Claim No: HP-2016-000046

# IN THE HIGH COURT OF JUSTICE CHANCERY DIVISION PATENTS COURT

**BETWEEN**:

### (1) PHILIPS LIGHTING NORTH AMERICA CORPORATION (a company incorporated under the laws of the USA)

# (2) PHILIPS LIGHTING HOLDING B.V. (a company incorporated under the laws of the Netherlands)

Claimants

-and-

### (1) MEGAMAN (UK) LIMITED

### (2) NEONLITE INTERNATIONAL LIMITED

# (3) NEONLITE ELECTRONIC & LIGHTING (HK) LIMITED (a company incorporated under the laws of Hong Kong)

### **Defendants**

# ANNEX B – SCHEDULE OF AMENDMENTS OF THE FIRST REQUEST

The proposed conditional amendments to European Patent (UK) No. 2 407 009 (the "Patent") of the First Request are as follows:-

Old	New	Conditional Amendment
Claim	Claim	
1	1	Lighting device (100), comprising:
		an LED driver (101) capable of receiving an input mains voltage
		and acting as a current source to convert the input mains voltage so as to
		generatinge dimmed LED current suitable for driving an LED array
		consisting of LEDs;

	a two-terminal LED module (110; 300; 400; 500; 600), having two
	input terminals (111, 112) for receiving the dimmed LED current as an
	input current (Iin) from the LED driver (101) and comprising:
	a first LED group (113) comprising at least one first type LED for
	producing light having a first color temperature;
	a second LED group (114) comprising at least one second type LED
	for producing light having a second color temperature different from the
	first color temperature;
	wherein the module is capable of supplying LED currents to the
	LED groups, these LED currents being derived from the input current
	(Iin);
	wherein the LED module produces a light output having at least
	light output contributions from the first LED group (113) and from th
	second LED group (114);
	and wherein the module is designed to vary the individual LEI
	currents in the individual LED groups in dependency of the averag
	magnitude of the received input current (Iin), such that the color point of
	the light output of the module varies as a function of the input currer
	magnitude; and
	characterized in that wherein the LED module comprises a
	electronic division circuit (115) capable of controlling a ratio of the LEI
	currents (I1, I2) in said first and second LED groups (113, 114) as
	function of the input current level received at the input of the LEI
	module.
2	Lighting device according to claim 1, wherein the LED module
	designed to vary the individual LED currents in the individual LEI
	groups such that the color point of the light output of the module of
	dimming follows a black body curve.
3	Lighting device according to claim 1, wherein the LED module
	designed to vary the individual LED currents in the individual LED
	groups such that the color behavior of the light output of the module of
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4	4	Lighting device according to claim 1, wherein the lighting device is
		configured to produce light with a color temperature CT at an average
		current of x%, $CT(x\%)$ , supplied to the terminals following the
		relationship:
		CT (x%) = CT(100%)*(x/100)1/9.5
5	5	Lighting device according to claim 1, wherein the first group of
		LEDs has a varying first luminous flux output as a function of junction
		temperature of the first type LED, and the second group of LEDs has a
		varying second luminous flux output as a function of junction temperature
		of the second type LED, and wherein, at varying junction temperatures,
		the ratio of the first luminous flux output to the second luminous flux
		output varies;
		and wherein the first color temperature is lower than the second
		color temperature, while, at decreasing junction temperatures, the ratio of
		the first luminous flux output to the second luminous flux output
		increases, and vice versa.
6	6	Lighting device according to claim 1, wherein a gradient of the first
		luminous flux output as a function of junction temperature of the first type
		LED differs from a gradient of the second luminous flux output as a
		function of junction temperature of the second type LED;
		and wherein the first color temperature is lower than the second
		color temperature, while the absolute value of the gradient of the first
		luminous flux output as a function of temperature of the first type LED is
		higher than the gradient of the second luminous flux output as a function
		of temperature of the second type LED.
7	7	Lighting device according to claim 1, wherein a thermal resistance
		to ambient of the first group of LEDs differs from the thermal resistance
		to ambient of the second group of LEDs;
		and wherein the first color temperature is lower than the second
		color temperature, while the thermal resistance to ambient of the first
		group of LEDs is higher than the thermal resistance to ambient of the
		second group of LEDs.

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8	8	Lighting device according to claim 1, wherein the first group of
		LEDs has a first dynamic electrical resistance, and the second group of
		LEDs has a second dynamic electrical resistance.
9	9	Lighting device according to claim 1, comprising:
		an LED driver (101) capable of generating dimmed LED current;
		and
		a two-terminal LED module (110; 300; 400; 500; 600), having two
		input terminals (111, 112) for receiving the dimmed LED current as an
		input current (Iin) from the LED driver (101) and comprising:
		a first LED group (113) comprising at least one first type LED for
		producing light having a first color temperature;
		a second LED group (114) comprising at least one second type LED
		for producing light having a second color temperature different from the
		first color temperature;
		wherein the module is capable of supplying LED currents to the
		LED groups, these LED currents being derived from the input current
		<u>(Iin):</u>
		wherein the LED module produces a light output having at least a
		light output contributions from the first LED group (113) and from th
		second LED group (114);
		wherein the module is designed to vary the individual LED current
		in the individual LED groups in dependency of the average magnitude of
		the received input current (Iin), such that the color point of the light output
		of the module varies as a function of the input current magnitude;
		wherein the LED module comprises an electronic division circu
		(115) capable of controlling a ratio of the LED currents (I1, I2) in sai
		first and second LED groups (113, 114) as a function of the input currer
		level received at the input of the LED module; and
		wherein at least one of the first group of LEDs and the second grou
		of LEDs is connected in series with a resistor, and wherein this first series
		arrangement is connected in parallel to the other one of the first group of

		arrangement is connected between the two input terminals (111, 112) of
		the LED module <del>;</del> .
		and wherein the resistor is a negative temperature coefficient, NTC,
		type resistor.
	10	Lighting device according to claim 9,
	10	wherein the other one of the first group of LEDs and the second
		group of LEDs is comprised in a second series arrangement;
		the first series arrangement in said parallel arrangement has a first
		dynamic electrical resistance and the second series arrangement has a
		second dynamic electrical resistance; and
- C		
	2	the first dynamic electrical resistance is different from the second
	11	dynamic electrical resistance.
	- <u>11</u>	Lighting device according to claim 9 or 10, wherein the LED
	10	module consists of LEDs and at least one resistor.
	<u>12</u>	Lighting device of claim 9, wherein the resistor is a negative
		temperature coefficient, NTC, type resistor.
<del>10</del>	<u>13</u>	Lighting device according to any of the preceding claims <u>1-9 or 12</u> .
	· ·	wherein the first type LED is an AlInGaP type LED, and/or wherein the
		second type LED is an In- GaN type LED.
11	14	Lighting device according to claim 1, wherein the electronic
		division circuit is capable of supplying the two groups of LEDs with
		constant current and of controlling the LED currents (I1, I2) such that the
2 <sup>10</sup>		following formulas apply:
	1	$I1 = p \cdot Iin \text{ and } I2 = q \cdot Iin, \text{ and } p + q = 1$
		with Iin denoting the input current magnitude,
		I1 denoting the current magnitude in the first group of LEDs,
		I2 denoting the current magnitude in the second group of LEDs;
		wherein there is at least a range of input current magnitudes where
		dp/d(Iin) is always positive and dq/d (Iin) is always negative.
12	<u>15</u>	dp/d(Iin) is always positive and dq/d (Iin) is always negative. Lighting device according to claim <u>1114</u> , wherein the LED module

LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module;			
another of said groups of LEDs;         a current sensing element (350) arranged for sensing the input current received at the input terminals of the LED module;         and a regulator driver (310) receiving a sense output signal from the sensing element and driving the current regulating element on the basis of this sense output signal.         13       16       Lighting device according to claim 1, wherein the electronic division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (lin) between the two groups of LEDs;         a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T;         a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module;         the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.         14       17       Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is d			a current regulating element (320) arranged in series with one of
a current sensing element (350) arranged for sensing the input current received at the input terminals of the LED module;         and a regulator driver (310) receiving a sense output signal from the sensing element and driving the current regulating element on the basis of this sense output signal.         13       16       Lighting device according to claim 1, wherein the electronic division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (lin) between the two groups of LEDs;         a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T;         a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module;         the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.         14       17       Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			said groups of LEDs, this series arrangement being coupled in parallel to
43       16       current received at the input terminals of the LED module;         43       16       Lighting device according to claim 1, wherein the electronic division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (lin) between the two groups of LEDs;         a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T;         a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module;         the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio 11/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.         14       17       Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			another of said groups of LEDs;
and a regulator driver (310) receiving a sense output signal from the sensing element and driving the current regulating element on the basis of this sense output signal.1316Lighting device according to claim 1, wherein the electronic division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (lin) between the two groups of LEDs; a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T; a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module; the control device being coupled to receive a sense output signal 			a current sensing element (350) arranged for sensing the input
43       16       Lighting device according to claim 1, wherein the electronic division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (lin) between the two groups of LEDs;			current received at the input terminals of the LED module;
1316Lighting device according to claim 1, wherein the electronic division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (Iin) between the two groups of LEDs; a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T; a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module; the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			and a regulator driver (310) receiving a sense output signal from the
13       16       Lighting device according to claim 1, wherein the electronic division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (Iin) between the two groups of LEDs;			sensing element and driving the current regulating element on the basis
division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (lin) between the two groups of LEDs; a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T; a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module; the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			of this sense output signal.
temporally dividing de received input current (Iin) between the two groups of LEDs; a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T; a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module; the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the	13	<u>16</u>	Lighting device according to claim 1, wherein the electronic
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a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T; a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module; the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			temporally dividing de received input current (Iin) between the two
period T such that the input current is passed on to the first group of LEDs for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T; a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module; the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			groups of LEDs;
1417141714171417151417151417141718191914111214131414141516171819110111112112113114115115115116117117118119119119110111111112113113114115115115116117117118119119119119119119119119119119119119119119119119119119119 <th></th> <th></th> <th>a control device (520) for controlling the switch (501) at a switching</th>			a control device (520) for controlling the switch (501) at a switching
group of LEDs for a second time duration t2, with t1+t2=T; a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module; the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			period T such that the input current is passed on to the first group of LEDs
a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module; the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio 11/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (Iin) is always negative.1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			for a first time duration t1 and the input current is passed on to the second
current received at the input terminals of the LED module;         the control device being coupled to receive a sense output signal         from the sensing element and being designed to vary the ratio t1/t2 of the         switching of the switch on the basis of said sense output signal, such that         there is at least a range of input current magnitudes where dt1(lin) is         always positive and dt2 (lin) is always negative.         14       17         Lighting device according to claim 1, wherein the second group of         LEDs (114) is supplied by a current converter (601) having its input         terminals connected in parallel to the first group of LEDs (113);         wherein the current converter comprises a control circuit (620)         receiving a sense output signal from a current sensing element (116)         sensing the input cur- rent of the LED module;         and wherein this control circuit (620) is designed to control the			group of LEDs for a second time duration t2, with t1+t2=T;
the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			a current sensing element (116) arranged for sensing the input
<ul> <li>from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(Iin) is always positive and dt2 (Iin) is always negative.</li> <li>Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the</li> </ul>			current received at the input terminals of the LED module;
<ul> <li>switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(lin) is always positive and dt2 (lin) is always negative.</li> <li>14 <u>17</u> Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the</li> </ul>			the control device being coupled to receive a sense output signal
1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			from the sensing element and being designed to vary the ratio t1/t2 of the
1417Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			switching of the switch on the basis of said sense output signal, such that
14       17       Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			there is at least a range of input current magnitudes where dt1(lin) is
LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			always positive and dt2 (Iin) is always negative.
terminals connected in parallel to the first group of LEDs (113); wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the	-14	<u>17</u>	Lighting device according to claim 1, wherein the second group of
wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			LEDs (114) is supplied by a current converter (601) having its input
receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			terminals connected in parallel to the first group of LEDs (113);
sensing the input cur- rent of the LED module; and wherein this control circuit (620) is designed to control the			wherein the current converter comprises a control circuit (620)
and wherein this control circuit (620) is designed to control the			receiving a sense output signal from a current sensing element (116)
			sensing the input cur- rent of the LED module;
current converter (601) on the basis of the sense output signal received			and wherein this control circuit (620) is designed to control the
			current converter (601) on the basis of the sense output signal received
from the current sensing element (116).			from the current sensing element (116).

15	<u>18</u>	Lighting device according to claim 1, wherein the first group of
		LEDs (113) is supplied by a first current converter (730) and the second
		group of LEDs (114) is supplied by a second current converter (740), and
		wherein these two current converter have their input terminals connected
		in series;
		wherein the LED module comprises a control circuit (720)
		receiving a sense output signal from a current sensing element (116)
-		sensing the input current of the LED module;
		and wherein this control circuit (720) is designed to control the
		current converters (730, 740) on the basis of the sense output signal
vi.		received from the current sensing element (116).
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		nendments to the Description of the Patent
Old	New	Conditional Amendment
Page	Page	
3	3	The device known from US 2006/0273331 receives an input voltage
		signal that carries power and a control signal. In the device, the control
		signal is taken from the input signal and transferred to the intelligent
		control device, that controls the individual current sources on the basis of
		the received control data. By changing the ratio between the respective
		light outputs, the relative contributions to the overall light output is
		changed and hence the overall color of the overall light output, as
		perceived by an observer, is changed. Such lighting device, therefore,
		requires a separate control input signal.
		In LED lighting devices, a behavior of the color temperature of the
		LED light can be obtained which, in dimming conditions, is similar to that
		of an incandescent lamp, but until now only at the expense of extensive
		current control, such as e.g. known from DE10230105. The necessity of
		adding controls to the LED lighting device for the desired color
		temperature behavior increases the number of components, increases the
		complexity of the lighting device, and increases costs. These effects are

undesirable. Further relevant prior art is described in US 2008/224631 and WO 2007/093927.

### SUMMARY OF THE INVENTION

The present invention aims to provide a LED circuit for such LED lighting device, and a LED lighting device comprising such LED circuit, wherein an intelligent control can be omitted and wherein a feedback sensor can be omitted.

It would be desirable to provide an LED lighting device having a color temperature behavior, when dimmed, resembling or approaching the color temperature behavior of an incandescent lamp, when dimmed. It would also be desirable to provide an LED lighting device having an incandescent lamp color temperature behavior, when dimmed, without the need of extensive controls.

To better address one or more of these concerns, in an aspect of the invention an LED lighting device is provided, comprising an LED driver capable of receiving an input mains voltage and acting as a current source to convert the input mains voltage so as to generatinge dimmed LED current suitable for diving an LED array consisting of LEDs; and a two-terminal LED module, having two input terminals for receiving the dimmed LED current as an input current from the LED driver. The LED module comprises a first LED group comprising at least one first type LED for producing light having a first color temperature, and a second LED group comprising at least one second type LED for producing light having a first color temperature. The LED module is capable of supplying LED currents to the LED groups, these LED currents being derived from the input current. The LED module produces a light output

4	4	having at least a light output contributions from the first LED group and
		from the second LED group. The LED module is designed to vary the
		individual LED currents in the individual LED groups in dependency of
		the average magnitude of the received input current, such that the color
		point of the light output of the module varies as a function of the input

current magnitude. The LED module comprises an electronic division circuit capable of controlling a ratio of the LED currents in said first and second LED groups as a function of the input current level received at the input of the LED module.

According to an aspect of the present invention, an LED lighting device comprises a single dimmable current source and an LED module receiving current from the current source. The LED module behaves as a load to the current source, similar to an array existing consisting of LEDs only. In embodiments, Wwithin the LED module, an electronic circuit senses the current magnitude of the input current, and distributes the current to different LED sections of the LED module on the basis of the sensed current magnitude. No intelligent current control is needed in the current source.

In an aspect of the invention an LED lighting device is provided, comprising a plurality of LEDs, and two terminals for supplying current to the lighting device. The lighting device comprise a first set of at least one LED of a first type producing light having a first color temperature, and a second color temperature different from the first color temperature. The first set and the second set aremay be connected in series or in parallel between the terminals.

In embodiments, **T**the lighting device is configured to produce light with a color point varying in accordance with a blackbody curve at a variation of an average current supplied to the terminals.

A color temperature behavior of an incandescent lamp may be described by the following relationship:

 $CT(x\%) = CT(100\%) * (x/100)^{\frac{1}{9.5}}$ 

where CT(100%) is the color temperature of the light at full power (100% current) of the lamp, CT(x%) is the color temperature of the light at x% dimming of the lamp (x% current, with  $0 \le x \le 100$ ).

4a	4a	In an embodiment, the first set has a varying first luminous flux
		output as a function of junction temperature of the LED of the first type,

and the second set has a varying second luminous flux output as a function of junction temperature of the LED of the second type, and wherein, at varying junction temperatures, the ratio of the first luminous flux output to the second luminous flux output varies. In particular, when the first color temperature is lower than the second color temperature, the lighting device is configured such that, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa. In such a configuration, e.g. having the first set connected in series with the second set, the first luminous flux output increases relative to the second flux output when the lighting device is dimmed, thereby producing light having a lower color temperature.

In an embodiment, the first set has a first dynamic electrical resistance, and the second set has a second dynamic electrical resistance. When e.g. the first set is connected in parallel with the second set, different luminous flux outputs of the first set and the second set result, which can be designed to produce light having a lower color temperature when dimmed.

- According to another aspect of the present invention, there is provided a lighting device comprising an LED driver capable of generating dimmed LED current; and a two-terminal LED module, having two input terminals for receiving the dimmed LED currentas an input current from the LED driver and comprising a first LED group comprising at least one first type LED for producing light having a first color temperature; a second LED group comprising at least one second type LED for producing light having a second color temperature different from the first color temperature; wherein the module is capable of supplying LED currents to the LED groups, these LED currents being derived from the input current; wherein the LED module produces a light output having at least a light output contributions from the first LED group and from the second LED group; and wherein the module is designed to vary the individual LED currents in the individual LED groups in dependency of the average magnitude of the received input current, such that the color point of the light output of the module varies as a function of the input current magnitude; wherein the LED module comprises an electronic division circuit capable of controlling a ratio of the LED currents in said first and second LED groups as a function of the input current level received at the input of the LED module; wherein one of the first group of LEDs and the second group of LEDs is connected in series with a resistor, and wherein this series arrangement is connected in parallel to the other one of the first group of LEDs and the

<u>4b</u>

second group of LEDs, and wherein this parallel arrangement is connected between the two input terminals of the LED module.

In another aspect of the present invention, a lighting kit of parts is provided, comprising a dimmer having input terminals adapted to be connected to an electrical power supply, and having output terminals adapted to provide a variable electrical power. An embodiment of the lighting device according to the present invention has terminals configured to be connected to the output terminals of the dimmer.

Further advantageous elaborations are mentioned in the dependent claims.

### BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects, features and advantages of the present invention will be further explained by the following description of one or more preferred embodiments with reference to the drawings, in which same reference numerals indicate same or similar parts, and in

Claim No: HP-2016-000046

# IN THE HIGH COURT OF JUSTICE CHANCERY DIVISION PATENTS COURT

**BETWEEN**:

# (1) PHILIPS LIGHTING NORTH AMERICA CORPORATION (a company incorporated under the laws of the USA)

## (2) PHILIPS LIGHTING HOLDING B.V. (a company incorporated under the laws of the Netherlands)

**Claimants** 

-and-

## (1) MEGAMAN (UK) LIMITED

### (2) NEONLITE INTERNATIONAL LIMITED

### (3) NEONLITE ELECTRONIC & LIGHTING (HK) LIMITED (a company incorporated under the laws of Hong Kong)

### Defendants

## ANNEX C - SCHEDULE OF AMENDMENTS OF THE SECOND REQUEST

The proposed conditional amendments to European Patent (UK) No. 2 407 009 (the "**Patent**") of the Second Request are as follows:-

Old	New	Conditional Amendment
Claim	Claim	
1	1	Lighting device (100), comprising:
		an LED driver (101) capable of receiving an input mains voltag
		and acting as a current source to convert the input mains voltage so as t
		generatinge dimmed LED current suitable for driving an LED arra
		consisting of LEDs;

	a two-terminal LED module (110; 300; 400; 500; 600) for replacing
	the LED array, the two-terminal LED module having two input terminals
(	(111, 112) for receiving an input current (Iin) from the LED driver (101)
	and comprising:
-	a first LED group (113) comprising at least one first type LED for
	producing light having a first color temperature;
	a second LED group (114) comprising at least one second type LED
-	for producing light having a second color temperature different from the
	first color temperature;
	wherein the module is capable of supplying LED currents to the
	LED groups, these LED currents being derived from the input current
	(Iin);
	wherein the LED module produces a light output having at least a
	light output contributions from the first LED group (113) and from the
	second LED group (114);
	and wherein the module is designed to vary the individual LED
-	currents in the individual LED groups in dependency of the average
	magnitude of the received input current (Iin), such that the color point of
	the light output of the module varies as a function of the input current
	magnitude <sub>7</sub> ; and
	characterized in that wherein the LED module comprises curren
5	sensor means (116) arranged to sense an input current level of the input
	current (Iin), and an electronic division circuit (115) capable o
	controlling a ratio of the LED currents (I1, I2) in said first and second
	LED groups (113, 114) by distributing the input current to the first and
	second LED groups as a function of the input current level received at the
	input of the LED module sensed by the current sensor means.
2	Lighting device according to claim 1, wherein the LED module i
	designed to vary the individual LED currents in the individual LED
	groups such that the color point of the light output of the module or
	dimming follows a black body curve.
3	Lighting device according to claim 1, wherein the LED module i
	designed to vary the individual LED currents in the individual LEI

	groups such that the color behavior of the light output of the module on
	dimming resembles the color behavior of an incandescent lamp.
4	Lighting device according to claim 1, wherein the lighting device is
	configured to produce light with a color temperature CT at an average
	current of x%, $CT(x\%)$ , supplied to the terminals following the
	relationship:
	$CT (x\%) = CT(100\%)^*(x/100)1/9.5$
5	Lighting device according to claim 1, wherein the first group of
	LEDs has a varying first luminous flux output as a function of junction
	temperature of the first type LED, and the second group of LEDs has a
	varying second luminous flux output as a function of junction temperature
	of the second type LED, and wherein, at varying junction temperatures,
	the ratio of the first luminous flux output to the second luminous flux
	output varies;
	and wherein the first color temperature is lower than the second
	color temperature, while, at decreasing junction temperatures, the ratio of
	the first luminous flux output to the second luminous flux output
	increases, and vice versa.
6	Lighting device according to claim 1, wherein a gradient of the first
	luminous flux output as a function of junction temperature of the first type
	LED differs from a gradient of the second luminous flux output as a
	function of junction temperature of the second type LED;
	and wherein the first color temperature is lower than the second
	color temperature, while the absolute value of the gradient of the first
	luminous flux output as a function of temperature of the first type LED is
	higher than the gradient of the second luminous flux output as a function
	of temperature of the second type LED.
7	Lighting device according to claim 1, wherein a thermal resistance
	to ambient of the first group of LEDs differs from the thermal resistance
	to ambient of the second group of LEDs;
	and wherein the first color temperature is lower than the second
	color temperature, while the thermal resistance to ambient of the first

		group of LEDs is higher than the thermal resistance to ambient of the
		second group of LEDs.
8		Lighting device according to claim 1, wherein the first group of
		LEDs has a first dynamic electrical resistance, and the second group of
		LEDs has a second dynamic electrical resistance.
9		Lighting device according to claim 1, comprising:
		an LED driver (101) capable of generating dimmed LED current
		and
		a two-terminal LED module (110; 300; 400; 500; 600), having two
-		input terminals (111, 112) for receiving the dimmed LED current as an
		input current (Iin) from the LED driver (101) and comprising:
		a first LED group (113) comprising at least one first type LED for
		producing light having a first color temperature;
		a second LED group (114) comprising at least one second type LEI
		for producing light having a second color temperature different from the
		first color temperature;
		wherein the module is capable of supplying LED currents to the
		LED groups, these LED currents being derived from the input current
		<u>(Iin);</u>
		wherein the LED module produces a light output having at least
		light output contributions from the first LED group (113) and from the
		second LED group (114);
		wherein the module is designed to vary the individual LED current
		in the individual LED groups in dependency of the average magnitude of
		the received input current (Iin), such that the color point of the light output
		of the module varies as a function of the input current magnitude;
	×.	wherein the LED module comprises an electronic division circu
		(115) capable of controlling a ratio of the LED currents (I1, I2) in sai
÷		first and second LED groups (113, 114) as a function of the input current
		level received at the input of the LED module;
		wherein one of the first group of LEDs and the second group of
		LEDs is connected in series with a resistor, and wherein this first series

		<u>comprising</u> the other one of the first group of LEDs and the second group
		of LEDs, and wherein this parallel arrangement is connected between the
		two input terminals (111, 112) of the LED module; and
		wherein the first series arrangement in said parallel arrangement has
		a first dynamic electrical resistance and the second series arrangement has
		a second dynamic electrical resistance, and the first dynamic electrical
		resistance is different from the second dynamic electrical resistance, so
(e		that as a result the ratio of the LED currents (I1, I2) in said first and second
		LED groups (113,114) is variable.
		and wherein the resistor is a negative temperature coefficient, NTC,
		type resistor.
	10	Lighting device according to claim 9, wherein the resistor is a
		negative temperature coefficient, NTC, type resistor.
10	<u>11</u>	Lighting device according to any of the preceding claims, wherein
		the first type LED is an AlInGaP type LED, and/or wherein the second
		type LED is an In- GaN type LED.
	<u>12</u>	Lighting device according to claim 9, wherein the LED module
		consists of LEDs and at least one resistor.
++	<u>13</u>	Lighting device according to claim 1, wherein the electronic
		division circuit is capable of supplying the two groups of LEDs with
		constant current and of controlling the LED currents (I1, I2) such that the
		following formulas apply:
		$I1 = p \bullet Iin and I2 = q \bullet Iin, and p + q = 1$
		with Iin denoting the input current magnitude,
		I1 denoting the current magnitude in the first group of LEDs,
		I2 denoting the current magnitude in the second group of LEDs;
		wherein there is at least a range of input current magnitudes where
		dp/d(Iin) is always positive and dq/d (Iin) is always negative.
12	<u>14</u>	Lighting device according to claim 44 <u>13</u> , wherein the LED module
		comprises:
		a current regulating element (320) arranged in series with one of
8		a current regulating element (320) arranged in series with one of said groups of LEDs, this series arrangement being coupled in parallel to

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		a current sensing element (350) arranged for sensing the input current
	4	received at the input terminals of the LED module;
		and a regulator driver (310) receiving a sense output signal from the
		current sensing means element providing information on the sensed input
		current level, and driving the current regulating element on the basis of
		this sense output signal.
13	<u>15</u>	Lighting device according to claim 1, wherein the electronic
		division circuit (515) comprises a controllable switch (501) fo
		temporally dividing de received input current (Iin) between the two
		groups of LEDs;
		a control device (520) for controlling the switch (501) at a switching
		period T such that the input current is passed on to the first group of LED
		for a first time duration t1 and the input current is passed on to the second
		group of LEDs for a second time duration t2, with $t1+t2=T$ ;
		a current sensing element (116) arranged for sensing the input
		current received at the input terminals of the LED module;
		the control device being coupled to receive a sense output signa
	4.1	from the sensing element and being designed to vary the ratio t1/t2 of th
		switching of the switch on the basis of said sense output signal, such that
		there is at least a range of input current magnitudes where dt1(lin) i
		always positive and dt2 (Iin) is always negative.
14	16	Lighting device according to claim 1, wherein the second group of
		LEDs (114) is supplied by a current converter (601) having its input
		terminals connected in parallel to the first group of LEDs (113);
		wherein the current converter comprises a control circuit (620
		receiving a sense output signal from a current sensing element (116
		sensing the input cur- rent of the LED module;
		and wherein this control circuit (620) is designed to control th
		current converter (601) on the basis of the sense output signal receive
15	17	from the current sensing element (116).
15	<u>17</u>	Lighting device according to claim 1, wherein the first group of
		LEDs (113) is supplied by a first current converter (730) and the second
		group of LEDs (114) is supplied by a second current converter (740), an

wherein these two current converter have their input terminals connected
in series;
wherein the LED module comprises a control circuit (720)
receiving a sense output signal from a current sensing element (116)
sensing the input current of the LED module;
and wherein this control circuit (720) is designed to control the
current converters (730, 740) on the basis of the sense output signal
received from the current sensing element (116).

