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(54) METHOD FOR CONTROLLING A LED LIGHTING DEVICE

(57) The present invention relates to a LED lighting device (1) and a method (100) of controlling the LED lighting device (1). The LED lighting device comprises a two-channel LED driver (10), a first set (LED1) of LED light sources, a second set (LED2) of LED light sources and a third set (LED3) of LED light sources. A first channel (C1) of the two-channel LED driver (10) provides a first channel current (IC1), and/or first channel voltage, which at least partly provides a first current (11), and/or first voltage, to the first set of LED light sources, and a second channel (C2) of the two-channel LED driver provides a second channel current (IC2), and/or second channel voltage, which at least partly provides a second current (I2), and/or second voltage, to the second set of LED light sources. The method comprises the steps of determining (102) a level of the first channel current (IC1), and/or first channel voltage; determining (104) a level of the second channel current (IC2), and/or second channel voltage; comparing (106) the determined level of the first channel current (IC1), and/or first channel voltage, with a first threshold (T1); comparing (108) the determined level of the second channel current (IC2), and/or second channel voltage, with a second threshold (T2); and if both the determined level of the first channel current (IC1), and/or first channel voltage, is below the first threshold (T1) and the determined level of the second channel current (IC2), and/or second channel voltage, is below the second threshold (T2), supplying (110), by means of the two-channel LED driver (10), a third current (I3), and/or third voltage, to the third set (LED3) of LED light sources.

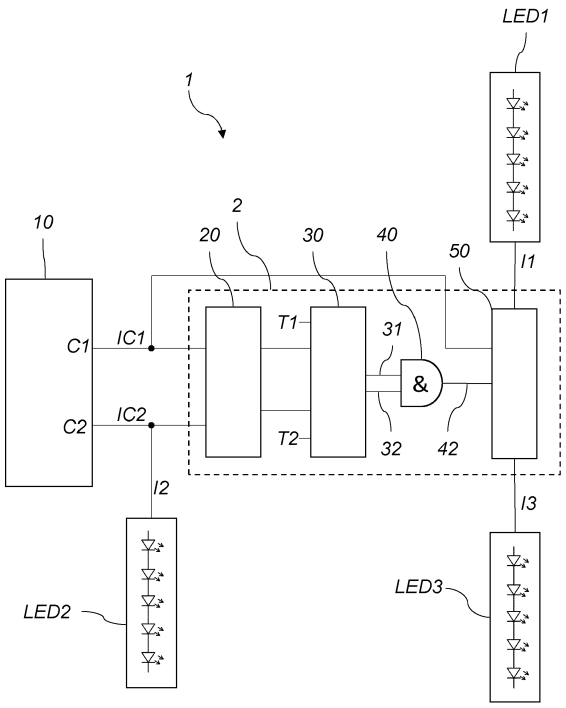

Fig. 1

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Description

Technical Field

[0001] The present disclosure relates to a LED lighting device, and especially to control of output color temperature from the LED lighting device.

Background

[0002] The color temperature of a LED light source can change with the brightness. This may be due to several factors such as the composition of LEDs in the LED light source when e.g. mixing colored LEDs to produce white light, and temperature effects on the LEDs.

[0003] When decreasing the brightness of an LED light (by reducing the current) from a LED lighting device, it might be necessary to adjust the color temperature to maintain a consistent perceived color.

[0004] In some LED lighting devices, the white light temperature may be controlled by a user in a spectra between cold and warm white. However, when dimming the overall brightness of the light from the LED lighting device, there may be a discrepancy in the perceived color temperature from the intended temperature based on the temperature control. Consequently, there is a need for an improved way of the controlling the output color temperature to a desired level throughout a dimming process of the LED lighting device.

Summary

[0005] It is an object of the present invention to provide an improved solution that alleviates the mentioned drawbacks with present devices. Furthermore, it is an object to provide a way of controlling the light output of a LED lighting device to get a desired resulting color temperature.

[0006] The invention is defined by the appended independent claims, with embodiments being set forth in the appended dependent claims, in the following description and in the drawings.

[0007] According to a first aspect of the invention there is provided a method of controlling a LED lighting device, the LED lighting device comprising a two-channel LED driver, a first set of LED light sources, a second set of LED light sources and a third set of LED light sources, wherein a first channel of the two-channel LED driver provides a first channel current, and/or a first channel voltage, which at least partly provides a first current, and/or first voltage, to the first set of LED light sources, and a second channel of the two-channel LED driver provides a second channel current, and/or the second channel voltage, which at least partly provides a second current, and/or second voltage, to the second set of LED light sources. The method comprises the steps of determining a level of the first channel current, and/or the first channel voltage; determining a level of the second channel current, and/or the second channel voltage; comparing the determined level of the first channel current, and/or the first channel voltage, with a first threshold; comparing the determined level of the second channel current, and/or the second channel voltage, with a second threshold; and if both the determined level of the first channel current, and/or the first channel voltage, is below the first threshold and the determined level of the second channel current, and/or the second channel voltage, is below the second threshold, supplying, by means of the two-channel LED driver, a third current, and/or a third voltage, to the third set of LED light sources.

[0008] The embodiments described below relating to supply and determination of the first channel current, second channel current, first current, second current and third current, may equally apply to embodiments supplying and determining one or more of the first channel voltage, second channel voltage, first voltage, second voltage and third voltage, in addition to or instead of said currents. Such embodiments may be implemented with a LED driver supplying constant currents, and using a modulation of the voltage to control the LED light sources. In some embodiments, the first and second thresholds may be compared with the determined first and second channel voltages being determined levels of the voltages supplied by the first and second channels of the LED driver.

[0009] The two-channel LED driver may supply the first channel current and the second channel current depending on a user setting. At least in a first state of the two-channel LED driver, in which no current is supplied to the third set of LED light sources, the first channel current may be equal to the first current supplied to the first set of LED light sources. In a second state of the two-channel LED driver, current may also be supplied to the third set of LED light sources. The LED driver may be in the second state when the conditions of the first and second channel currents relative to the thresholds are fulfilled. In one embodiment, the second channel current may be equal to the second current no matter which state the LED driver may be in.

[0010] The first and second sets of LED light sources may provide light with different color temperature, such as white light of different temperature. A user may control the output color temperature from the LED lighting device by controlling the mixture of light from the first and second sets of LED light sources, by controlling the current levels of the first and second currents supplied by the LED driver to the LED light sources. The user may further control an overall brightness level of the light output from the LED lighting device. When dimming the brightness level, the third set of LED light sources may be activated under certain circumstances, i.e. when the mixture control of light output from the first and second sets of LED light sources is set such that a level of contribution from the second set of LED light sources is below the second threshold. When the mixture is set such that the second current is above the second threshold, the third set of

LED light sources may not be activated, even though the level of the first channel current may be below the first threshold.

[0011] The light output of the third set of LED light sources may be adapted in color temperature to, when dimming of the first channel current reaches the first threshold, compensate for color temperature change effects during dimming. However, such compensation may only be necessary or relevant when the contribution from the second set of LED light sources is below the second threshold. This may be due to the fact that the need for compensation of color temperature change effects during dimming may be different depending on the resulting color temperature of the mixture of light output from the first and second sets of LED light sources.

[0012] The first and second channel currents may be determined using one or two sensor devices.

[0013] In one embodiment, the first set of LED light sources may comprise warm white LED light sources. In one embodiment, the first set of LED light sources may comprise only warm white LED light sources. The warm white LED light sources may provide light with a color temperature of below 3000 K, preferably about 2700 K.

