurality of chains of LED device while the group of the second secondary chains might comprise a single chain of LED devices.

**[0040]** Preferably, each of the secondary chains $N_1$, $N_2$, ..., $N_H$ comprises a different number $i_1$, $i_2$, ..., $i_H$ of LED devices.

**[0041]** However, in other embodiments of the present invention (not illustrated), all the secondary chains $N_1$, $N_2$, ..., $N_H$ may comprise a same number of LED devices.

**[0042]** Preferably, the primary chain $M_1$ comprises a number of LED devices greater than that the number of LED devices of each of the first and second secondary chains $N_1$, $N_2$, ..., $N_H$.

**[0043]** The lighting module 1 furthermore comprises one or more switches S, each of which is electrically connected in series to the LED devices of one of the first and second secondary chains $N_1$, $N_2$, ..., $N_H$.

**[0044]** In practice, each switch S is inserted in one of the first and second secondary chains $N_1$, $N_2$, ..., $N_H$ and is electrically connected in series with the LED devices thereof.

**[0045]** According to the invention, the switches S regulate the flow of the supply current $I_{UPPLY}$, provided by the current generator 10, along a first and second lighting unit $C_1$, $C_2$.

**[0046]** The first lighting unit $C_1$ comprises the LED devices of the primary chain $M_1$ and the LED devices of the (one or more) first secondary chains (e.g. the secondary chain $N_1$) while the second lighting unit $C_2$ comprises the LED devices of the primary chain $M_1$ and the LED devices of the (one or more) second secondary chains (e.g. the secondary chains $N_2$, ..., $N_H$). From the above, it is apparent that the actual number of LED devices of each lighting unit basically depends on the adopted grouping of the secondary chains of LED devices.

**[0047]** The switches S can advantageously regulate the passage of a current along the lighting units $C_1$, $C_2$, said current varying between zero and a maximum value ($I_{SUPPLY}$) set by the current generator 10.

**[0048]** In other words, the switches permit/prevent the flow of the supply current $I_{SUPPLY}$ along the first lighting unit $C_1$ and along a second lighting unit $C_2$, in an alternate manner.

**[0049]** The switches S are thus capable to regulate the flow of the supply current $I_{UPPLY}$ along alternative paths, which develop between the terminals $B_1$ and $B_2$ of the lighting module and which involve the LED devices of the first and second lighting units $C_1$, $C_2$, respectively. Each of said paths identifies a different lighting unit $C_1$, $C_2$ that is therefore able to emit its own characteristic light radiation when the supply current passes therethrough.

**[0050]** The number of switches S may be equal or smaller than the number of secondary chains $N_1$, $N_2$, ..., $N_H$. In other words, the switches S may be inserted in all or in some of the secondary chains of the lighting module 1.

**[0051]** The switches S can consist, for example, of a simple MOSFET or BJT transistors.

**[0052]** In alternative forms of the present invention, a more complex current switching circuits can be used.

**[0053]** Preferably, the electronic switches S are operatively combined with electronic control means (not illustrated) able to provide control signals in current or in voltage, for example a signal of the square wave type with duty-cycle adjustable by means of a PWM type adjustment system. In order to ensure the alternate activation of the lighting units $C_1$, $C_2$, the switches S electrically connected to the first secondary chains (first lighting unit $C_1$) are controlled by a common first control signal $V_{G1}$ while the switches S electrically connected to the second secondary chains (second lighting unit $C_2$) are controlled by a common second control signal $V_{G2}$.

**[0054]** Preferably, the LED devices of the primary chain $M_1$ and secondary chains $N_1$, $N_2$, ..., $N_H$ are selected so that the LED devices, comprised in each of the above-mentioned lighting units, have complementary emission spectra, i.e. spectra having emission peaks at different sided wavelength ranges.

**[0055]** For example, the primary chain $M_1$ can be provided with LED devices with emission peaks in the blue and yellow wavelengths and the secondary chains of each of the lighting units $C_1$, $C_2$ can be provided with LED devices with emission peaks in the green and red wavelengths.

**[0056]** In this way, the spectrum of the radiation emitted by each lighting unit can be advantageously modulated so as to get as close as possible to the trend of the emission spectrum of a black body.

**[0057]** This allows the colour rendering index of the light radiation emitted by the lighting module 1 to be maintained constantly high (greater than 90 Ra), whichever lighting unit is active in a given operating condition.

**[0058]** Preferably, the LED devices of the primary chain $M_1$ and the first and second secondary chains $N_1$, $N_2$, ..., $N_H$ are selected so that the lighting module 1 emits a light radiation with a different colour temperature when the supply current $I_{UPPLY}$ passes along each of the above-mentioned lighting units $C_1$, $C_2$.

**[0059]** In this way, the switches S are able to modulate the colour temperature of the light radiation emitted by selectively regulating the flow of the supply current $I_{SUPPLY}$ along the different lighting units $C_1$, $C_2$.

**[0060]** Preferably, the LED devices of the primary chain $M_1$ and the LED devices of the first and second secondary chains $N_1$, $N_2$, ..., $N_H$ are selected so that the lighting module 1 emits a light radiation with constant light flux when the supply current $I_{SUPPLY}$ passes along each of the above-mentioned lighting units $C_1$, $C_2$.

**[0061]** This ensures that, in all operating conditions, the lighting module 1 emits a substantially uniform light flux.

**[0062]** Preferably, the LED devices comprised in the lighting module 1 are solid-state devices based on properly chosen semiconductor materials or compounds, according to the needs.

**[0063]** In a preferred embodiment of the present invention, the lighting module 1 comprises a single primary chain $M_1$ of LED devices, a single first secondary chain $N_1$ and single second secondary chain $N_2$ (figures 2-3).

**[0064]** The primary chain $M_1$ is electrically connected in series to the current generator 10 while the first and second secondary chains $N_1$, $N_2$ are connected in parallel to one another and in series to the current generator 10 and to the primary chain $M_1$.

**[0065]** The secondary chains $N_1$, $N_2$ comprise a different number of LED devices with respect to the primary chain $M_1$, preferably a lower number of LED devices.