Conditi	Conditional Amendments to the Description of the Patent	
Old	New	Conditional Amendment
Page	Page	
3	3	The device known from US 2006/0273331 receives an input voltage
		signal that carries power and a control signal. In the device, the control
		signal is taken from the input signal and transferred to the intelligent
		control device, that controls the individual current sources on the basis of
		the received control data. By changing the ratio between the respective
		light outputs, the relative contributions to the overall light output is
		changed and hence the overall color of the overall light output, as
		perceived by an observer, is changed. Such lighting device, therefore,
		requires a separate control input signal.
		In LED lighting devices, a behavior of the color temperature of the
		LED light can be obtained which, in dimming conditions, is similar to that
		of an incandescent lamp, but until now only at the expense of extensive
		current control, such as e.g. known from DE10230105. The necessity of
		adding controls to the LED lighting device for the desired color
		temperature behavior increases the number of components, increases the
ļ		complexity of the lighting device, and increases costs. These effects are
		undesirable. Further relevant prior art is described in US 2008/224631
		and WO 2007/093927.
		SUMMARY OF THE INVENTION

The present invention aims to provide a LED circuit for such LED lighting device, and a LED lighting device comprising such LED circuit, wherein an intelligent control can be omitted and wherein a feedback sensor can be omitted.

It would be desirable to provide an LED lighting device having a color temperature behavior, when dimmed, resembling or approaching the color temperature behavior of an incandescent lamp, when dimmed. It would also be desirable to provide an LED lighting device having an incandescent lamp color temperature behavior, when dimmed, without the need of extensive controls.

To better address one or more of these concerns, in an aspect of the invention an LED lighting device is provided, comprising an LED driver capable of receiving an input mains voltage and acting as a current source to convert the input mains voltage so as to generatinge dimmed LED current suitable for driving an LED array consisting of LEDs; and a two-terminal LED module for replacing the LED array, the two-terminal module having two input terminals for receiving the dimmed LED current as an input current from the LED driver. The LED module comprises a first LED group comprising at least one first type LED for producing light having a first color temperature, and a second LED group comprising at least one second type LED for producing light having a second color temperature different from the first color temperature. The LED module is capable of supplying LED currents to the LED groups, these LED currents being derived from the input current. The LED module

produces a light output having at least a light output contributions from the first LED group and from the second LED group. The LED module is designed to vary the individual LED currents in the individual LED groups in dependency of the average magnitude of the received input current, such that the color point of the light output of the module varies as a function of the input current magnitude. The LED module comprises current sensor means arranged to sense an input current level of the input current, and an electronic division circuit capable of controlling a ratio of the LED currents in said first and second LED groups by distributing the

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input current to the first and second LED groups as a function of the input current level sensed by the current sensor means received at the input of the LED module.

According to an aspect of the present invention, an LED lighting device comprises a single dimmable current source and an LED module receiving current from the current source. The LED module behaves as a load to the current source, similar to an array existing of LEDs only. Within the LED module, an electronic circuit senses the current magnitude of the input current, and distributes the current to different LED sections of the LED module on the basis of the sensed current magnitude. No intelligent current control is needed in the current source.

In an aspect of the invention an LED lighting device is provided, comprising a plurality of LEDs, and two terminals for supplying current to the lighting device. The lighting device comprises a first set of at elast one LED of a first type producing light having a first color temperature, and a second color temperature different from the first color temperature. The first set and the second are <u>may be</u> connected in series or in parallel between the terminals.

<u>**TIn embodiments, the**</u> lighting device is configured to produce light with a color point varying in accordance with a blackbody curve at a variation of an average current supplied to the terminals.

A color temperature behavior of an incandescent lamp may be described by the following relationship:

 $CT(x\%) = CT(100\%) * (x/100)^{\frac{1}{9.5}}$ 

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		8
4a	4a	
		(
		á

where CT(100%) is the color temperature of the light at full power (100% current) of the lamp, CT(x%) is the color temperature of the light at x% dimming of the lamp (x% current, with 0 < x < 100).

In an embodiment, the first set has a varying first luminous flux
output as a function of junction temperature of the LED of the first type,
and the second set has a varying second luminous flux output as a function
of junction temperature of the LED of the second type, and wherein, at

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varying junction temperatures, the ratio of the first luminous flux output to the second luminous flux output varies. In particular, when the first color temperature is lower than the second color temperature, the lighting device is configured such that, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa. In such a configuration, e.g. having the first set connected in series with the second set, the first luminous flux output increases relative to the second flux output when the lighting device is dimmed, thereby producing light having a lower color temperature.

In an embodiment, the first set has a first dynamic electrical resistance, and the second set has a second dynamic electrical resistance. When e.g. the first set is connected in 15 parallel with the second set, different luminous flux outputs of the first set and the second set result, which can be designed to produce light having a lower color temperature when dimmed.

According to another aspect of the present invention, there is provided a lighting device comprising an LED driver capable of generating dimmed LED current; and a two-terminal LED module, having two input terminals for receiving the dimmed LED current as an input current from the LED driver and comprising: a first LED group comprising at least one first type LED for producing light having a first color temperature; a second LED group comprising at least one second type LED for producing light having a second color temperature different from the first color temperature; wherein the module is capable of supplying LED currents to the LED groups, these LED currents being derived from the input current; wherein the LED module produces a light output having at least a light output contributions from the first LED group and from the second LED group; and wherein the module is designed to vary the individual LED currents in the individual LED groups in dependency of the average magnitude of the received input current, such that the color point of the light output of the module varies as a function of the input current magnitude; wherein the LED module comprises an electronic division circuit capable of controlling a ratio of

	the LED currents in said first and second LED groups as a function of the
÷	input current level received at the input of the LED module; wherein one
	of the first group of LEDs and the second group of LEDs is connected in
	series with a resistor, and wherein this first series
<u>4b</u>	arrangement is connected in parallel to a second series arrangement
	comprising the other one of the first group of LEDs and the second group
	of LEDs, and wherein this parallel arrangement is connected between the
	two input terminals of the LED module; and wherein the first series
	arrangement has a first dynamic electrical resistance and the second series
	arrangement has a second dynamic electrical resistance, and the first
	dynamic electrical resistance is different from the second dynamic
	electrical resistance, so that as a result the ratio of the LED currents in
1	said first and second LED groups is variable.
	In another aspect of the present invention, a lighting kit of parts is
	provided, comprising a dimmer having input terminals adapted to be
	connected to an electrical power supply, and having output terminals
16	adapted to provide a variable electrical power. An embodiment of the
1.00	lighting device according to the present invention has terminals
	configured to be connected to the output terminals of the dimmer.
2	Further advantageous elaborations are mentioned in the dependent
	claims.
	BRIEF DESCRIPTION OF THE DRAWINGS
	These and other aspects, features and advantages of the present invention
	will be further explained by the following description of one or more
	preferred embodiments with reference to the drawings, in which same
	reference numerals indicate same or similar parts, and in
-	

Claim No: HP-2016-000046

# IN THE HIGH COURT OF JUSTICE CHANCERY DIVISION PATENTS COURT

**BETWEEN**:

# (1) PHILIPS LIGHTING NORTH AMERICA CORPORATION (a company incorporated under the laws of the USA)

# (2) PHILIPS LIGHTING HOLDING B.V. (a company incorporated under the laws of the Netherlands)

**Claimants** 

-and-

# (1) MEGAMAN (UK) LIMITED

### (2) NEONLITE INTERNATIONAL LIMITED

# (3) NEONLITE ELECTRONIC & LIGHTING (HK) LIMITED (a company incorporated under the laws of Hong Kong)

**Defendants** 

# ANNEX D – SCHEDULE OF AMENDMENTS OF THE THIRD REQUEST

The proposed conditional amendments to European Patent (UK) No. 2 407 009 (the "Patent") of the Third Request are as follows:-

Old New Conditional Amendment		Conditional Amendment
Claim	Claim	
1	1	Lighting device (100), comprising:
		an LED driver (101) capable of generating dimmed LED current;
		a two-terminal LED module (110; 300; 400; 500; 600), having two
		input terminals (111, 112) for receiving an input current (Iin) from the
		LED driver (101) and comprising:

a first LED group (113) comprising at least one first type LED for producing light having a first color temperature;

a second LED group (114) comprising at least one second type LED for producing light having a second color temperature different from the first color temperature;

a current regulating element (320) arranged in series with one of said groups of LEDs, this series arrangement being coupled in parallel to another of said groups of LEDs;

a current sensing element (350) arranged for sensing the input current received at the input terminals of the LED module; and

a regulator driver (310) receiving a sense output signal from the sensing element and driving the current regulating element on the basis of this sense output signal;

wherein the module is capable of supplying LED currents to the LED groups, these LED currents being derived from the input current (Iin);

wherein the LED module produces a light output having at least a light output contributions from the first LED group (113) and from the second LED group (114);

and wherein the module is designed to vary the individual LED currents in the individual LED groups in dependency of the average magnitude of the received input current (Iin), such that the color point of the light output of the module varies as a function of the input current magnitude<sub>5</sub>:

characterized in that wherein the LED module comprises an electronic division circuit (115) capable of controlling a ratio of the LED currents (I1, I2) in said first and second LED groups (113, 114) as a function of the input current level received at the input of the LED module<del>,</del>; and

wherein the electronic division circuit is capable of supplying the two groups of LEDs with constant current and of controlling the LED currents (I1, I2) such that the following formulas apply: I1 = p·Iin and I2 = q·Iin, and p + q = 1, with Iin denoting the input current magnitude, I1