[0014] In one embodiment, the second set of LED light sources may comprise cold white LED light sources. In one embodiment, the second set of LED light sources may comprise only cold white LED light sources. The cold white LED light sources may provide light with a color temperature of above 5000 K, or at least 6000 K, preferably about 6500 K.

[0015] In one embodiment, the first set of LED light sources may provide a white color temperature warmer than the second set of LED light sources, and the third set of LED light sources may provide a white color temperature warmer than the first set of LED light sources. The third set of LED light sources may provide light with a color temperature of below 2500 K, or below 2000 K, preferably about 1800 K. The even warmer third set of LED light sources may provide the desired color temperature scheme when the conditions of the first and second channel currents are fulfilled.

[0016] In one embodiment, the first threshold may be a current level that corresponds to a brightness level of the first set of LED light sources of between 10-30%, preferably 15-25%, or more preferably around 20%. The third set of LED light sources may be desired to be activated when the brightness level of the LED lighting device falls below a certain level. It may be made to compensate for color temperature changes due to the dimming of the LED lighting device. Since the third current may only be supplied if also the second current is below the second threshold, the brightness level of the light output of the LED lighting device may be below the first threshold without the third set of LED light sources being activated, i.e. without the third current being supplied.

[0017] Brightness level may be referred to as amount of light output from the LED light sources, provided by the supplied current and/or voltage to the LED light sources. The percentage of brightness level may correspond to a current and/or voltage present across the LED light sources.

[0018] In one embodiment, the second threshold may be a current level and/or voltage level that corresponds to a brightness level of the second set of LED light sources at or below 30%, at or below 20%, at or below 10%, at or below 5%, or at or below 2%. The third set of LED light sources may be intended to be activated, i.e. the third current being supplied to the third set of LED light sources, when the second channel current is below a desired level. It may be desired that the contribution of the second set of LED light source in the total light output is below a certain level. In some embodiments, such desired level is at a low level or in some embodiments very low level. In such embodiments, the second set of LED light sources may in practice be turned off. In such embodiment, the third current may be supplied when the light provided by the LED lighting device is provided by the first set of LED light sources only, or the contribution from the second set of LED light sources is neglectable, and the first channel current falls below the first threshold. In such situation, the first channel current represents the total current supplied to any LED light sources, providing the total light output. In one embodiment the first threshold corresponds to a brightness level of the total light output of the LED lighting device of 10-30%, preferably 15-25%, or more preferably around 20%. Hence, when the total light output is only provided by the first set of LED light sources, which may be warm white LED light sources, and the brightness level falls below e.g. 20%, the third set of LED light sources may be activated. The third set of LED light sources may provide light of a color temperature warmer than the first set of LED light sources. The third set of LED light sources may be used during the further dimming below the e.g. 20% brightness level to provide a desired light output color temperature behavior for the LED lighting device.

[0019] In some embodiments, the second threshold may be a current level of between 0.05-2 mA, 0.08-1.5 mA, or preferably about 1 mA. Such current level of the second threshold may correspond to a low level of brightness output of the second set of LED light sources, making the contribution of the second set of LED light sources more or less neglectable.

[0020] In other embodiments, the second threshold may be higher than 1mA, such that the light output from the second set of LED light sources may not be neglected. The first threshold may then be a current level of the first channel current corresponding to 20% brightness level (or other first threshold level) of the first set of LED light sources only, or a current level of the first and second channel currents together corresponding to 20% brightness level (or other first threshold level) of the first and second sets of LED light sources together.

[0021] In one embodiment, when the first channel current decreases from a level at which the supply of the third

current started, the supply of the first current may be decreased at a higher rate than the supply of the third current. When the third current supply is initiated, the third current may be supplied at a first level. During the further decrease of the first channel current, the first current may decrease at a higher rate than the third current, at least during a portion of the decrease of the first channel current. This may be performed to achieve a light output behavior where the ratio between the third current and the first current increases during further dimming. The ratio between the third and first current may not be constant during the further dimming, i.e. decrease of the first channel current. The third current may constitute a larger and larger part of the total supplied current when the total supplied current moves towards zero.

[0022] In one embodiment, the method may comprise a step of, when the first channel current is decreased below a third threshold, stopping the supply of the first current to the first set of LED light sources, wherein the third threshold may be above zero. At the third threshold, the first set of LED light sources may be turned off, and the third set of LED light sources may provide the only light output of the LED lighting device. The first channel current may then be equal to the third current. At the lowest brightness levels of the light output of the LED lighting device, the desired color temperature may be the color temperature of the third set of LED light sources. The color temperature of the third set of LED light sources may be warmer than the first set of LED light sources, wherein the color temperature of the first set of LED light sources may be warm white, such as below 3000 K, preferably about 2700 K. The third set of LED light sources may provide a color temperature of below 2500 K, or below 2000 K, preferably around 1800 K. The third threshold may be a level above zero. In some embodiments, the third threshold may be at a level of the first channel current corresponding to a total brightness level of the light output of between 3-8%, or 4-6%.

[0023] In one embodiment, the third current may be supplied to the third set of LED light sources as a portion of the first channel current supplied by the first channel of the two-channel LED driver. The first channel current may thereby be divided into two portions when the conditions for supplying the third current is fulfilled, both portions being supplied by the first channel of the two-channel LED driver.

[0024] In one embodiment, the method may further comprise a step of distributing, when the conditions for supplying the third current is fulfilled, the first channel current provided by the first channel of the two-channel LED driver in two portions into the first current and the third current. The distribution may be performed by a current distribution unit which receives the first channel current and distributes in two portions.

[0025] In one embodiment, the distribution of the first channel current into the first and third currents may be applied momentarily when the first threshold is reached, such that the third current may be increased instantly from 0 to a first distribution portion level, and the first current is decreased instantly from a level corresponding to the first channel current IC1 to a second distribution portion level.

[0026] In another embodiment, the distribution of the first channel current into the first and third currents may be applied such that the third current, when the first threshold is reached and the first channel current is further decreased, is gradually increased from 0 to a first distribution portion level, and the first current is gradually decreased from a level corresponding to the first channel current to a second distribution portion level.

[0027] According to a second aspect of the invention, there is provided a LED lighting device comprising a first set of LED light sources; a second set of LED light sources; a third set of LED light sources; a two-channel LED driver wherein a first channel of the two-channel LED driver is configured to provide a first channel current, and/or a first channel voltage, wherein at least a portion thereof provides a first current, and/or first voltage, to the first set of LED light sources, and a second channel of the two-channel LED driver is configured to provide a second channel current, and/or a second channel voltage, wherein at least a portion thereof provides a second current, and(or second voltage, to the second set of LED light sources; a sensor device configured to determine a level of the first channel current, and/or the first channel voltage, and a level of the second channel current, and/or the second channel voltage; a comparing unit configured to compare the determined level of the first channel current, and/or first channel voltage, with a first threshold, and to comparing the determined level of the second channel current, and/or second channel voltage, with a second threshold. The two-channel LED driver is configured to, if both the determined level of the first channel current, and/or first channel voltage, is below the first threshold and the determined level of the second channel current, and/or second channel voltage, is below the second threshold, supply a third current, and/or third voltage, to the third set of LED light sources.