**[0066]** The lighting module 1 furthermore comprises a single electronic switch S, electrically connected in series with one of the secondary chains $N_1$, $N_2$ (e.g. the secondary chain $N_2$).

**[0067]** The electronic switch S advantageously allows/prevents, in an alternate manner, the flow of the supply current $I_{SUPPLY}$, provided by the current generator 10, along a first lighting unit $C_1$, which comprises the LED devices of the primary chain $M_1$ and of the first secondary chain $N_1$, and along a second lighting unit $C_2$, which comprises the LED devices of the primary chain $M_1$ and of the second secondary chain $N_2$.

**[0068]** In other words, the electronic switch S controls the flow of the supply current $I_{SUPPLY}$ so that it flows, in an alternate manner, through the lighting units $C_1$ or $C_2$.

**[0069]** Preferably, the first secondary chain $N_1$ comprises $P_1$ LED devices and the second secondary chain $N_2$ comprises $P_2$ LED devices, where $P_1$ is a number greater than $P_2$.

**[0070]** To reduce the costs and overall dimensions of the lighting module 1, the number of LED devices in the secondary chains $N_1$, $N_2$ are selected to ensure the relation $P_1 = P_2+1$.

**[0071]** Said solution is furthermore expedient as it reduces the fluctuations in voltage perceived by the current generator 10, when the supply current $I_{SUPPLY}$ is addressed from one lighting unit to another.

**[0072]** Preferably, the electronic switch S consists of a MOSFET transistor, having drain and source terminals connected in series with the LED devices of the second secondary chain $N_2$ and the gate terminal connected to appropriate control means (not illustrated).

**[0073]** The switch S is advantageously driven in a conducting state (ON) or in an interdicting state (OFF) by a voltage signal $V_G$ of the square wave type, applied to the gate terminal. Advantageously, the drive signal $V_G$ has an adjustable duty-cycle, for example by PWM type adjustment.

**[0074]** In this way, the switch S does not require a control circuit specifically designed for the purpose, since the switch S could be connected to PWM modulation (dimming) systems already present, as happens in numerous lighting plants and systems.

**[0075]** Thanks to the PWM regulation, furthermore, the switch S dissipates a negligible electrical power, not compromising the efficiency of the system.

**[0076]** Preferably, decoupling means 15 (such an opto-insulator) are electrically connected between the switch S and the control means thereof, so as to electrically decouple the ground terminal(s) of the switch S from the ground terminal(s) of said control means.

**[0077]** Preferably, in the embodiment of figure 2, the LED devices of the primary chain $M_1$ and secondary chains $N_1$, $N_2$ are selected so that the lighting module 1 emits a light radiation with a first colour temperature $T_1$ when the supply current $I_{SUPPLY}$ passes along the first lighting unit $C_1$, and a light radiation with a second colour temperature $T_2$, different from $T_1$, when the supply current $I_{SUPPLY}$ passes along the second lighting unit $C_2$.

**[0078]** In particular, the LED devices of the primary chain $M_1$ and secondary chains $N_1$, $N_2$ are selected so that the first colour temperature $T_1$ is below the second colour temperature $T_2$.

**[0079]** By properly controlling the switch S, it is thus possible to guarantee that the lighting module provides a colour temperature of the resulting light within the range T1-T2.

**[0080]** The LED devices of the primary chain $M_1$ and secondary chains $N_1$, $N_2$ are selected so that the colour rendering index is higher than 90 when the chains $N_1$ and $N_2$ are alternatively switched on.

**[0081]** This allows a colour rendering index greater than or equal to 90 to be guaranteed in all operating conditions.

**[0082]** Operation of the lighting module 1, in the embodiment of figures 2-3, is now described in further detail.

**[0083]** When the electronic switch is in the interdiction state (OFF), corresponding to a signal $V_G$ at "low" logic level, all passage of current along the second secondary chain $N_2$ is prevented. The supply current $I_{SUPPLY}$ is thus forced to pass along the first lighting unit $C_1$, i.e. along a path that comprises the LED devices of the primary chain $M_1$ and the first secondary chain $N_1$.

**[0084]** In this condition, the lighting module 1 emits the light radiation generated by the first lighting unit $C_1$.

**[0085]** When the electronic switch S is in the conducting state (ON), corresponding to a "high" logic level signal $V_G$, current flow is theoretically allowed along both secondary chains $N_1$, $N_2$.

**[0086]** Since the second secondary chain $N_2$ has a lower number of LED devices compared to the first secondary chain $N_1$, the voltage drop induced at its ends by the supply current $I_{SUPPLY}$ is lower than the one induced at the ends of the first secondary chain $N_1$ and in any case not sufficient to set the LED devices of the latter to the conducting state.

**[0087]** The supply current $I_{SUPPLY}$, which runs through the primary chain $M_1$, is thus forced to flow through the second secondary chain $N_2$.

**[0088]** The supply current $I_{SUPPLY}$ therefore passes along the second lighting unit $C_2$, i.e. along a path that comprises the LED devices of the primary chain $M_1$ and of the second secondary chain $N_2$.

**[0089]** In this condition, the lighting module 1 emits the light radiation generated by the second lighting unit $C_2$.

**[0090]** By modulating the operating status of the electronic switch S with an appropriate drive signal $V_G$, it is possible to obtain a mixture of the light emitted by the two lighting units $C_1$ and $C_2$ over time.

**[0091]** If the frequency of the signal $V_G$ is high enough (>100 Hz), the human eye, due to the phenomenon of persistence of vision, perceives a light stimulus mediated between the light radiations emitted by the two lighting units $C_1$ and $C_2$ over time.

**[0092]** By modulating the status of the electronic switch S with an appropriate drive signal $V_G$, the colour temperature of the light radiation emitted by the lighting module 1 can be advantageously modulated over time.

**[0093]** For a certain duty-cycle value of the drive signal $V_G$, the radiation emitted by the lighting module 1 is thus characterised by a corresponding colour temperature value in the range T1-T2.

**[0094]** The colour temperature of the light radiation emitted by the lighting module 1 can thus be modulated in a simple effective manner, by adjustment of the duty-cycle of the signal $V_G$, for example using open chain control means.