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		denoting the current magnitude in the first group of LEDs, and I2
		denoting the current magnitude in the second group of LEDs.
2		Lighting device according to claim 1, wherein the LED module is
		designed to vary the individual LED currents in the individual LED
		groups such that the color point of the light output of the module on
		dimming follows a black body curve.
3		Lighting device according to claim 1, wherein the LED module is
-		designed to vary the individual LED currents in the individual LED
		groups such that the color behavior of the light output of the module on
		dimming resembles the color behavior of an incandescent lamp.
4		Lighting device according to claim 1, wherein the lighting device is
		configured to produce light with a color temperature CT at an average
		current of x%, CT(x%), supplied to the terminals following the
		relationship:
		CT (x%) = CT(100%)*(x/100)1/9.5
5		Lighting device according to claim 1, wherein the first group of
		LEDs has a varying first luminous flux output as a function of junction
		temperature of the first type LED, and the second group of LEDs has a
		varying second luminous flux output as a function of junction temperature
		of the second type LED, and wherein, at varying junction temperatures,
		the ratio of the first luminous flux output to the second luminous flux
		output varies;
4		and wherein the first color temperature is lower than the second
		color temperature, while, at decreasing junction temperatures, the ratio of
	~	the first luminous flux output to the second luminous flux output
		increases, and vice versa.
6		Lighting device according to claim 1, wherein a gradient of the first
		luminous flux output as a function of junction temperature of the first type
		LED differs from a gradient of the second luminous flux output as a
		function of junction temperature of the second type LED;
		and wherein the first color temperature is lower than the second
		color temperature, while the absolute value of the gradient of the first
		luminous flux output as a function of temperature of the first type LED is

	higher than the gradient of the second luminous flux output as a function
<u>.</u>	of temperature of the second type LED.
7	Lighting device according to claim 1, wherein a thermal resistance
	to ambient of the first group of LEDs differs from the thermal resistance
	to ambient of the second group of LEDs;
	and wherein the first color temperature is lower than the second
	color temperature, while the thermal resistance to ambient of the first
	group of LEDs is higher than the thermal resistance to ambient of the
	second group of LEDs.
8	Lighting device according to claim 1, wherein the first group of
	LEDs has a first dynamic electrical resistance, and the second group o
	LEDs has a second dynamic electrical resistance.
9 .	Lighting device according to claim 1, comprising:
	an LED driver (101) capable of generating dimmed LED current
	and
	a two-terminal LED module (110; 300; 400; 500; 600), having two
	input terminals (111, 112) for receiving an input current (Iin) from the
	LED driver (101) and comprising:
	a first LED group (113) comprising at least one first type LED for
	producing light having a first color temperature;
-	a second LED group (114) comprising at least one second type LEI
	for producing light having a second color temperature different from th
	first color temperature;
	wherein the module is capable of supplying LED currents to the
	LED groups, these LED currents being derived from the input current
	<u>(Iin);</u>
	wherein the LED module produces a light output having at least
	light output contributions from the first LED group (113) and from the
	second LED group (114):
	and wherein the module is designed to vary the individual LEI
	and wherein the module is designed to vary the individual LEI currents in the individual LED groups in dependency of the average

		the light output of the module varies as a function of the input current
-		magnitude:
		wherein the LED module comprises an electronic division circuit
		(115) capable of controlling a ratio of the LED currents (I1, I2) in said
		first and second LED groups (113, 114) as a function of the input current
1	-	level received at the input of the LED module;
		wherein one of the first group of LEDs and the second group of
		LEDs is connected in series with a resistor, and wherein this series
		arrangement is connected in parallel to the other one of the first group of
		LEDs and the second group of LEDs, and wherein this parallel
		arrangement is connected between the two input terminals (111, 112) of
		the LED module <u>;</u> .
8		and wherein the resistor is a negative temperature coefficient, NTC,
		type resistor.
	<u>10</u>	Lighting device according to claim 9, wherein the resistor is a
		negative temperature coefficient, NTC, type resistor.
<del>10</del>	<u>11</u>	Lighting device according to any of the preceding claims, wherein
		the first type LED is an AlInGaP type LED, and/or wherein the second
		type LED is an In- GaN type LED.
11	<u>12</u>	Lighting device according to claim 1, wherein the electronic
		division circuit is capable of supplying the two groups of LEDs with
		constant current and of controlling the LED currents (I1, I2) such that the
		following formulas apply:
		$I1 = p \cdot Iin and I2 = q \cdot Iin, and p + q = 1$
		with Iin denoting the input current magnitude,
		11 denoting the current magnitude in the first group of LEDs,
		12 denoting the current magnitude in the second group of LEDs;
		wherein there is at least a range of input current magnitudes where
		dp/d(Iin) is always positive and dq/d(Iin) is always negative.
<del>12</del>		Lighting device according to claim 11, wherein the LED module
		comprises:
1. Contract (1. Contract)		

		a current regulating element (320) arranged in series with one o
		said groups of LEDs, this series arrangement being coupled in parallel t
		another of said groups of LEDs;
		a current sensing element (350) arranged for sensing the input
		current received at the input terminals of the LED module;
*		and a regulator driver (310) receiving a sense output signal from th
	5	sensing element and driving the current regulating element on the bas
		of this sense output signal.
13		Lighting device according to claim 1, wherein the electron
15		division circuit (515) comprises a controllable switch (501) for
		temporally dividing de received input current (Iin) between the tw
		groups of LEDs;
		a control device (520) for controlling the switch (501) at a switchir
		period T such that the input current is passed on to the first group of LEE
		for a first time duration t1 and the input current is passed on to the secon
		group of LEDs for a second time duration t2, with t1+t2=T;
		a current sensing element (116) arranged for sensing the inp
		current received at the input terminals of the LED module;
		the control device being coupled to receive a sense output sign
		from the sensing element and being designed to vary the ratio t1/t2 of the
		switching of the switch on the basis of said sense output signal, such th
		there is at least a range of input current magnitudes where dt1(Iin)
14		always positive and dt2 (Iin) is always negative.
14		Lighting device according to claim 1, wherein the second group
		LEDs (114) is supplied by a current converter (601) having its inp
		terminals connected in parallel to the first group of LEDs (113);
		wherein the current converter comprises a control circuit (62
		receiving a sense output signal from a current sensing element (11
		sensing the input cur-rent of the LED module;
		and wherein this control circuit (620) is designed to control t
		current converter (601) on the basis of the sense output signal receive
		from the current sensing element (116).

15	Lighting device according to claim 1, wherein the first group of
	LEDs (113) is supplied by a first current converter (730) and the second
	group of LEDs (114) is supplied by a second current converter (740), and
	wherein these two current converter have their input terminals connected
-	in series;
	wherein the LED module comprises a control circuit (720)
	receiving a sense output signal from a current sensing element (116)
	sensing the input current of the LED module;
	and wherein this control circuit (720) is designed to control the
	current converters (730, 740) on the basis of the sense output signal
	received from the current sensing element (116).

Old Page	New Page	Conditional Amendment
3	3	The device known from US 2006/0273331 receives an input voltage signal that carries power and a control signal. In the device, the control signal is taken from the input signal and transferred to the intelligent control device, that controls the individual current sources on the basis of the received control data. By changing the ratio between the respective light outputs, the relative contributions to the overall light output is changed and hence the overall color of the overall light output, as perceived by an observer, is changed. Such lighting device, therefore requires a separate control input signal. In LED lighting devices, a behavior of the color temperature of the LED light can be obtained which, in dimming conditions, is similar to tha of an incandescent lamp, but until now only at the expense of extensive current control, such as e.g. known from DE10230105. The necessity o adding controls to the LED lighting device for the desired colo temperature behavior increases the number of components, increases the complexity of the lighting device, and increases costs. These effects and

undesirable. Further relevant prior art is described in US 2008/224631 and WO 2007/093927.

### SUMMARY OF THE INVENTION

The present invention aims to provide a LED circuit for such LED lighting device, and a LED lighting device comprising such LED circuit, wherein an intelligent control can be omitted and wherein a feedback sensor can be omitted.

It would be desirable to provide an LED lighting device having a color temperature behavior, when dimmed, resembling or approaching the color temperature behavior of an incandescent lamp, when dimmed. It would also be desirable to provide an LED lighting device having an incandescent lamp color temperature behavior, when dimmed, without the need of extensive controls.

To better address one or more of these concerns, in an aspect of the invention an LED lighting device is provided, comprising an LED driver capable of generating dimmed LED current, and a two-terminal LED module, having two input terminals for receiving an input current from the LED driver. The LED module comprises: a first LED group comprising at least one first type LED for producing light having a first color temperature, and a second LED group comprising at least one second type LED for producing light having a second color temperature different from the first color temperature, a current regulating element arranged in series with one of said groups of LEDs, this series a current sensing element arranged for sensing the input current received at the input terminals of the LED module, and a regulator

driver receiving a sense output signal from the sensing element and<br/>driving the current regulating element on the basis of this sense output<br/>signal. The LED module is capable of supplying LED currents to the LED<br/>groups, these LED currents being derived from the input current. The<br/>LED module produces a light output having at least a light output<br/>contributions from the first LED group and from the second LED group.