[0028] The LED lighting device may be configured to operate according to a method as in any one of the embodiments described above. The features of any one of the embodiments described herein may be equally applicable to the relevant features of the LED lighting device. The embodiments described below relating to supply and determination of the first channel current, second channel current, first current, second current and third current, may equally apply to embodiments configured to supply and determine one or more of the first channel voltage, second channel voltage, first voltage, second voltage and third voltage, in addition to or instead of said currents. Such embodiments may be implemented with a LED driver supplying constant currents, and using a modulation of the voltage to control the LED light sources. In some embodiments, the first and second thresholds may be compared with the determined first and second channel voltages being deter-

mined levels of the voltages supplied by the first and second channels of the LED driver.

[0029] In one embodiment, the two-channel LED driver may be configured to supply the third current as a portion of the first channel current provided by the first channel.

[0030] In one embodiment, the LED lighting unit may further comprise a current distribution unit configured to, when the third current is supplied to the third set of LED light sources, distribute the first channel current in two portions as the first current and the third current to the first set and third set of LED light sources, respectively. When the requirements for the third set of LED light sources to be activated is fulfilled, the first channel current may be used to supply current to the third set as well. The first and third sets of LED light sources may be supplied by the same channel of the two-channel LED driver. The current distribution unit may receive the first channel current as input, and distribute the first channel current into the two portions to the first and third sets of LED light sources. In a first state, when the requirements for supply of the third current is not fulfilled, the current distribution unit may only distribute the incoming first channel current in full to the first set as the first current. In a second state, when current is to be supplied to the third set as well, the incoming first channel current may be distributed in two portions as the first and third currents. During further dimming of the light output of the LED lighting device, i.e. during further decrease of the first channel current, the distribution of the current as the first and third currents may be changed. For instance, the first current may, at least during a portion of the decrease of the first channel current, decrease at a higher rate than the third current during decrease of the first channel current.

[0031] In one embodiment, the current distribution unit may be provided with a predetermined distribution scheme based on the level of the incoming first channel current. I.e. depending on the present current level of the first channel current, when being below the first threshold, the distribution of the first channel current into the first and third currents may be different. In one alternative embodiment, the distribution may not be predetermined based on the first channel current, but based on an additional input, e.g. from a user or an external device, such as a light or other environmental sensor. Such input may then be used by the current distribution unit to distribute the first channel current into the two portions.

[0032] At a third threshold of the first channel current (or the third current), the supply of the first current may be stopped, and at levels of the first channel current below the third threshold, the third current may be equal to the first channel current. The third threshold may be a level above zero. In some embodiments, the third threshold may be at a level of the first channel current corresponding to a total brightness level of the light output of between 3-8%, or 4-6%.

Brief Description of the Drawings

[0033] The invention will in the following be described in more detail with reference to the enclosed drawings, wherein:

Fig. 1 shows a schematic block scheme of a LED lighting device according to an embodiment of the invention.
Fig. 2 shows a chart of currents supplied according to an embodiment of the invention.
Fig. 3 shows a chart of currents supplied according to an embodiment of the invention.
Fig. 4 shows a chart of currents supplied according to an embodiment of the invention.
Fig. 5 shows a chart of currents supplied according to an embodiment of the invention.
Fig. 6 shows a circuit design of a LED lighting device according to an embodiment of the invention.
Fig. 7 shows a circuit of supply to LED light sources according to an embodiment of the invention.
Fig. 8 shows a flow chart of a method according to an embodiment of the invention.

Description of Embodiments

[0034] The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, like numbers refer to like elements.

[0035] Fig. 1 illustrates a LED lighting device 1 according to an embodiment of the present invention. The LED lighting device 1 comprises a two-channel LED driver 10 supplying currents in two separate channels C1, C2. A first channel C1 provides a first channel current IC1, and a second channel C2 provides a second channel current IC2.

[0036] The LED lighting device 1 further comprises three sets of LED light sources, a first set LED1, a second set LED2, and a third set LED3. The second channel current IC2 is supplied to the second set LED2. The first channel current IC1 is supplied to the first set LED1 and to the third set LED3 when active. The first set LED1 of LED light sources is supplied with a first current 11. The second set LED2 of LED light sources is supplied with a second current I2. The third set LED3 of LED light sources is supplied with a third current I3.

[0037] The LED lighting device 1 further comprises a control unit 2. The control unit 2 comprises a sensor device 20 configured to determine levels of the first and second channel currents IC1, IC2. The determined levels of the first and second channel currents IC1, IC2

are provided to a comparing unit 30. The comparing unit 30 is configured to compare the determined first channel current IC1 to a first threshold T1, and to compare the second channel current IC2 to a second threshold T2. The thresholds may be provided to the comparing unit as reference values corresponding to the desired current thresholds.

[0038] The comparing unit 30 provides a first and a second signal output 31, 32. The first signal output 31 may provide a high level signal or a low level signal. The high level signal is provided if the determined first channel current IC1 is below the first threshold T1. Alternatively, a high level signal may be provided when the determined first channel current IC1 is above the first threshold T1. The same applies to the second signal output 32, with is provided as a high level signal if the determined second channel current IC2 is below the second threshold T2 (or alternatively a low level signal). The signal outputs 31, 32 are received by an AND gate 40. The AND gate 40 (which alternatively may be a NAND gate) provides, when both signal outputs 31, 32 from the comparing unit 30 indicates that the determined channel currents IC1, IC2 are below the respective thresholds T1, T2, a control signal 42 to a current distribution unit 50. The purpose of the control signal 42 is to indicate to the current distribution unit 50 when the conditions of the channel currents IC1, IC2 being below the respective thresholds are fulfilled. The control signal 42 may be provided as a high or low signal, representing TRUE or FALSE.

[0039] When the control signal 42 is FALSE, or in any other way indicates that the conditions are not fulfilled, the first channel current IC1 received by the current distribution unit 50 is distributed in full to the first set LED1 of LED light sources as the first current 11. When the control signal 42 is TRUE, or in any other way indicates that the conditions are fulfilled, the current distribution unit 50 distributes the first channel current IC1 in two portions to the first and third sets LED1, LED3 of LED light sources as the first current I1 and the third current I3. The distribution may be based on a predetermined distribution scheme depending on the level of the incoming first channel current IC1.

[0040] In some embodiments, not illustrated in fig. 1, the comparing unit 30 may further compare the determined first channel current IC1 to a third threshold T3, and be configured to indicate to the current distribution unit 50 when the first channel current is below the third threshold T3. The third threshold T3 is lower than the first threshold T1. The third threshold T3 may indicate a level at and below which the current distribution unit 50 should supply the first channel current IC1 to the third set LED3 of the LED light sources as the third current I3 only. The supply of the first current I1 is thereby stopped. Figs. 2-5 illustrate the relationships between the current levels of the first and second channel currents IC1, IC2 and the brightness level output from the LED light sources supplied by the two channel currents, respectively.

[0041] Figs. 2 and 3 illustrate how the total first channel current IC1 is distributed between the first current I1 and the third current I3 when the second channel current IC2 is below the second threshold T2, and the first channel current IC1 is below the first threshold T1. In fig. 2 the second channel current IC2 is not shown. In the illustrated embodiments, the first threshold T1 is set at a level corresponding to about 20% of the brightness output level of the first set LED1 of LED light sources, and the second threshold T2 is set at a level below 1mA. In another embodiment, the second threshold T2 may be expressed as a brightness output level of the second set of LED light sources. Such threshold level could be for instance 5% brightness level. In practice, a second threshold T2 of 5% may be a current level of the second channel current IC2 that provides such brightness level output of the second set of LED light sources.