EXAMPLE

**[0095]** An example of practical embodiment of the lighting module 1 is now described below, in the embodiment of figures 2-3.

**[0096]** In such an embodiment example, the primary chain $M_1$ of the lighting module 1 was produced by using 24 LED devices, connected in series.

**[0097]** In particular, 22 LED devices were used able to emit white light with colour temperature equal to 2700K, one LED device able to emit blue light, with emission peak at a wavelength between 460 nm and 480 nm, and one LED device able to emit green light, with emission peak at a wavelength between 520 nm and 530 nm.

**[0098]** The first secondary chain $N_1$ of the lighting module 1 comprises 8 LED devices, connected in series, with emission wavelength between 450 nm and 550 nm.

**[0099]** In particular, 1 LED device was used able to emit blue light, with emission peak at a wavelength between 460 nm and 480 nm, 2 LED devices able to emit royal blue light, with emission peak at a wavelength between 450 nm and 460 nm and 5 LED devices able to emit green light, with emission peak at a wavelength between 520 nm and 530 nm.

**[0100]** The secondary second chain $N_2$ of the lighting module 1 was produced using 5 LED devices, connected in series.

**[0101]** In particular, 4 LED devices capable to emit white light with colour temperature equal to 2700 K and 1 LED device capable to emit red light, with emission peak at a wavelength between 600 nm and 650 nm were used.

**[0102]** For the switch S, a type N MOSFET depletion transistor was used.

**[0103]** The experimental measurements performed on the light radiation emitted by the lighting module 1 during passage of the supply current $I_{SUPPLY}$ along each of the lighting units $C_1$ and $C_2$ gave the following results (supply current $I_{SUPPLY}$ = 350mA):

| Lighting unit | Colour temperature (K) | Colour rendering index (Ra) | Flux (lumen) | Chromatic coordinate X | Chromatic coordinate Y |
|---|---|---|---|---|---|
| $C_1$ | 5329K | 93 | 2474 | 0.34 | 0.345 |
| $C_2$ | 2796K | 93 | 2255 | 0.45 | 0.40 |

**[0104]** The emission spectra of the light radiation emitted by the lighting module 1, during passage of the supply current $I_{SUPPLY}$ along each of the lighting units $C_1$ and $C_2$, are illustrated in figure 4. Modulation of the chromatic characteristics of the light radiation emitted by the lighting module 1 was performed by controlling the electronic switch S with a drive signal $V_G$ with amplitude of 10V, frequency 4kHz and duty-cycle varying between 0 and 100%.

**[0105]** During said modulation, the drive current $I_{SUPPLY}$ was maintained at a constant value of 350mA.

**[0106]** The results of the photometric measurements performed on the light radiation emitted by the lighting module 1, during modulation, are shown in figures 5-8.

**[0107]** The following is highlighted:

- the colour temperature of the light radiation emitted can vary throughout the range between 2800K and 5300K, showing a gradual variation of the colour temperature when the duty-cycle varies;
- the colour rendering index is constantly greater than the value of 93. For a duty cycle values between 20% and 70%, the colour rendering index exceeds the value of 95;
- the light flux undergoes relatively few variations when the duty-cycle varies (the light flux measured is equal to 2360 lumen +/- 5%);
- the locus of the points of the light radiation emitted at the various colour temperatures, in the CIE 1931 chromaticity diagram, differs only very slightly from the Planckian black body emission curve. This indicates an optimal chromatic quality of the light radiation emitted.

**[0108]** It has been seen in practice that the connection device 1, according to the invention, solves the drawbacks described in the known art, achieving the set objects.

**[0109]** The lighting module 1 allows the chromatic characteristics of the light radiation emitted to be varied in a simple effective manner.

**[0110]** In particular, it allows variation of the colour temperature over a very wide range of values, while substantially maintaining the light flux and the colour rendering index constant, the latter at a relatively high level (always greater than 90 Ra).

**[0111]** The lighting module 1 therefore falls into class 1A for lighting devices, according to the classification of the UNI 10380 standard.

**[0112]** The lighting module 1 allows variation of the chromatic characteristics of the light radiation emitted using a relatively low number of LED devices and one single very cheap and compact current regulation device.

**[0113]** The lighting module 1 thus has a relatively simple compact overall structure, which is easy to produce at industrial level with relatively low industrial costs.

## Claims

1. A LED lighting module (1) **characterised in that** it comprises:

   - a primary chain ($M_1$) of LED devices, which is electrically connected in series to a current generator (10) that provides a supply current ($I_{SUPPLY}$);
   - one or more first and second secondary chains ($N_1$, $N_2$, $N_H$) of LED devices electrically connected in parallel to one another and electrically connected in series to said current generator (10) and to said primary chain ($M_1$);
   - one or more electronic switches (S), each of which is electrically connected in series with the LED devices of one of said first and second secondary chains ($N_1$, $N_2$, $N_H$), said electronic switches permitting/preventing, in an alternate manner, the flow of said supply current ($I_{SUPPLY}$) along a first lighting unit ($C_1$), which comprises the LED devices of said primary chain ($M_1$) and the LED devices of said first secondary chains ($N_1$), and along a second lighting unit ($C_2$), which comprises the LED devices of said primary chain ($M_1$) and the LED devices of said second secondary chains ($N_2$, $N_H$).

2. A lighting module, as claimed in claim 1, **characterised in that** the LED devices comprised in each of said first and second lighting units ($C_1$, $C_2$) have complementary emission spectra.

3. A lighting module, as claimed in one or more of the preceding claims, **characterised in that** the LED devices of said primary and secondary chains are selected so that said lighting module emits a light radiation with a different colour temperature ($T_1$, $T_2$) when said supply current ($I_{SUPPLY}$) passes along each of said first and second lighting units ($C_1$, $C_2$).

4. A lighting module, as claimed in one or more of the preceding claims, **characterised in that** the LED devices of said primary and secondary chains are selected so that said lighting module emits a light radiation with constant light flux when said supply current ($I_{SUPPLY}$) passes along each of said first and second lighting units ($C_1$, $C_2$).