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The LED module is designed to vary the individual LED currents in the individual LED groups in dependency of the average magnitude of the received input current, such that the color point of the light output of the module varies as a function of the input current magnitude. The LED module comprises an electronic division circuit capable of controlling a ratio of the LED currents in said first and second LED groups as a function of the input current level received at the input of the LED module. The electronic division circuit is capable of suppling the two groups of LEDs with constant current and of controlling the LED currents such that the following formulas apply:  $II = p \cdot Iin$  and  $I2 = q \cdot Iin$ , and p + q = 1, with Iin denoting the input current magnitude. I1 denoting the current magnitude in the first group of LEDs.

According to an aspect of the present invention, an LED lighting device comprises a single dimmable current source and an LED module receiving current from the current source. The LED module behaves as a load to the current source, similar to an array existing of LEDs only. Within the LED module, an electronic circuit senses the current magnitude of the input current, and distributes the current to different LED sections of the LED module on the basis of the sensed current magnitude. No intelligent current control is needed in the current source.

In an aspect of the invention an LED lighting device is provided, comprising a plurality of LEDs, and two terminals for supplying current to the lighting device. The lighting device comprises a first set of at least one LED of a first type producing light having a first color temperature, and a second set of at least one LED of a second type producing light having a second color temperature different from the first color temperature. The first set and the second set are<u>may be</u> connected in series or in parallel between the terminals.

**T**<u>In embodiments, the lighting device is configured to produce light</u> with a color point varying in accordance with a blackbody curve at a variation of an average current supplied to the terminals.

		A color temperature behavior of an incandescent lamp may be
		described by the following relationship:
4a	4a	· · · · · · · · · · · · · · · · · · ·
		$CT(x\%) = CT(100\%) * (x/100)^{\frac{1}{9.5}}$
		where $CT(100\%)$ is the color temperature of the light at full power
		(100% current) of the lamp, $CT(x\%)$ is the color temperature of the light
		at x% dimming of the lamp (x% current, with $0 < x < 100$ ).
		In an embodiment, the first set has a varying first luminous flux
		output as a function of junction temperature of the LED of the first type,
		and the second set has a varying second luminous flux output as a function
		of junction temperature of the LED of the second type, and wherein, at
		varying junction temperatures, the ratio of the first luminous flux output
		to the second luminous flux output varies. In particular, when the first
		color temperature is lower than the second color temperature, the lighting
		device is configured such that, at decreasing junction temperatures, the
		ratio of the first luminous flux output to the second luminous flux output
		increases, and vice versa. In such a configuration, e.g. having the first set
		connected in series with the second set, the first luminous flux output
		increases relative to the second flux output when the lighting device is
		dimmed, thereby producing light having a lower color temperature.
		In an embodiment, the first set has a first dynamic electrical
		resistance, and the second set has a second dynamic electrical resistance.
		When e.g. the first 20 set is connected in parallel with the second set,
		different luminous flux outputs of the first set and the second set result,
		which can be designed to produce light having a lower color temperature
		when dimmed.
		According to another aspect of the present invention, there is
		provided a lighting device comprising: an LED driver capable of
		generating dimmed LED current; and a two-terminal LED module,
		having two input terminals for receiving an input current from the LED
		driver and comprising: a first LED group comprising at least one first type
N		LED for producing light having a first color temperature; a second LED

	group comprising at least one second type LED for producing light having
	a second color temperature different from the first color temperature
	wherein the module is capable of suppling LED currents to the LED
	groups, these LED currents being derived from the input current; whereir
	the LED module produces a light output having at least a light output
	contributions from the first LED group and from the second LED group
	and wherein the module is designed to vary the individual LED currents
	in the individual LED groups in dependency of the average magnitude o
	the received input current, such that the color point of the light output o
	the module varies as a
<u>4b</u>	function of the input current magnitude; wherein the LED modul
	comprises an electronic division circuit capable of controlling a ratio of
	the LED currents in said first and second LED groups as a function of th
	input current level received at the input of the LED module; wherein on
	of the first group of LEDs and the second group of LEDs in connected i
	series with a resistor, and wherein this series arrangement is connected i
	parallel to the other one of the first group of LEDs and the second grou
	of LEDs, and wherein this parallel arrangement is connected between th
	two input terminals of the LED module.
	In another aspect of the present invention, a lighting kit of parts
	provided, comprising a dimmer having input terminals adapted to t
	connected to an electrical power supply, and having output termina
	adapted to provide a variable electrical power. An embodiment of th
	lighting device according to the present invention has termina
	configured to be connected to the output terminals of the dimmer.
	Further advantageous elaborations are mentioned in the dependent
	claims.
	BRIEF DESCRIPTION OF THE DRAWINGS
	These and other aspects, features and advantages of the present invention
	will be further explained by the following description of one or more
	preferred embodiments with reference to the drawings, in which same
	reference numerals indicate same or similar parts, and in

Claim No: HP-2016-000046

# IN THE HIGH COURT OF JUSTICE CHANCERY DIVISION PATENTS COURT

**BETWEEN**:

## (1) PHILIPS LIGHTING NORTH AMERICA CORPORATION (a company incorporated under the laws of the USA)

### (2) PHILIPS LIGHTING HOLDING B.V. (a company incorporated under the laws of the Netherlands)

**Claimants** 

-and-

### (1) MEGAMAN (UK) LIMITED

## (2) NEONLITE INTERNATIONAL LIMITED

### (3) NEONLITE ELECTRONIC & LIGHTING (HK) LIMITED (a company incorporated under the laws of Hong Kong)

Defendants

### ANNEX E – SCHEDULE OF AMENDMENTS OF THE FOURTH REQUEST

The proposed conditional amendments to European Patent (UK) No. 2 407 009 (the "Patent") of the Fourth Request are as follows:-

Old Claim	New Claim	Conditional Amendment
+		Lighting device (100), comprising: an LED driver (101) capable of generating dimmed LED current; a two-terminal LED module (110; 300; 400; 500; 600), having two input terminals (111, 112) for receiving an input current (Iin) from the LED driver (101) and comprising:

	a first LED group (113) comprising at least one first type LED for
	producing light having a first color temperature;
*	a second LED group (114) comprising at least one second type LED
	for producing light having a second color temperature different from the
	first color temperature;
	wherein the module is capable of supplying LED currents to the
	LED groups, these LED currents being derived from the input current
	<del>(lin);</del>
	wherein the LED module produces a light output having at least a
	light output contributions from the first LED group (113) and from the
	second LED group (114);
	and wherein the module is designed to vary the individual LED
	currents in the individual LED groups in dependency of the average
	magnitude of the received input current (Iin), such that the color point of
-	the light output of the module varies as a function of the input current
1.1	magnitude,
	characterized in that the LED module comprises an electronic
	division circuit (115) capable of controlling a ratio of the LED currents
	(I1, I2) in said first and second LED groups (113, 114) as a function of
	the input current level received at the input of the LED module.
2	Lighting device according to claim 1, wherein the LED module is
	designed to vary the individual LED currents in the individual LED
- 1	groups such that the color point of the light output of the module or
	dimming follows a black body curve.
3	Lighting device according to claim 1, wherein the LED module i
	designed to vary the individual LED currents in the individual LEI
	groups such that the color behavior of the light output of the module of
	dimming resembles the color behavior of an incandescent lamp.
. 4	Lighting device according to claim 1, wherein the lighting device i
	configured to produce light with a color temperature CT at an averag
	current of $x\%$ , CT( $x\%$ ), supplied to the terminals following th
	relationship:
	toradonship.

