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(54) Method and apparatus for monitoring the condition of LEDs

(57) The invention relates to a method and apparatus for monitoring the condition of a LED illuminator comprising one or more light emitting diodes. The invention comprises the steps of: controlling the LEDs by means of pulsed current, measuring the light outputs of the LEDs or the LED illuminator by means of one or more light sensors separately during a minimum and maximum level of the pulsed control current. On the basis of the light outputs measured separately during the minimum and maximum levels of the pulsed control current, two separate measurement signals are generated to compare the light output signals corresponding to the minimum and maximum levels with each other and to thereby make conclusions on the operating condition of the LEDs or the LED illuminator.

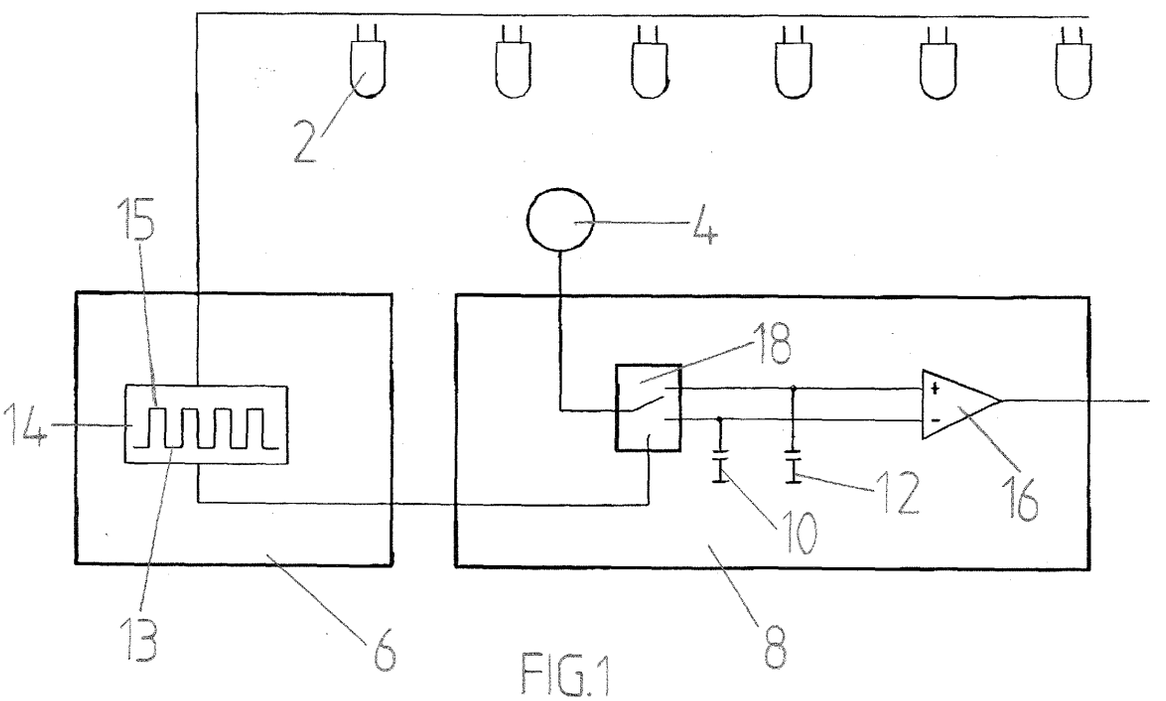

FIG.1

EP 1 562 406 A1

Description

BACKGROUND OF THE INVENTION

[0001] The invention relates to a method according to the preamble of claim 1 for monitoring the condition of a LED illuminator comprising one or more light emitting diodes and to an apparatus according to the preamble of claim 7 for monitoring the condition of a LED illuminator comprising one or more light emitting diodes.

[0002] Regular control of the condition of all types of safety illuminators is prescribed by regulations. Automated condition monitoring of safety lighting fixtures provided with an incandescent or a discharge lamp is a standard procedure. The operating condition of these lamps can be easily established by measuring electric parameters of the lamps.