5. A lighting module, as claimed in one or more of the preceding claims, **characterised in that** it comprises:

   - a primary chain ($M_1$) of LED devices, connected in series to said current generator (10);
   - a first secondary chain ($N_1$) and a second secondary chain ($N_2$) of LED devices, electrically connected in parallel to one another and electrically connected in series to said current generator (10) and to said primary chain ($M_1$), said first and second secondary chains ($N_1$, $N_2$) comprising a different number of LED devices;
   - an electronic switch (S), electrically connected in series with the LED devices of one of said first and second secondary chains ($N_1$, $N_2$), said electronic switch permitting/preventing, in an alternate manner, the flow of said supply current ($I_{SUPPLY}$) along a first lighting unit ($C_1$), which comprises the LED devices of said primary chain ($M_1$) and the LED devices of said first secondary chain ($N_1$), and along a second lighting unit ($C_2$), which comprises the LED devices of said primary chain ($M_1$) and the LED devices of said second secondary chain ($N_2$).

6. A lighting module, as claimed in claim 5, **characterised in that** said first secondary chain ($N_1$) comprises $P_1$ LED devices and said second secondary chain ($N_2$) comprises $P_2$ LED devices, where $P_1$ is a positive number greater than $P_2$.

7. A lighting module, as claimed in claim 6, **characterised in that** said first secondary chain ($N_1$) comprises $P_1$ LED devices and said second secondary chain ($N_2$) comprises $P_2$ LED devices, with $P_1 = P_2 + 1$.

8. A lighting module, as claimed in one or more of the claims from 5 to 7, **characterised in that** said electronic switch (S) is electrically connected in series to the LED devices of said second secondary chain ($N_2$).

9. A lighting module, as claimed in one or more of the claims from 5 to 8, **characterised in that** it emits a light radiation with a first colour temperature ($T_1$) when said supply current ($I_{SUPPLY}$) passes along said first lighting unit ($C_1$), and a light radiation with a second colour temperature ($T_2$) when said supply current ($I_{SUPPLY}$) passes along said second lighting unit ($C_2$), said first colour temperature ($T_1$) being higher than said second colour temperature ($T_2$).

**10.** A lighting body or device **characterised in that** it comprises a lighting module (1), as claimed in one or more of the preceding claims.