itemperature of the first type LED, and the second group of LEDs has a varying second luminous flux output as a function of junction temperature of the second type LED, and wherein, at varying junction temperatures the ratio of the first luminous flux output to the second luminous flux output varies;         and wherein the first color temperature is lower than the second color temperature, while, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa.         6       Lighting device according to claim 1, wherein a gradient of the first luminous flux output as a function of junction temperature of the first type LED differs from a gradient of the second luminous flux output as a function of junction temperature of the first type LED differs from a gradient of the second type LED; and wherein the first color temperature of the gradient of the first luminous flux output as a function of temperature of the first type LED is higher than the gradient of the second luminous flux output as a function of temperature of the first type LED.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs is higher than the thermal resistance to ambient of the first group of LEDs.         9       1       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic ele	5		Lighting device according to claim 1, wherein the first group of
varying second luminous flux output as a function of junction temperatures of the second type LED, and wherein, at varying junction temperatures the ratio of the first luminous flux output to the second luminous flux output varies;         and wherein the first color temperature is lower than the second color temperature, while, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa.         6       Lighting device according to claim 1, wherein a gradient of the first luminous flux output as a function of junction temperature of the first type LED differs from a gradient of the second type LED; and wherein the first color temperature is lower than the second color temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the second type LED; and wherein the first color temperature of the first type LED is higher than the gradient of the second luminous flux output as a function of temperature of the first type LED.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs is higher than the thermal resistance to ambient of the second group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance.         9       1       Lighting device according to claim 1, wherein the first group of LEDs has a second dynamic electrical resistance.			LEDs has a varying first luminous flux output as a function of junction
of the second type LED, and wherein, at varying junction temperatures the ratio of the first luminous flux output to the second luminous flux output varies; and wherein the first color temperature is lower than the second ecolor temperature, while, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa.           6         Lighting device according to claim 1, wherein a gradient of the first luminous flux output as a function of junction temperature of the first typ LED differs from a gradient of the second luminous flux output as a function of junction temperature of the second type LED; and wherein the first color temperature of the first type LED is higher than the gradient of the second luminous flux output as a function of junction temperature of the second type LED; and wherein the first color temperature of the first type LED is higher than the gradient of the second luminous flux output as a function of temperature of the second luminous flux output as a function of temperature of the second type LED.           7         Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs is higher than the thermal resistance to ambient of the second group of LEDs.           8         Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.           9         1         Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED curren			temperature of the first type LED, and the second group of LEDs has a
the ratio of the first luminous flux output to the second luminous flux output varies;         and wherein the first color temperature is lower than the second color temperature, while, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa.         6       Lighting device according to claim 1, wherein a gradient of the first luminous flux output as a function of junction temperature of the first typ LED differs from a gradient of the second luminous flux output as a function of junction temperature is lower than the second eolor temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the first type LED;         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs;         8       Lighting device according to claim 1, wherein the first group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs is higher than the thermal resistance to ambient of the first group of LEDs.         9       1       Lighting device according to claim 1, wherein the first group of LEDs has a second dynamic electrical resistance.			varying second luminous flux output as a function of junction temperature
9       1       cutput varies;         and wherein the first color temperature is lower than the second color temperature, while, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa.         6       Lighting device according to claim 1, wherein a gradient of the first luminous flux output as a function of junction temperature of the first typ LED differs from a gradient of the second luminous flux output as a function of junction temperature of the first typ LED differs from a gradient of the second luminous flux output as a function of junction temperature is lower than the second eolor temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the first type LED i higher than the gradient of the second luminous flux output as a function of temperature of the first type LED.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs; and wherein the first color temperature is lower than the second eolor temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second eolor temperature, while the thermal resistance to ambient of the first group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current dim the first color temperature. <td></td> <td></td> <td>of the second type LED, and wherein, at varying junction temperatures,</td>			of the second type LED, and wherein, at varying junction temperatures,
and wherein the first color temperature is lower than the second color temperature, while, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa.         6       Lighting device according to claim 1, wherein a gradient of the first type LED differs from a gradient of the second luminous flux output as a function of junction temperature of the first type LED differs from a gradient of the second type LED; and wherein the first color temperature is lower than the second color temperature, while the absolute value of the gradient of the first type LED in higher than the gradient of the second luminous flux output as a function of temperature of the first type LED is differs from the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second second rype LED.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current in the first color temperature. <td></td> <td></td> <td>the ratio of the first luminous flux output to the second luminous flux</td>			the ratio of the first luminous flux output to the second luminous flux
eolor temperature, while, at decreasing junction temperatures, the ratio of the first-luminous flux output to the second luminous flux output increases, and vice versa.         6       Lighting device according to claim 1, wherein a gradient of the first luminous flux output as a function of junction temperature of the first type LED differs from a gradient of the second luminous flux output as a function of junction temperature of the second luminous flux output as a function of junction temperature is lower than the second color temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the first type LED is higher than the gradient of the second luminous flux output as a function of temperature of the first group of LEDs is higher than the first color temperature is lower than the second to ambient of the first group of LEDs;         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs;         8       Lighting device according to claim 1, wherein the the second group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs is higher than the thermal resistance to ambient of the first group of LEDs.         9       1         1       Lighting device according to claim 1, wherein the first group of LEDs has a second group of LEDs.	~ 1		output varies;
the first luminous flux output to the second luminous flux output increases, and vice versa.         6       Lighting device according to claim 1, wherein a gradient of the first type LED differs from a gradient of the second luminous flux output as a function of junction temperature of the second luminous flux output as a function of junction temperature is lower than the second color temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the first type LED i higher than the gradient of the second luminous flux output as a function of temperature of the first type LED.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current		~	and wherein the first color temperature is lower than the second
9       Increases, and vice versa.         6       Lighting device according to claim 1, wherein a gradient of the first type LED differs from a gradient of the second luminous flux output as a function of junction temperature of the second type LED; and wherein the first color temperature is lower than the second color temperature, while the absolute value of the gradient of the first type LED i higher than the gradient of the second luminous flux output as a function of temperature of the first type LED i higher than the gradient of the second luminous flux output as a function of temperature of the first type LED.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current			color temperature, while, at decreasing junction temperatures, the ratio of
<ul> <li>6 Lighting device according to claim 1, wherein a gradient of the first luminous flux output as a function of junction temperature of the first type LED differs from a gradient of the second luminous flux output as a function of junction temperature of the second type LED; and wherein the first color temperature is lower than the second color temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the first type LED i higher than the gradient of the second luminous flux output as a function of temperature of the second luminous flux output as a function of temperature of the first type LED.</li> <li>7 Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs.</li> <li>8 Lighting device according to claim 1, wherein the first group of LEDs.</li> <li>9 1 Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current</li> </ul>			the first luminous flux output to the second luminous flux output
9       1         1       uminous flux output as a function of junction temperature of the first type         1       LED differs from a gradient of the second luminous flux output as a function of junction temperature of the second type LED;         and wherein the first color temperature is lower than the second color temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the first type LED is higher than the gradient of the second luminous flux output as a function of temperature of the first type LED.         7       1         7       1         1       1         8       1         8       1         9       1         9       1         9       1         1       1         9       1         1       1         9       1			increases, and vice versa.
9       1       LED differs from a gradient of the second luminous flux output as a function of junction temperature of the second type LED; and wherein the first color temperature is lower than the second color temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the first type LED i higher than the gradient of the second luminous flux output as a function of temperature of the second luminous flux output as a function of temperature of the second luminous flux output as a function of temperature of the first group of LEDs.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current	6		Lighting device according to claim 1, wherein a gradient of the first
9       1       function of junction temperature of the second type LED; and wherein the first color temperature is lower than the second color temperature, while the absolute value of the gradient of the first luminous flux output as a function of temperature of the first type LED is higher than the gradient of the second luminous flux output as a function of temperature of the second type LED.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs is higher than the thermal resistance to ambient of the second group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current			luminous flux output as a function of junction temperature of the first type
9       1       Lighting device according to claim 1, wherein the first group of LEDs.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED curren			LED differs from a gradient of the second luminous flux output as a
9       1       Lighting device according to claim 1, wherein the first group of LEDs.         9       1       Lighting device according to claim 1, wherein the first group of LEDs has a second dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED curren		-	function of junction temperature of the second type LED;
9       1         9       1         1       Lighting device according to claim 1, wherein the first group of LEDs.         7       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs;         8       Lighting device according to claim 1, wherein the first group of LEDs.         9       1       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance.			and wherein the first color temperature is lower than the second
9       1       Lighting device according to claim 1, wherein the first group of LEDs.         9       1       Lighting device according to claim 1, wherein the first group of LEDs.         9       1       Lighting device according to claim 1, wherein the first group of LEDs has a second group of LEDs.			color temperature, while the absolute value of the gradient of the first
9       1       Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs is higher than the thermal resistance to ambient of the second group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current			luminous flux output as a function of temperature of the first type LED i
<ul> <li>7 Lighting device according to claim 1, wherein a thermal resistance to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs; and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs is higher than the thermal resistance to ambient of the second group of LEDs.</li> <li>8 Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.</li> <li>9 1 Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current</li> </ul>			higher than the gradient of the second luminous flux output as a function
to ambient of the first group of LEDs differs from the thermal resistance to ambient of the second group of LEDs;         and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs is higher than the thermal resistance to ambient of the second group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current			of temperature of the second type LED.
9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current	7		Lighting device according to claim 1, wherein a thermal resistance
and wherein the first color temperature is lower than the second color temperature, while the thermal resistance to ambient of the first group of LEDs is higher than the thermal resistance to ambient of the second group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current			to ambient of the first group of LEDs differs from the thermal resistance
9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current		(1)	to ambient of the second group of LEDs;
group of LEDs is higher than the thermal resistance to ambient of the second group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.         9       1         Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current			and wherein the first color temperature is lower than the second
second group of LEDs.         8       Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.         9       1         Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current			color temperature, while the thermal resistance to ambient of the first
<ul> <li>8 Lighting device according to claim 1, wherein the first group of LEDs has a first dynamic electrical resistance, and the second group of LEDs has a second dynamic electrical resistance.</li> <li>9 1 Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current</li> </ul>			group of LEDs is higher than the thermal resistance to ambient of th
9       1       LED shas a second dynamic electrical resistance.         9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current			second group of LEDs.
9       1       Lighting device according to claim 1, comprising: an LED driver (101) capable of generating dimmed LED current	8		Lighting device according to claim 1, wherein the first group of
9       1       Lighting device according to claim 1, comprising:         an LED driver (101) capable of generating dimmed LED current			LEDs has a first dynamic electrical resistance, and the second group of
an LED driver (101) capable of generating dimmed LED curren		· · · ·	LEDs has a second dynamic electrical resistance.
	9	1	Lighting device according to claim 1, comprising:
and			an LED driver (101) capable of generating dimmed LED current
			and

a two-terminal LED module (110; 300; 400; 500; 600), having two input terminals (111, 112) for receiving an input current (Iin) from the LED driver (101) and comprising:

a first LED group (113) comprising at least one first type LED for producing light having a first color temperature;

a second LED group (114) comprising at least one second type LED for producing light having a second color temperature different from the first color temperature;

wherein the module is capable of supplying LED currents to the LED groups, these LED currents being derived from the input current (lin);

wherein the LED module produces a light output having at least a light output contributions from the first LED group (113) and from the second LED group (114);

and wherein the module is designed to vary the individual LED currents in the individual LED groups in dependency of the average magnitude of the received input current (Iin), such that the color point of the light output of the module varies as a function of the input current magnitude;

wherein the LED module comprises an electronic division circuit (115) capable of controlling a ratio of the LED currents (I1, I2) in said first and second LED groups (113, 114) as a function of the input current level received at the input of the LED module;

wherein one of the first group of LEDs and the second group of LEDs is connected in series with a resistor, and wherein this series arrangement is connected in parallel to the other one of the first group of LEDs and the second group of LEDs, and wherein this parallel arrangement is connected between the two input terminals (111, 112) of the LED module; and

wherein the electronic division circuit (115) consists of an electronic circuit with passive electronic components and wherein the electronic circuit design defines a relationship between the input current