[0042] In practice the second set LED2 of LED light sources are turned off when the output level reaches 20%. By then the two conditions are fulfilled and the third current I3 is supplied to the third set LED3 of LED light sources. When the first channel current IC1 is decreased further, the distribution of the first channel current IC1 into the first current I1 and the third current I3 is not static. The ratio between the first current I1 and the third current I3 changes with the first channel current IC1. When the first channel current IC1 reaches the third threshold T3, the first current I1 reaches zero, providing that the entire first channel current IC1 is distributed as the third current I3 to the third set LED3 of LED light sources.

[0043] In other embodiments, the second threshold T2 may be higher than 1mA, such that the light output from the second set LED2 of LED light sources may not be neglected. The first threshold T1 may then be a current level of the first channel current IC1 corresponding to 20% brightness level (or other first threshold level) of the first set LED1 of LED light sources only, or a current level of the first and second channel currents IC1, IC2 together corresponding to 20% brightness level (or other first threshold level) of the first and second sets LED1, LED2 of LED light sources together.

[0044] In the embodiments illustrated in figs. 2 and 3, the distribution of the first channel current into the first and third currents are applied momentarily when the first threshold T1 is reached, such that the third current I3 is increased instantly from 0 to a first distribution portion level, and the first current I1 is decreased instantly from a level corresponding to the first channel current IC1 to a second distribution portion level.

[0045] In fig. 4, an alternative embodiment is illustrated, wherein the third current I3, when the first threshold T1 is reached and the first channel current IC1 is further decreased, is gradually increased from 0 to a first distribution portion level, and the first current I1 is gradually decreased from a level corresponding to the first channel current IC1 to a second distribution portion level.

[0046] In fig. 5, a situation is illustrated in which the second channel current IC2 is not below the second threshold T2, providing that the first channel current

IC1 is not distributed to the third set LED3 of LED light sources even though the first channel current IC1 is below the first threshold T1.

[0047] Figs. 6 and 7 illustrate a more detailed circuit scheme of the LED lighting device 1. The two-channel LED driver 10 comprises the two channels C1, C2, here indicated as Driver WW for warm white and Driver CW for cold white. The Driver WW- and Driver CW- minus connections are provided to the sensor device 20 which receives the first and second channel currents IC1, IC2 from the Driver WW and Driver CW channels. The sensor device 20 comprises a sensor circuit which receives the Driver WW- and Driver CW- signals, which are distributed further as LED_WW- and LED_CW- to the LED2700- and LED6500- connections, being the minus connections of the first and second sets LED1, LED2 of LED light sources, respectively.

[0048] The first and second sets LED1, LED2 of LED light sources receives the plus connection from the LED driver 10 as Driver WW+ and Driver CW+ connections respectively. The third set LED3 of LED light sources, in fig. 6 indicated as LED1800, further receives the Driver WW+ connection from the LED driver 10.

[0049] Signals representing the determined levels of the first and second channel currents, Driver WW-, Driver CW-, are supplied by the sensor device 20 to the comparing unit 30. The comparing unit 30 is supplied with reference signals WW_ref corresponding to the first threshold T1 and CW_ref corresponding to the second threshold T2. The reference signals are used by a comparing circuit to generate signals 31, 32 which indicate, for each of the comparisons with the respective reference signal/threshold, whether the determined channel current is below or above the reference signal/threshold. The AND gate 40 receives the signals 31, 32 from the comparing unit 30 indicating whether the determined levels of Driver WW- and Driver CW- are below the respective reference level WW_ref, CW_ref or not. If both conditions are fulfilled, the output signal 42 of the AND gate 40 will indicate this to the current distribution unit 50.

[0050] The current distribution unit 50 outputs the distributed LED_WW- and LED_1800- levels according to the embodiments discussed above. These levels represent the distributed first and third currents I1, I3 as discussed above.

[0051] Fig. 8 illustrates a flowchart of a method 100 of controlling a LED lighting device 1 according to an embodiment of the invention. The LED lighting device comprises a two-channel LED driver 10, a first set LED1 of LED light sources, a second set LED2 of LED light sources and a third set LED3 of LED light sources. A first channel C1 of the two-channel LED driver provides a first channel current IC1 which at least partly provides a first current I1 to the first set of LED light sources and a second channel C2 of the two-channel LED driver provides a second channel current IC2 which at least partly provides a second current I2 to the second set LED2 of LED light sources. The method 100 comprises the steps of determining 102 a level of the first channel current IC1; determining 104 a level of the second channel current IC2; comparing 106 the determined level of the first channel current IC1 with a first threshold T1; comparing 108 the determined level of the second channel current IC2 with a second threshold T2; and, if both the determined level of the first channel current IC1 is below the first threshold T1 and the determined level of the second channel current IC2 is below the second threshold T2, supplying 110 a third current I3 to the third set LED3 of LED light sources.

[0052] The embodiments described in relation to the figures and relating to supply and determination of the first channel current, second channel current, first current, second current and third current, may additionally or alternatively relate to supply and determination of one or more of a first channel voltage, a second channel voltage, a first voltage, a second voltage and a third voltage, in addition to or instead of said currents. Such embodiments may be implemented with a LED driver supplying constant currents, and using a modulation of the voltage to control the LED light sources. In some embodiments, the first and second thresholds may be compared with the determined first and second channel voltages being determined levels of the voltages supplied by the first and second channels of the LED driver.

[0053] In the drawings and specification, there have been disclosed preferred embodiments and examples of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation, the scope of the invention being set forth in the following claims.

Claims

1. Method of controlling a LED lighting device (1), the LED lighting device comprising a two-channel LED driver (10), a first set (LED1) of LED light sources, a second set (LED2) of LED light sources and a third set (LED3) of LED light sources, wherein a first channel (C1) of the two-channel LED driver provides a first channel current (IC1), and/or first channel voltage, which at least partly provides a first current (11), and/or first voltage, to the first set of LED light sources and a second channel (C2) of the two-channel LED driver provides a second channel current (IC2), and/or first channel voltage, which at least partly provides a second current (I2), and/or second voltage, to the second set (LED2) of LED light sources, the method comprising the steps of

   determining a level of the first channel current (IC1) and/or the first channel voltage;
   determining a level of the second channel current (IC2) and/or the second channel voltage;
   comparing the determined level of the first channel current (IC1) and/or the first channel voltage

with a first threshold (T1);
comparing the determined level of the second channel current (IC2) and/or the second channel voltage with a second threshold (T2);
if both the determined level of the first channel current (IC1) and/or the first channel voltage is below the first threshold (T1) and the determined level of the second channel current (IC2) and/or the second channel voltage is below the second threshold (T2), supplying, by means of the two-channel LED driver (10), a third current (I3) and/or third voltage to the third set (LED3) of LED light sources.

2. The method according to claim 1, wherein the first set (LED1) of LED light sources comprises warm white LED light sources.

3. The method according to claim 1 or 2, wherein the second set (LED2) of LED light sources comprises cold white LED light sources.

4. The method according to any one of the preceding claims, wherein the first set (LED1) of LED light sources has a white color temperature warmer than the second set (LED2) of LED light sources, and wherein the third set (LED3) of LED light sources has a white color temperature warmer than the first set (LED1) of LED light sources.