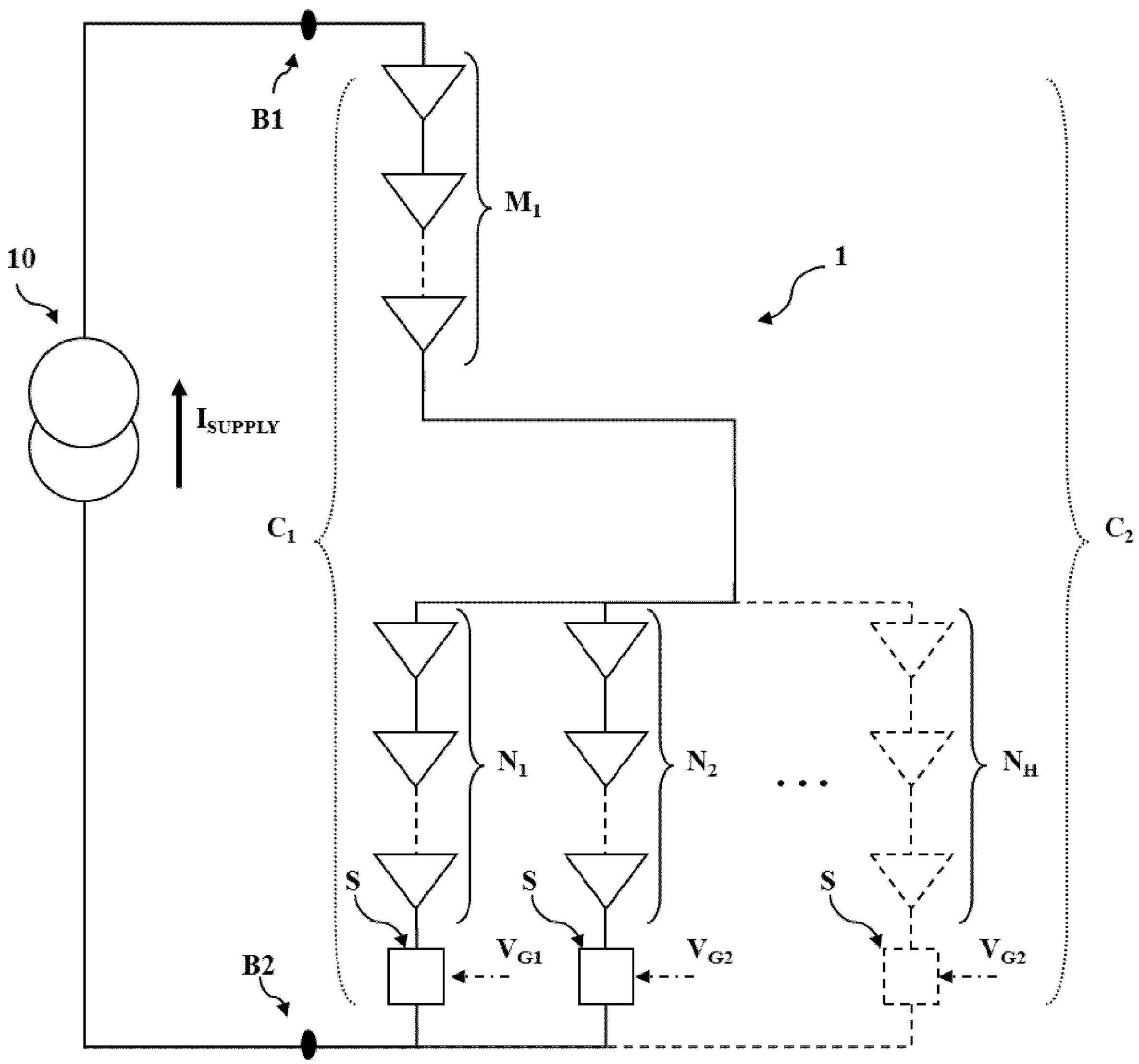


FIG. 1

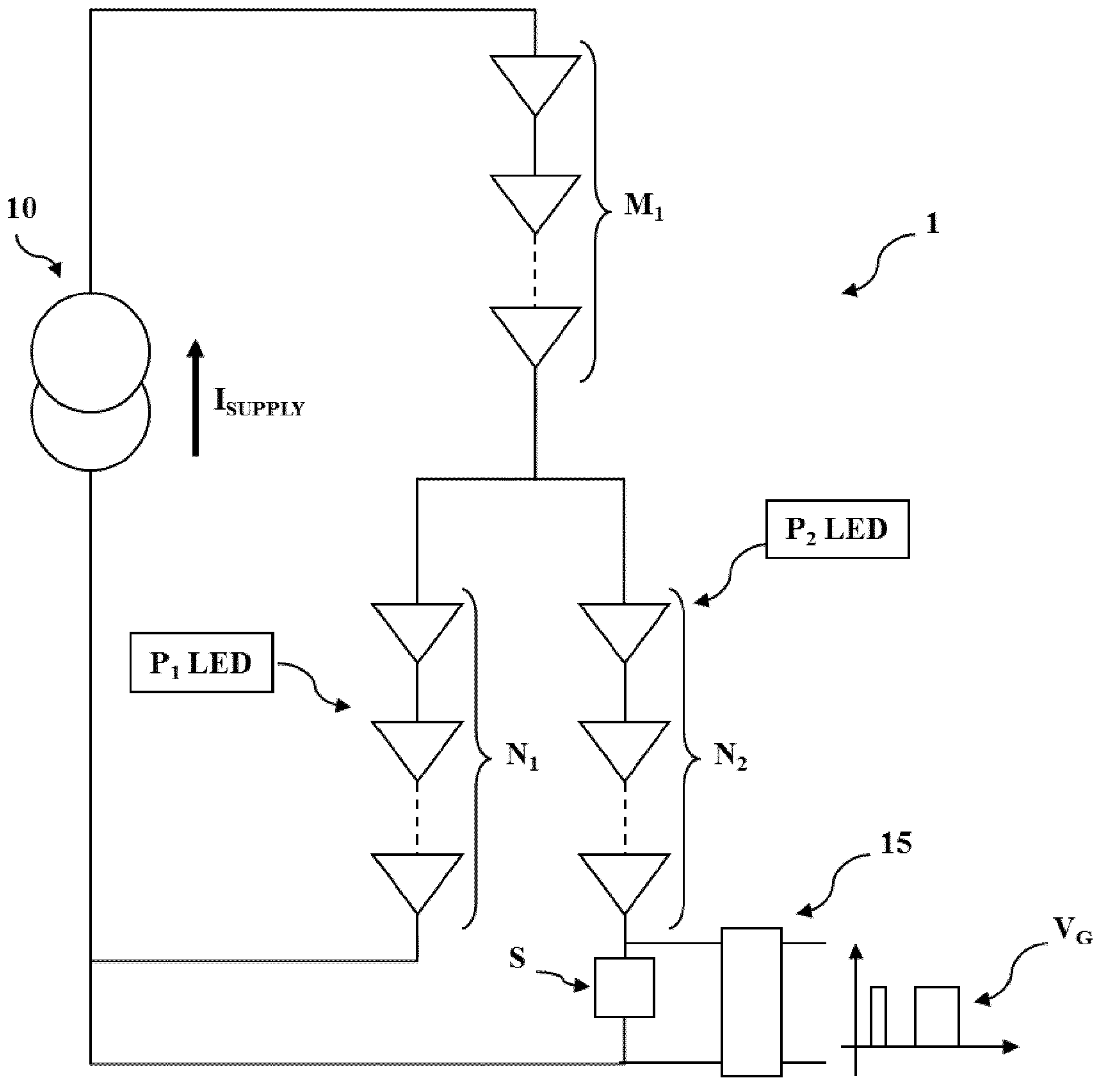


FIG. 2

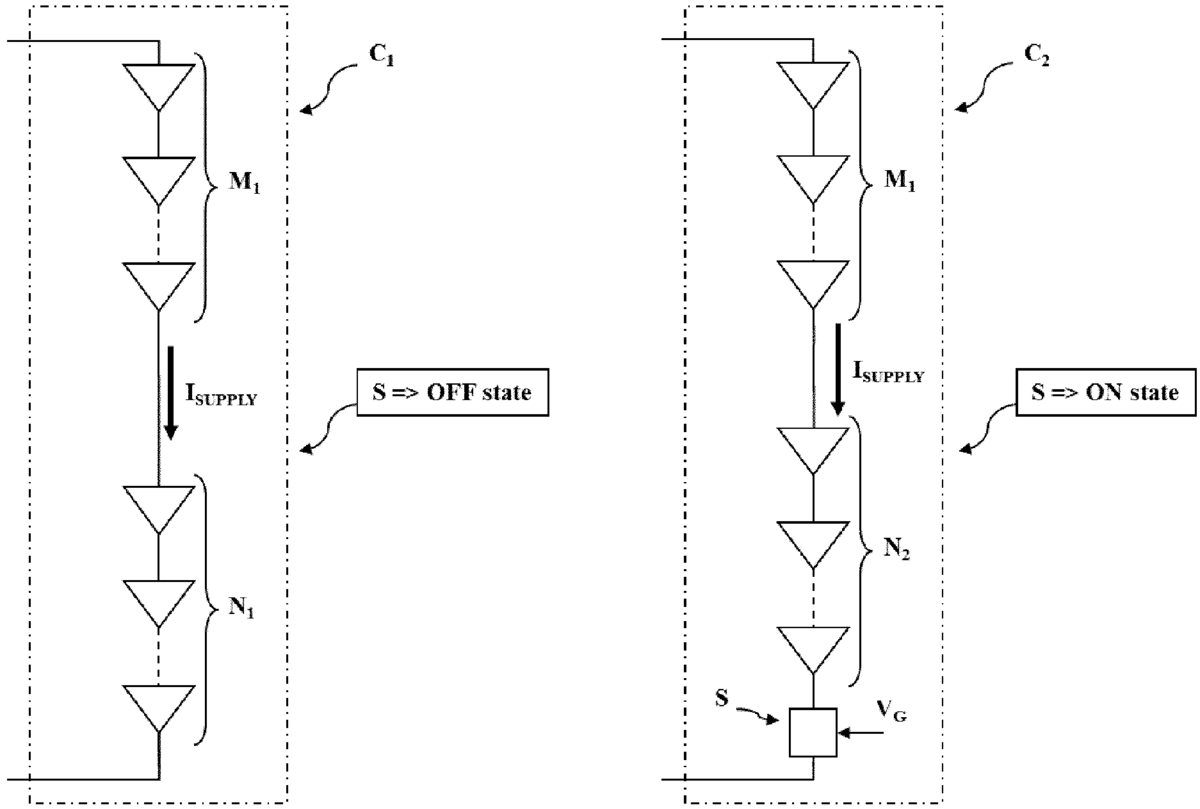


FIG. 3

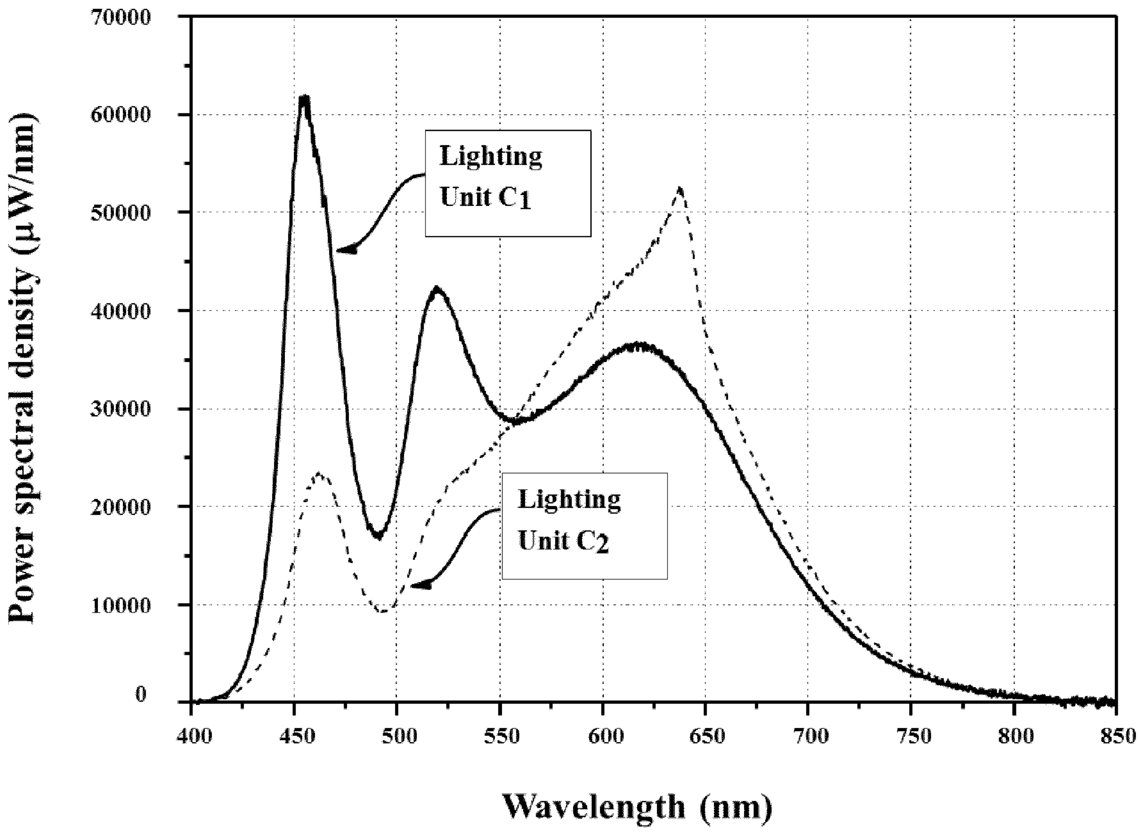
Power spectral density (μW/nm)
70000
60000
50000