		· · · · · · · · · · · · · · · · · · ·
		(Iin) and the ratio of the LED currents in said first and second LED groups
		(113, 114).
		and wherein the resistor is a negative temperature coefficient, NTC,
		type resistor.
	2	Lighting device according to claim 1, wherein a memory function
	4	is implemented in the electronic circuit design as an integral part of the
		electronic division circuit, the memory function defining the relationship
		between the input current (Iin) and the ratio of the LED currents in said
		first and second LED groups (113, 114).
<del>10</del>		Lighting device according to any of the preceding claims, wherein
		the first type LED is an AllnGaP type LED, and/or wherein the second
	- 1	type LED is an In-GaN type LED.
11		Lighting device according to claim 1, wherein the electronic
		division circuit is capable of supplying the two groups of LEDs with
		constant current and of controlling the LED currents (11, 12) such that the
1		following formulas apply:
÷	× -	$I1 = p \cdot Iin and I2 = q \cdot Iin, and p + q = 1$
		with Iin denoting the input current magnitude,
		11 denoting the current magnitude in the first group of LEDs,
	+ X	12 denoting the current magnitude in the second group of LEDs;
		wherein there is at least a range of input current magnitudes where
		dp/d(Iin) is always positive and dq/d (Iin) is always negative.
<del>12</del>		Lighting device according to claim 11, wherein the LED module
		comprises:
	10	a current regulating element (320) arranged in series with one o
	а <u>н</u>	said groups of LEDs, this series arrangement being coupled in parallel to
		another of said groups of LEDs;
		a current sensing element (350) arranged for sensing the inpu
		current received at the input terminals of the LED module;
		and a regulator driver (310) receiving a sense output signal from the
	×.	sensing element and driving the current regulating element on the basi

Lighting device according to claim 1, wherein the electronic division circuit (515) comprises a controllable switch (501) for temporally dividing de received input current (Iin) between the two groups of LEDs; a control device (520) for controlling the switch (501) at a switching period T such that the input current is passed on to the first group of LEDs

for a first time duration t1 and the input current is passed on to the second group of LEDs for a second time duration t2, with t1+t2=T;

a current sensing element (116) arranged for sensing the input current received at the input terminals of the LED module;

the control device being coupled to receive a sense output signal from the sensing element and being designed to vary the ratio t1/t2 of the switching of the switch on the basis of said sense output signal, such that there is at least a range of input current magnitudes where dt1(Iin) is always positive and dt2 (Iin) is always negative.

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Lighting device according to claim 1, wherein the second group of LEDs (114) is supplied by a current converter (601) having its input terminals connected in parallel to the first group of LEDs (113);

wherein the current converter comprises a control circuit (620) receiving a sense output signal from a current sensing element (116) sensing the input cur- rent of the LED module;

and wherein this control circuit (620) is designed to control the current converter (601) on the basis of the sense output signal received from the current sensing element (116).

Lighting device according to claim 1, wherein the first group of LEDs (113) is supplied by a first current converter (730) and the second group of LEDs (114) is supplied by a second current converter (740), and wherein these two current converter have their input terminals connected in series;

wherein the LED module comprises a control circuit (720) receiving a sense output signal from a current sensing element (116) sensing the input current of the LED module;

and wherein this control circuit (720) is designed to control the
current converters (730, 740) on the basis of the sense output signal
received from the current sensing element (116).

Old	New	Conditional Amendment
Page	Page	
3	3	The device known from US 2006/0273331 receives an input voltag
		signal that carries power and a control signal. In the device, the control
		signal is taken from the input signal and transferred to the intelliger
	- v	control device, that controls the individual current sources on the basis of
		the received control data. By changing the ratio between the respectiv
		light outputs, the relative contributions to the overall light output
		changed and hence the overall color of the overall light output, a
		perceived by an observer, is changed. Such lighting device, therefore
		requires a separate control input signal.
		In LED lighting devices, a behavior of the color temperature of the
		LED light can be obtained which, in dimming conditions, is similar to th
		of an incandescent lamp, but until now only at the expense of extensiv
		current control, such as e.g. known from DE10230105. The necessity of
		adding controls to the LED lighting device for the desired cold
		temperature behavior increases the number of components, increases the
		complexity of the lighting device, and increases costs. These effects at
		undesirable. Further relevant prior art is described in US 2008/22463
		and WO 2007/093927.
		SUMMARY OF THE INVENTION
		The present invention aims to provide a LED circuit for such LE
		lighting device, and a LED lighting device comprising such LED circu
		wherein an intelligent control can be omitted and wherein a feedbac
		sensor can be omitted.

It would be desirable to provide an LED lighting device having a
color temperature behavior, when dimmed, resembling or approaching
the color temperature behavior of an incandescent lamp, when dimmed It
would also be desirable to provide an LED lighting device having an
incandescent lamp color temperature behavior, when dimmed, without
the need of extensive controls.

To better address one or more of these concerns, in an aspect of the invention an LED lighting device is provided, comprising a lighting device comprising: an LED driver capable of generating dimmed LED currentz; and a two-terminal LED module, having two input terminals for receiving an input current from the LED driver. The LED module comprises and comprising: a first LED group comprising at least one first type LED for producing light having a first color temperature, and; a second LED group comprising at least one second type LED for producing light having a second color temperature different from the first color temperature. The LED; wherein the module is capable of supplying LED currents to the LED groups, these LED currents being derived from the input current. The; wherein the LED module produces a light output having at least a light output contributions from the first LED group and from the second LED group. The LED; and wherein the module is designed to vary the individual LED currents in the individual LED groups in dependency of the average magnitude of the received input current, such that the color point of the light output of the module varies as a function of the input current magnitude. The; wherein the LED module comprises an electronic division circuit capable of controlling a ratio of the LED currents in said first and second LED groups as a function of the input current level received at the input of the LED module-: wherein one of the first group of LEDs and the second group of LEDs is connected in series with a resistor, and wherein this series arrangement is connected in parallel to the other one of the first group of LEDs and the second group of LEDs and wherein this parallel arrangement is connected between the two input terminals or the LED module; and

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	wherein the electronic division circuit consists of an electronic
circu	ait with passive electronic components and wherein the electronic
circu	ait design defines a relationship between the input current and the
ratio	of the LED currents in said first and second LED groups.
	According to an aspect of the present invention, an LED lighting
devi	ce comprises a single dimmable current source and an LED module

device comprises a single dimmable current source and an LED module receiving current from the current source. The LED module behaves as a load to the current source, similar to an array existing of LEDs only. Within the LED module, an electronic circuit senses the current magnitude of the input current, and distributes the current to different LED sections of the LED module on the basis of the sensed current magnitude. No intelligent current control is needed in the current source.

In an aspect of the invention an LED lighting device is provided, comprising a plurality of LEDs, and two terminals for supplying current to the lighting device. The lighting device comprise a first set of at least one LED of a first type producing light having a first color temperature, and a second color temperature different from the first color temperature. The first set and the second set are connected in series or in parallel between the terminals.

The lighting device is configured to produce light with a color point varying in accordance with a blackbody curve at a variation of an average current supplied to the terminals.

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		A color temperature behavior of an incandescent lamp may be
		described by the following relationship:
4a	4a	$CT(x\%) = CT(100\%) * (x/100)^{\frac{1}{95}}$
	e.	where CT(100%) is the color temperature of the light at full power
		(100%  current) of the lamp, CT(x%) is the color temperature of the light
		at x% dimming of the lamp (x% current, with $0 < x < 100$ ).
		In an embodiment, the first set has a varying first luminous flux
		output as a function of junction temperature of the LED of the first type,
		and the second set has a varying second luminous flux output as a function
		of junction temperature of the LED of the second type, and wherein, at
		varying junction temperatures, the ratio of the first luminous flux output

to the second luminous flux output varies. In particular, when the first color temperature is lower than the second color temperature, the lighting device is configured such that, at decreasing junction temperatures, the ratio of the first luminous flux output to the second luminous flux output increases, and vice versa. In such a configuration, e.g. having the first set connected in series with the second set, the first luminous flux output increases relative to the second flux output when the lighting device is dimmed, thereby producing light having a lower color temperature.

In an embodiment, the first set has a first dynamic electrical resistance, and the second set has a second dynamic electrical resistance. When e.g. the first set is connected in parallel with the second set, different luminous flux outputs of the first set and the second set result, which can be designed to produce light having a lower color temperature when dimmed.

In another aspect of the present invention, a lighting kit of parts is provided, comprising a dimmer having input terminals adapted to be connected to an electrical power supply, and having output terminals adapted to provide a variable electrical power. An embodiment of the lighting device according to the present invention has terminals configured to be connected to the output terminals of the dimmer.

<u>A</u>Ffurther advantageous elaborations are is mentioned in the dependent claims.

### BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects, features and advantages of the present invention will be further explained by the following description of one or more preferred embodiments with reference to the drawings, in which same reference numerals indicate same or similar parts, and in