5. The method according to any one of the preceding claims, wherein the first threshold (T1) is a current level and/or voltage level that corresponds to a brightness level of the first set (LED1) of LED light sources of between 5-50%, between 10-30%, preferably 15-25%, or more preferably around 20%.

6. The method according to any one of the preceding claims, wherein the second threshold (T2) is a current level and/or voltage level that corresponds to a brightness level of the second set (LED2) of LED light sources below 30%, below 20%, below 10%, below 5%, or below 2%.

7. The method according to any one of the preceding claims, wherein, when the first channel current (IC1) and/or first channel voltage decreases from a level at which the supply of the third current (I3) and/or third voltage started, the supply of the first current (11) and/or first voltage decreases at a higher rate than the supply of the third current (I3) and/or third voltage.

8. The method according to any one of the preceding claims, wherein the method comprises a step of, when the first channel current (IC1), and/or the first channel voltage, is decreased below a third threshold (T3), stopping the supply of the first current (11) and/or third voltage to the first set (LED1) of LED light sources, wherein the third threshold (T3) is above zero.

9. The method according to any one of the preceding claims, wherein the third current (I3) and/or third voltage is supplied to the third set (LED3) of LED light sources as a portion of the first channel current (IC1) and/or first channel voltage supplied by the first channel (C1) of the two-channel LED driver (10).

10. The method according to any one of the preceding claims, further comprising the step of distributing, when conditions for supplying the third current (I3) and/or third voltage is fulfilled, the first channel current (IC1), and/or the first channel voltage, provided by the first channel (C1) of the two-channel LED driver (10) in two portions into the first current (11) and/or first voltage and the third current (I3) and/or third voltage.

11. A LED lighting device (1) comprising:

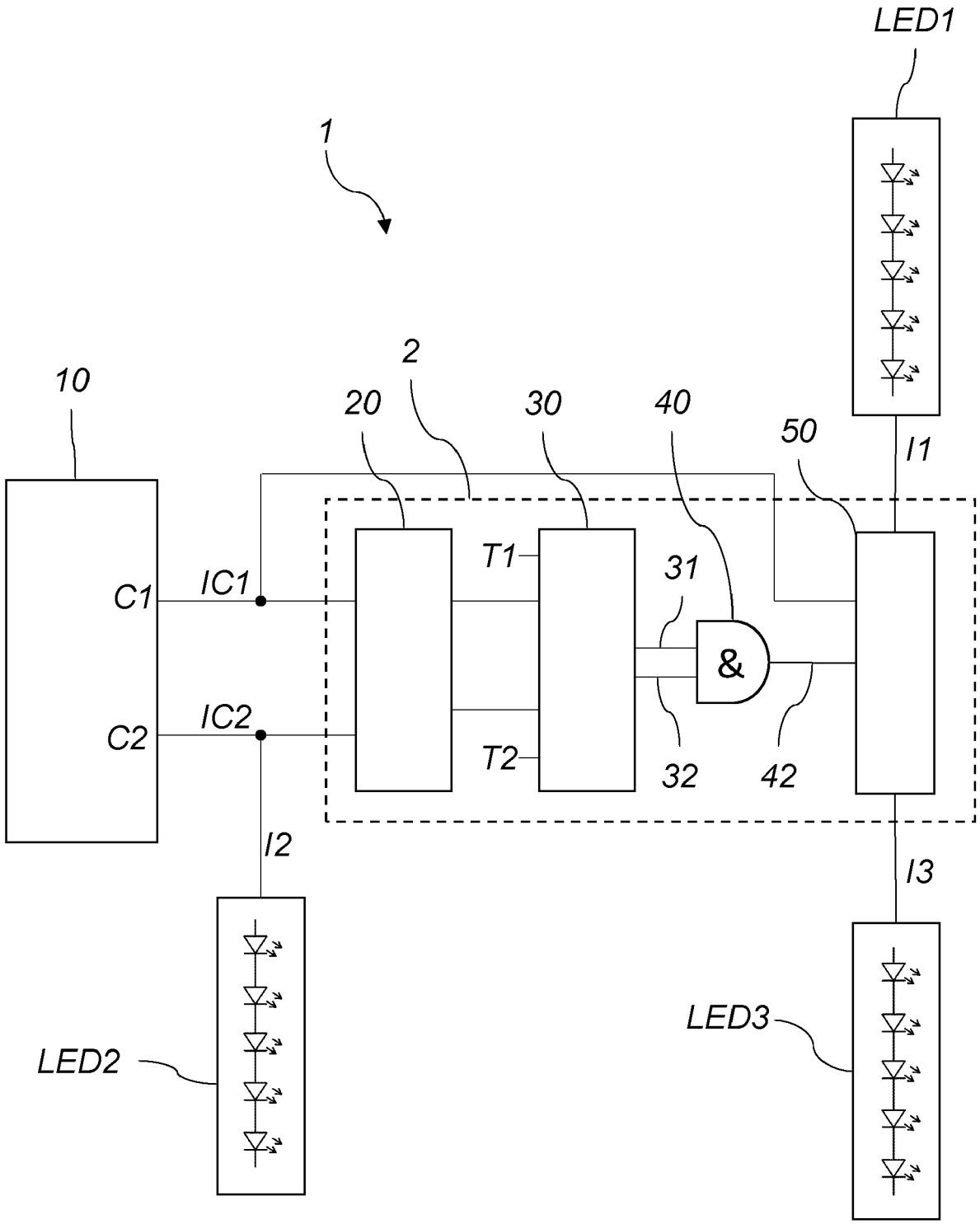
a first set (LED1) of LED light sources;
a second set (LED2) of LED light sources;
a third set (LED3) of LED light sources;
a two-channel LED driver (10) wherein a first channel (C1) of the two-channel LED driver is configured to provide a first channel current (IC1), and/or a first channel voltage, at least a portion thereof provides a first current (11), and/or first voltage, to the first set (LED1) of LED light sources, and a second channel (C2) of the two-channel LED driver is configured to provide a second channel current (IC2), and/or a second channel voltage, at least a portion thereof provides a second current (I2), and/or second voltage, to the second set (LED2) of LED light sources;
a sensor device (20) configured to determine a level of the first channel current (IC1), and/or the first channel voltage, and a level of the second channel current (IC2), and/or the second channel voltage;
a comparing unit (30, 40) configured to compare the determined level of the first channel current (IC1), and/or the first channel voltage, with a first threshold (T1), and to compare the determined level of the second channel current (IC2), and/or the second channel voltage, with a second threshold (T2);
wherein the two-channel LED driver (10) is configured to, if both the determined level of the first channel current (IC1), and/or the first channel voltage, is below the first threshold (T1) and the determined level of the second channel current (IC2), and/or the second channel voltage, is below the second threshold (T2), supply a third

current (I3), and/or third voltage, to the third set (LED3) of LED light sources.

12. The LED lighting device according to claim 11, wherein the two-channel LED driver (10) is configured to supply the third current (I3), and/or third voltage, as a portion of the first channel current (IC1), and/or the first channel voltage, provided by the first channel (C1).

13. The LED lighting device according to claim 11 or 12, further comprising a current distribution unit (50) configured to, when the third current (I3), and/or third voltage, is supplied to the third set (LED3) of LED light sources, distribute the first channel current (IC1), and/or the first channel voltage, provided by the first channel (C1) of the two-channel LED driver (10) in two portions as the first current (11), and/or first voltage, and the third current (I3), and/or third voltage, to the first set (LED1) and the third set (LED3) of LED light sources, respectively.