40000
30000
20000
10000
0
400
450
500
550
600
650
700
750
800
850
Wavelength (nm)
Lighting Unit C1
Lighting Unit C2

FIG. 4

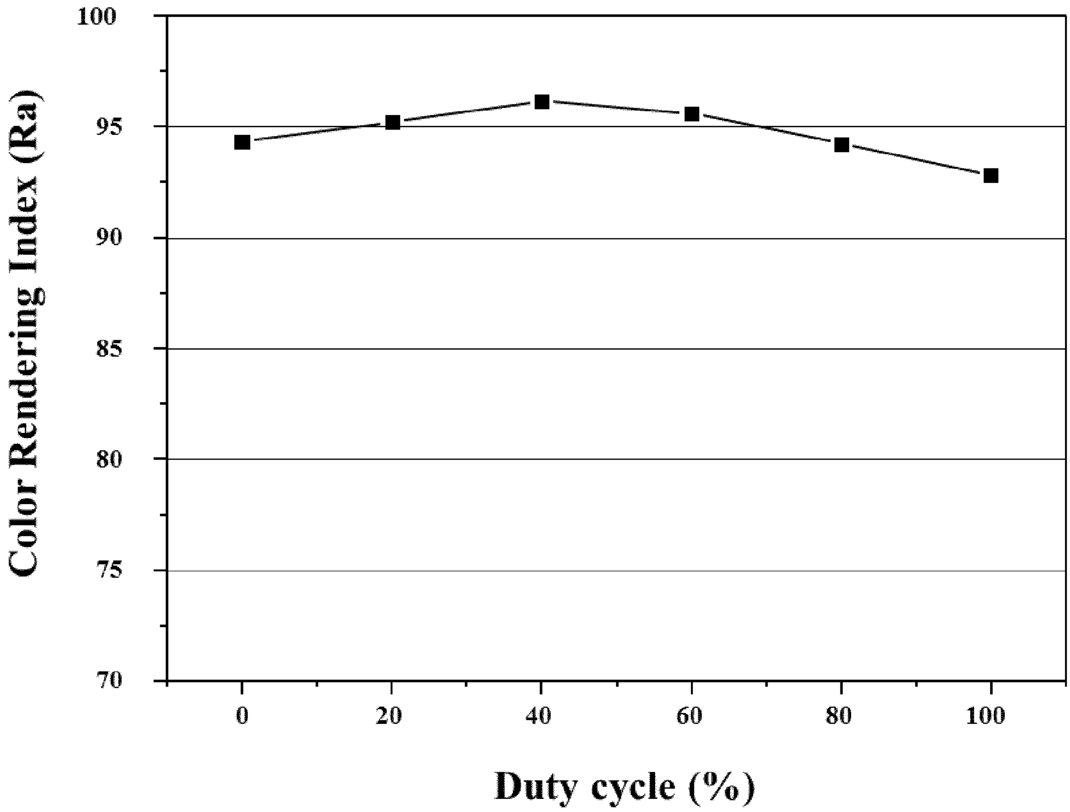
100
95
90
85
80
75
70
Color Rendering Index (Ra)
0
20
40
60
80
100
Duty cycle (%)

FIG. 5

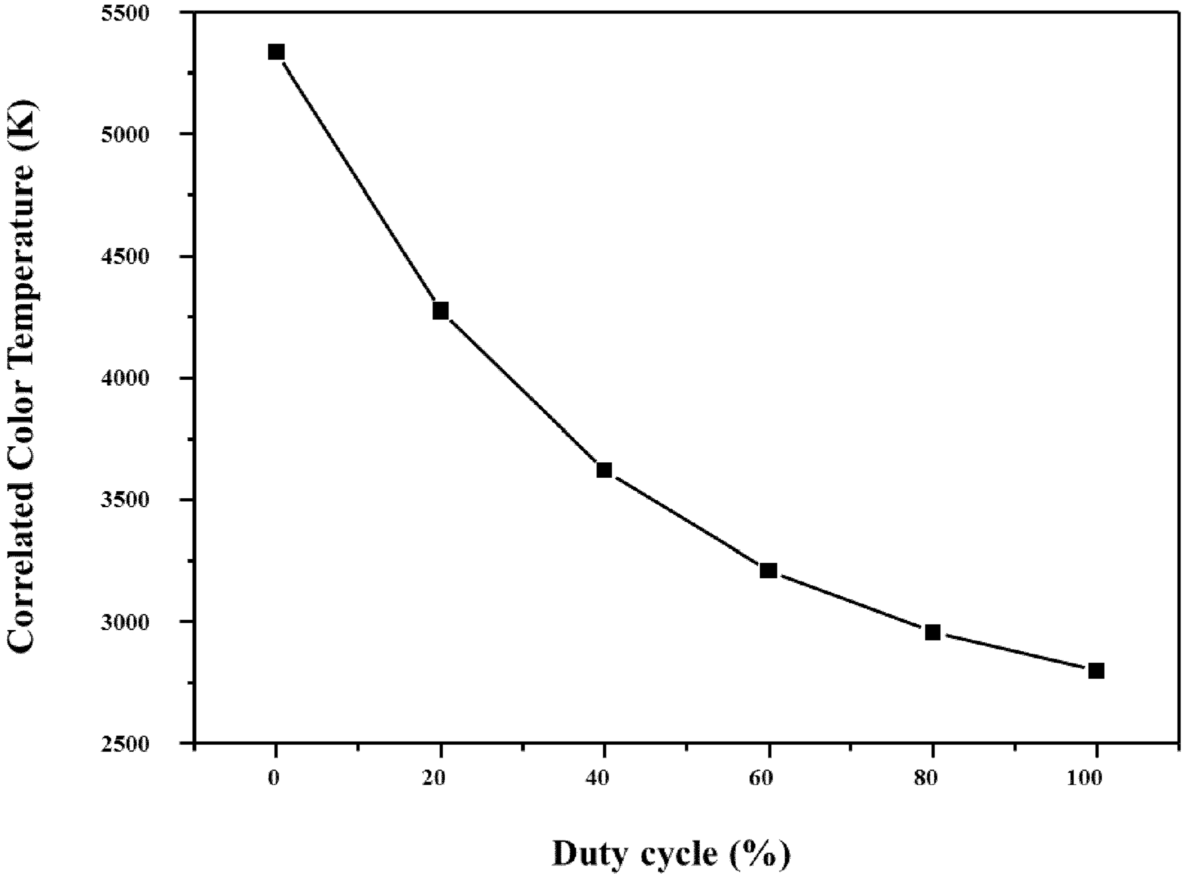
5500
5000
4500
4000
3500
3000
2500
Correlated Color Temperature (K)
0
20
40
60
80
100
Duty cycle (%)