14. The LED lighting device according to claim 13, wherein the current distribution unit (50) is configured to distribute the first channel current (IC1), and/or the first channel voltage, as the first current (11), and/or first voltage, and the third current (I3), and/or third voltage, according to a predetermined distribution scheme based on the level of the first channel current (IC1), and/or the first channel voltage.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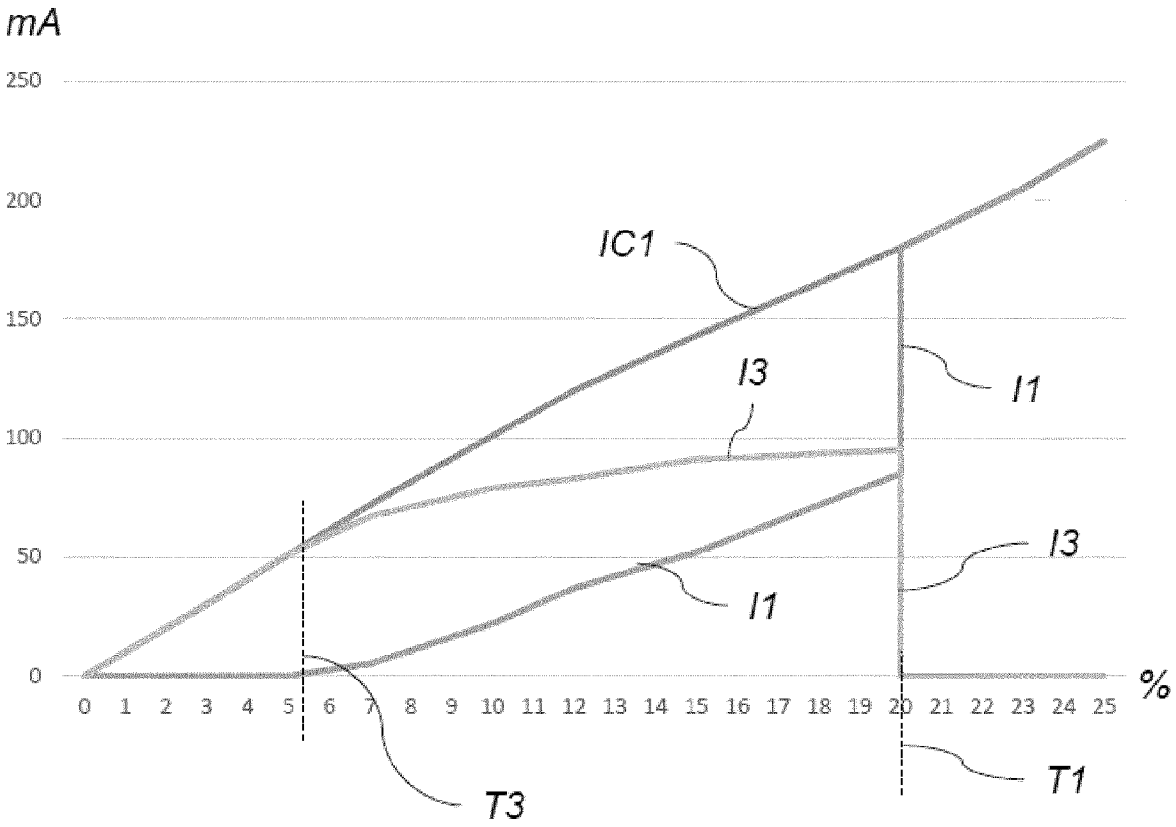
10
2
20
30
40
50
I1
C1
IC1
T1
31
&
C2
IC2
T2
32
42
I2
I3
LED2
LED3

Fig. 1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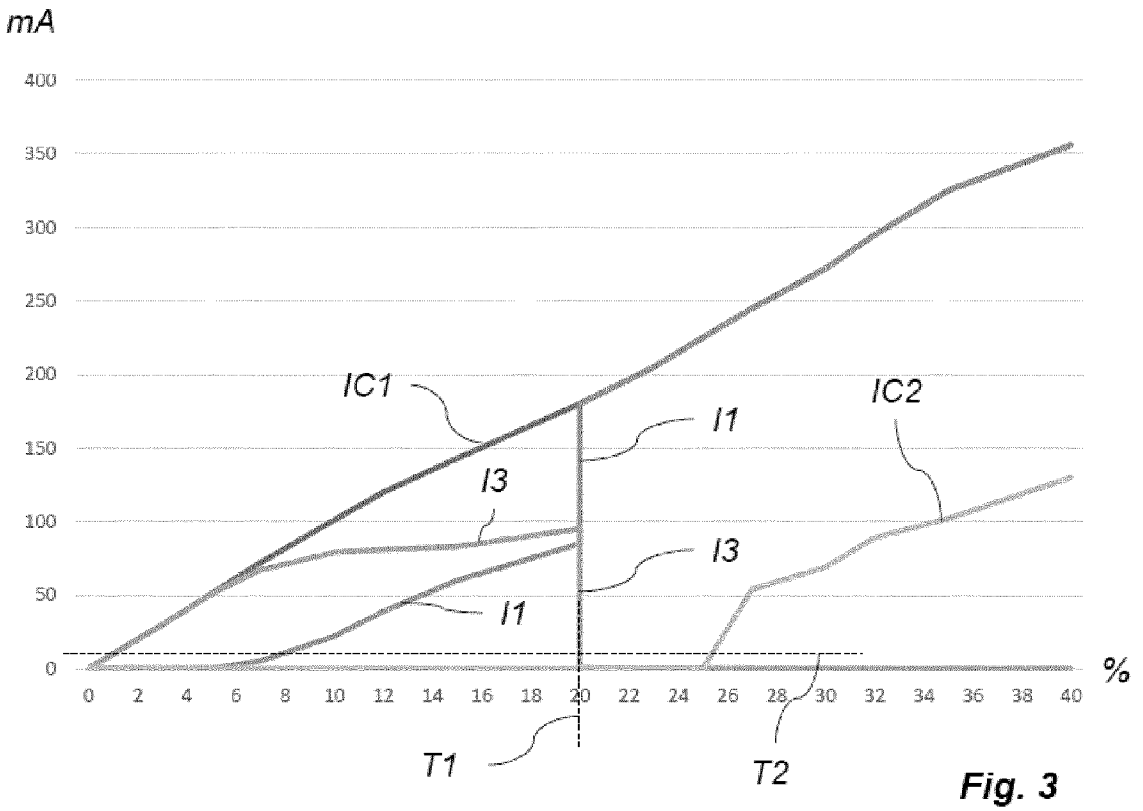
IC1
I3
I1
I3
I1
T3
T1