FIG. 6

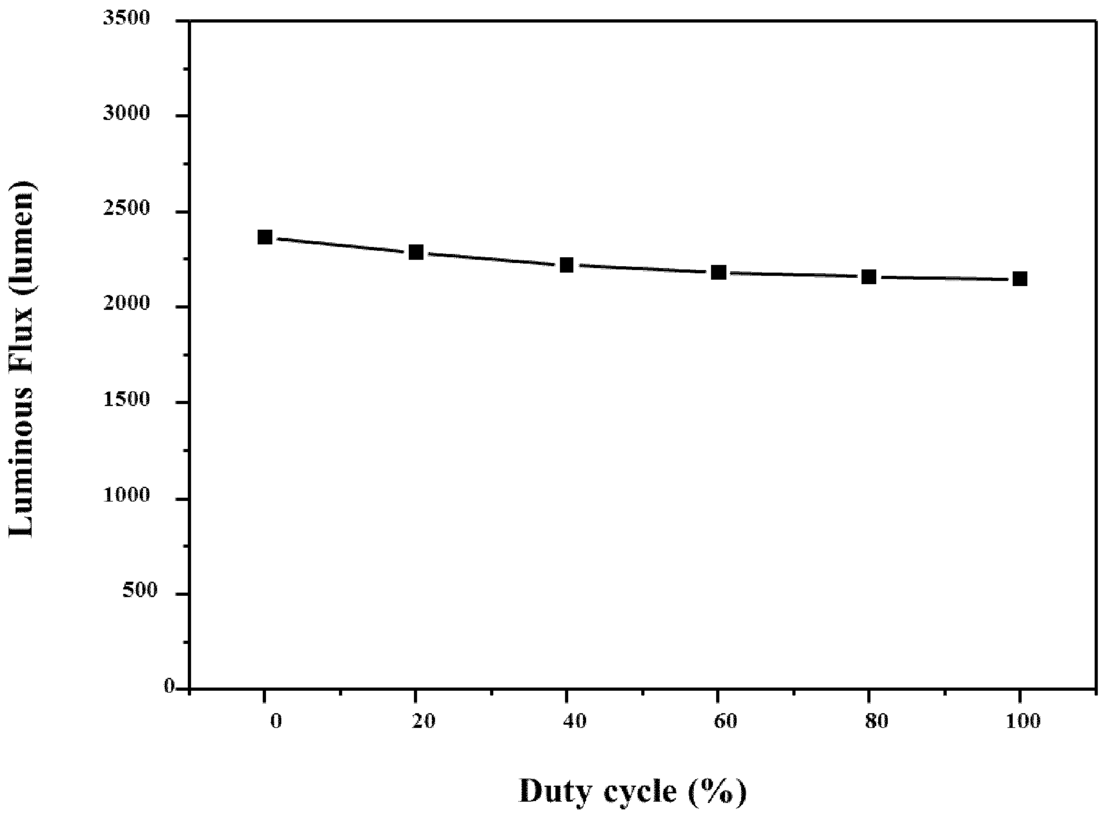
3500
3000
2500
2000
1500
1000
500
0
Luminous Flux (lumen)
0
20
40
60
80
100
Duty cycle (%)

FIG. 7

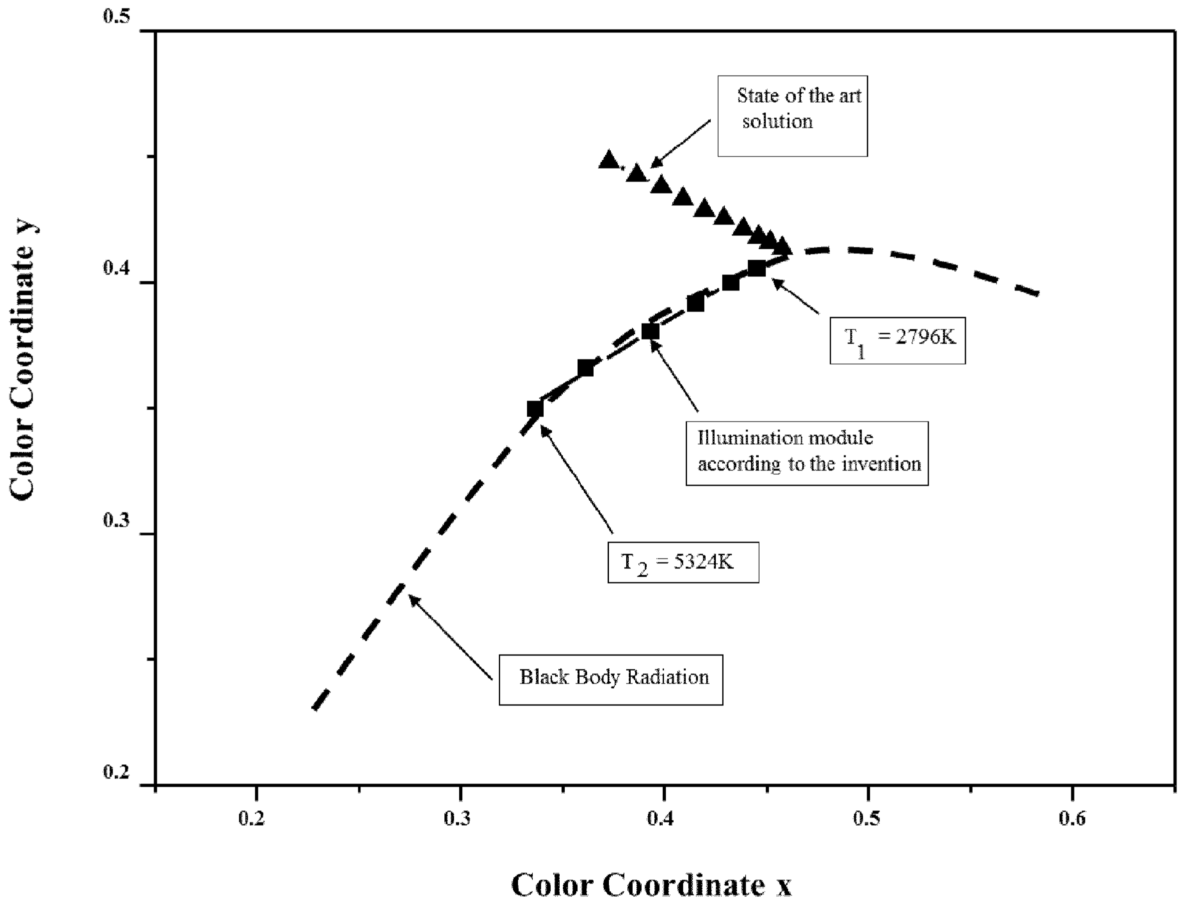
0.5
0.4
0.3
0.2
Color Coordinate y
0.2
0.3
0.4
0.5
0.6
Color Coordinate x
State of the art solution
T1 = 2796K
Illumination module according to the invention
T2 = 5324K
Black Body Radiation

**FIG. 8**

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# EUROPEAN SEARCH REPORT

Application Number
EP 13 15 1395

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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| Place of search | Date of completion of the search | Examiner |
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| The Hague | 31 May 2013 | João Carlos Silva |

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