Fig. 2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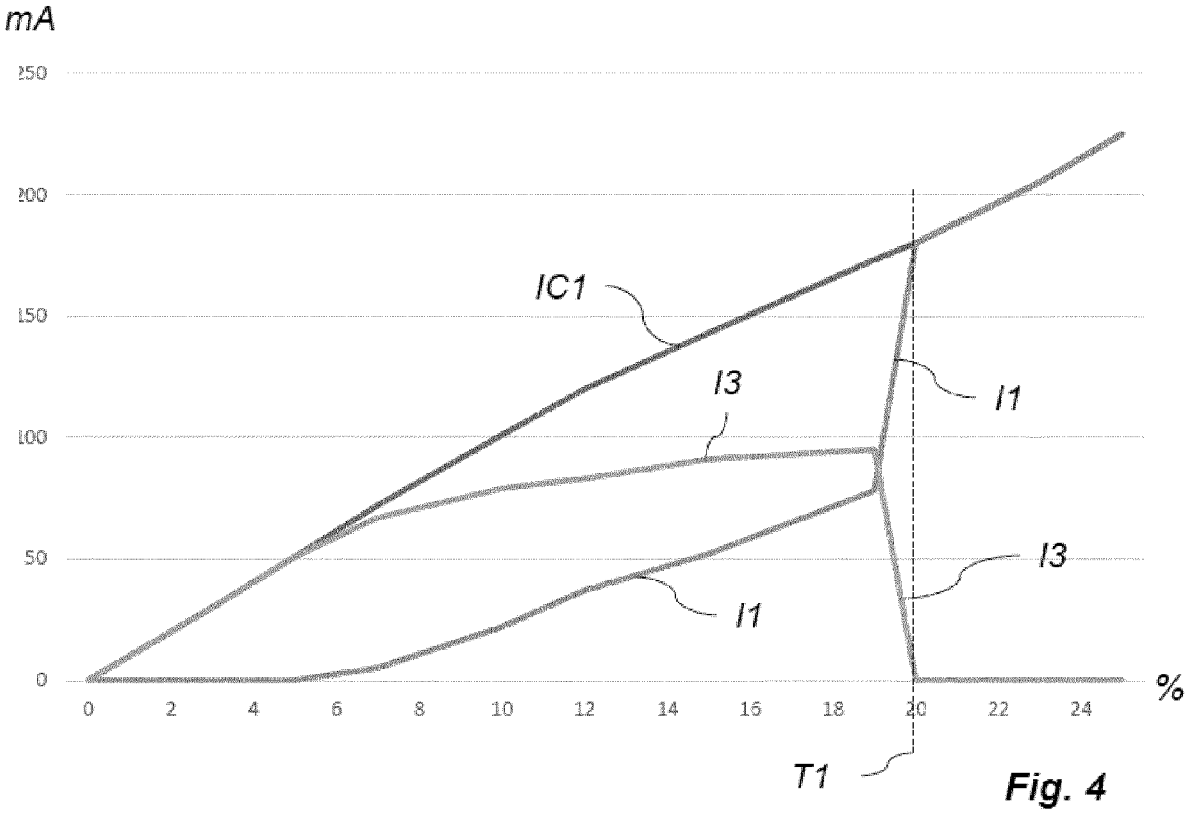
%
IC1
I1
IC2
I3
I3
I1
T1
T2

Fig. 3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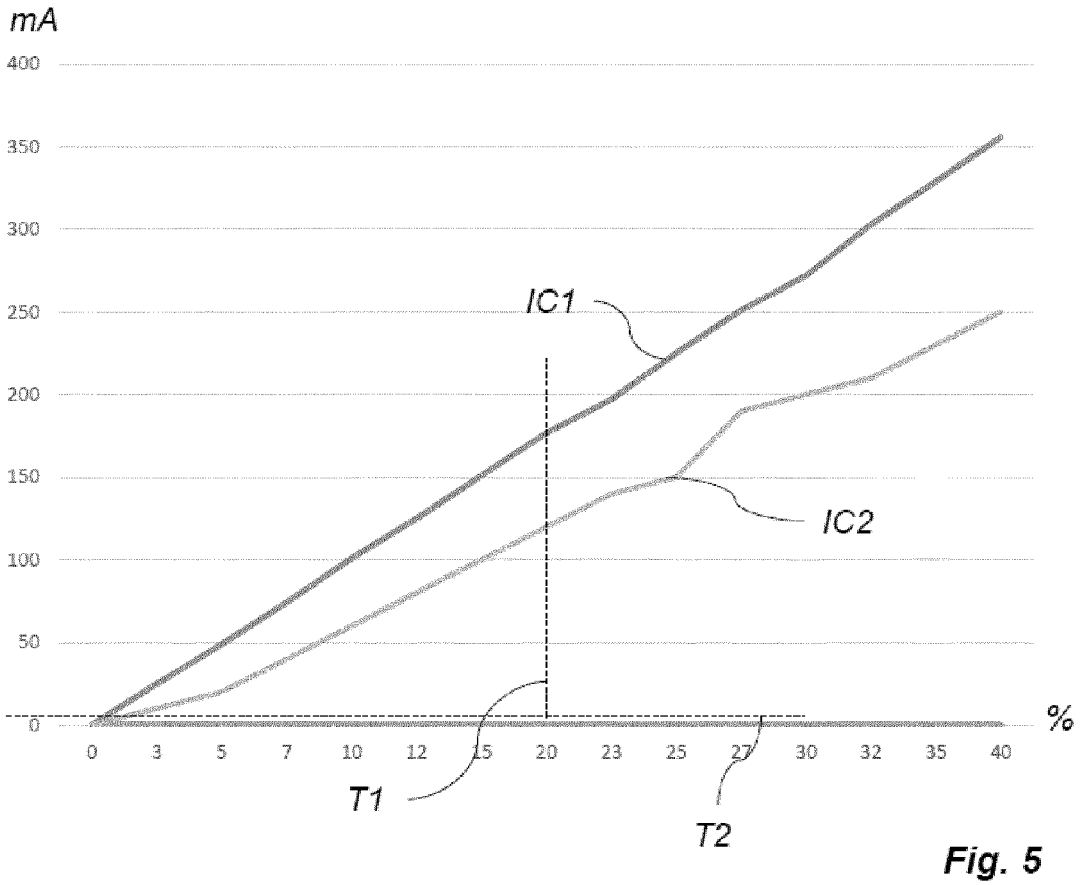
IC1
I3
I1
I1
I3
T1

Fig. 4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23
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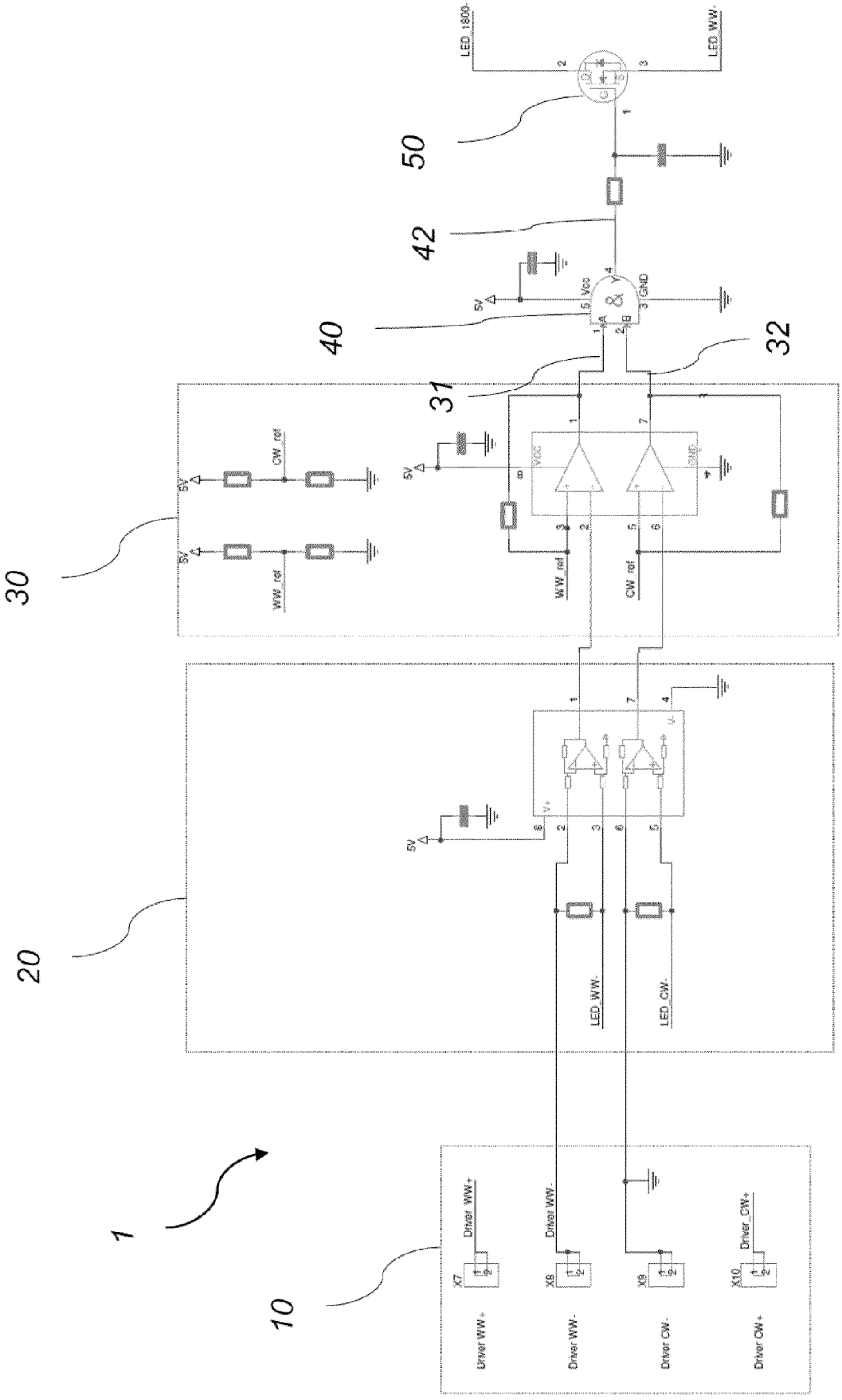
35
40
%
IC1
IC2
T1
T2

Fig. 5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LED_WW-
5V
Vcc
GND
CW_ref
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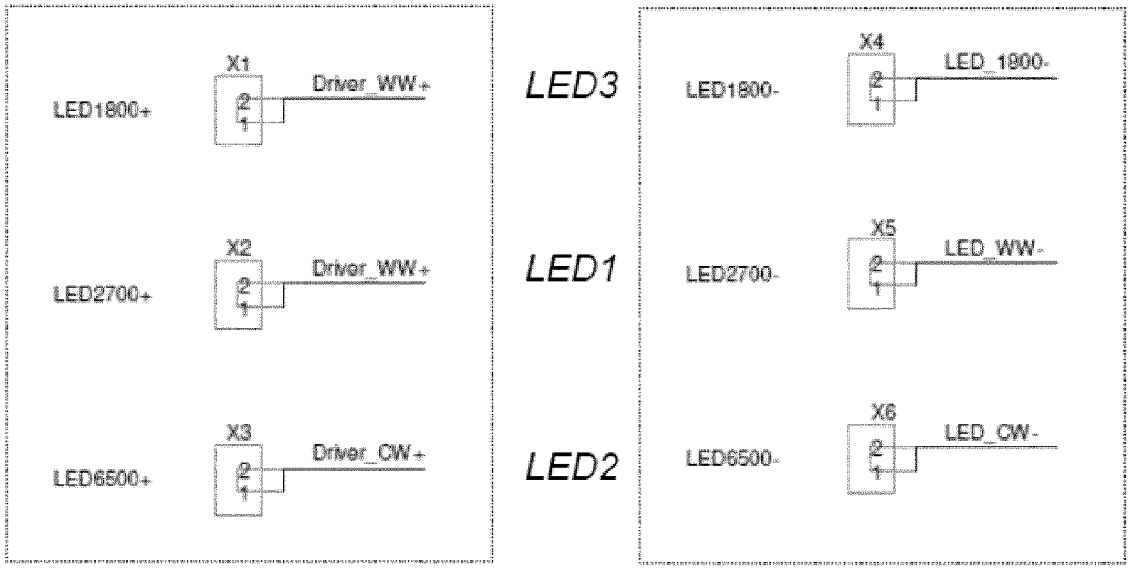
Driver CW-
Driver CW+
X7
X8
X9
X10

Fig. 6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X1
Driver_WW+
LED2700+
X2
Driver_WW+
LED6500+
X3
Driver_CW+
LED3
LED1
LED2
LED1800-
X4
LED_1800-
LED2700-
X5
LED_WW-
LED6500-
X6
LED_CW-

Fig. 7

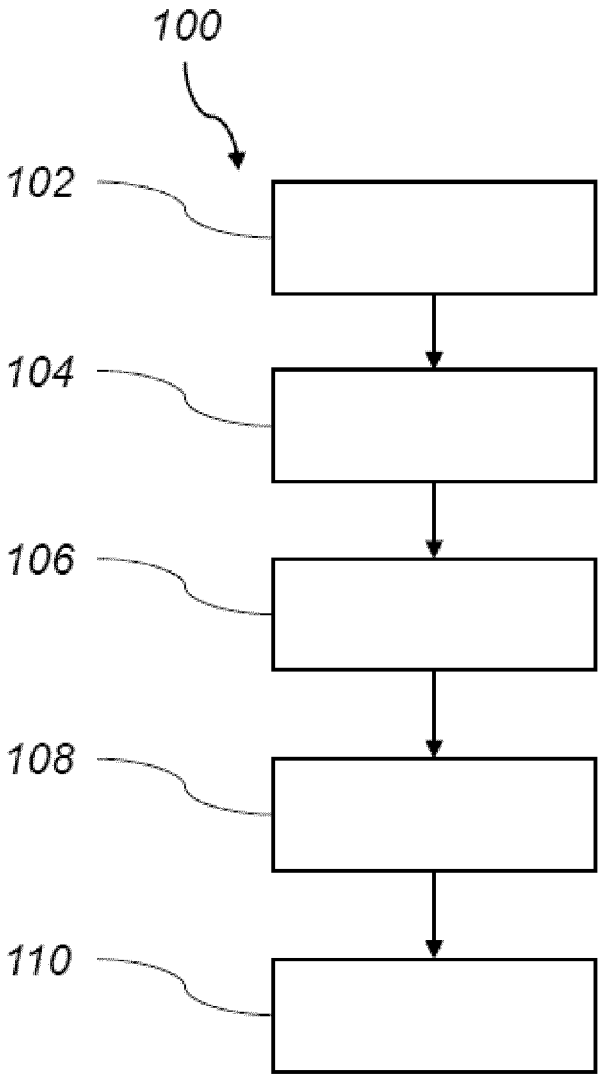
100
102
104
106
108
110

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 7961

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2018/295694 A1 (GHASEMI AFSHAR FARHANG [DE]) 11 October 2018 (2018-10-11) * paragraph [0034] - paragraph [0074]; figures 3, 4 *	1-14	INV. H05B45/24
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H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 March 2024	Plamann, Tobias

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21-03-2024

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