[0003] Today lighting equipment employing light emitting diodes (LEDs) is ever increasingly used in exit signs and safety illuminators. Also the condition of these must be monitored according to the regulations. In prior art arrangements for condition monitoring of LED illuminators, a problem arises from how to provide automated and reliable measurement of the condition of the lighting fixture, because a LED may lose its lighting capacity gradually; the amount of current it consumes does not change but remains at the original level. Therefore measurement of current or voltage, i.e. electric parameters, does not provide reliable information about the condition of LEDs.

[0004] It is also possible to try to measure the condition of LEDs by measuring the light produced by them from the outside of the lighting fixture. However, if the lighting fixture contains a plural number of LEDs and/or is placed in an environment with a bright background light, this is difficult because due to the light coming from the outside or from adjacent LEDs, the measuring results are unreliable.

BRIEF DESCRIPTION OF THE INVENTION

[0005] It is therefore an object of the invention to provide a method according to claim 1 and an apparatus according to claim 7 to enable the above problems to be solved. The object of the invention is achieved by a method characterized in that the method comprises the following steps: controlling the LEDs by means of pulsed current, measuring the light output of the LEDs or the LED illuminator by means of one or more light sensors during the minimum and maximum levels of the control current, separating two separate measurement signals from the light outputs measured during the minimum and maximum levels of the pulsed control current, and making conclusions on the operating condition of the LEDs or the LED illuminator by comparing the measurement signals corresponding to the minimum and maximum control current levels with each other. The object of the invention is further achieved by an apparatus characterized in that the apparatus comprises current supply means for supplying pulsed control current to the LEDs and/or the LED illuminator, one or more light sensors for measuring the light output of the LEDs and/or the LED illuminator, and signal processing means for processing signals received from the light sensor.

[0006] The preferred embodiments of the invention are disclosed in the dependent claims.

[0007] The invention is based on controlling a LED illuminator comprising one or more light emitting diodes with pulsed current, whereby the LEDs are alternately on and off, or they burn with a brighter or a dimmer light. The light output of the LEDs or the LED illuminator thus controlled is measured by means of one or more light sensors installed in connection with the illuminator. The light sensor produces a measurement signal that varies substantially in accordance with the pulsed current. The measurement signal is divided into two separate signals, one of which corresponds to the minimum current level and the other one to the maximum level. The two separated measurement signals are then compared with each other and, as a result, a difference between the light outputs of the LEDs during the minimum and maximum levels of the pulsed current is obtained. As the light output of the LEDs degrades, the difference becomes smaller and finally reaches zero when there is no output from the LEDs. When the LEDs are on, the light intensity observed by means of the light sensor consists of the sum of the light output produced by the LEDs and the ambient light, whereas when the LEDs are off, the measured light intensity consists of the ambient light alone, if the minimum level of the pulsed current is zero. Consequently, the difference between these two separate measurement results obtained from the light sensor corresponds to the light output produced by the LEDs at a particular moment.

[0008] An advantage of the method and apparatus of the invention is that it enables ambient outside light to be eliminated from the measurement result of the light sensor and thus the monitoring of the operating condition of the illuminator is no longer distorted by ambient light. In addition, the method and apparatus of the invention provide a reliable solution for monitoring the condition of LEDs independently of the electric parameters of the LEDs and the LED illuminator.

BRIEF DESCRIPTION OF THE FIGURES

[0009] In the following, the invention will be described in greater detail with reference to the preferred embodiments and the accompanying drawing, in which

Figure 1 is a schematic view of a LED illuminator whose operating condition is monitored in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Figure 1 shows a schematic view of a LED illuminator of the present invention comprising means for monitoring the operating condition of LEDs. The LED illuminator in question comprises one or more LEDs 2, whose operation is controlled by current supply means 6. The current supply means 6 are configured to supply pulsed current to the LEDs whereby the LEDs are alternately on and off. The frequency of this kind of pulsed current may vary from 20 to 500 Hz, for example. Figure 1 shows an example of pulsed current 14. At a maximum level 15 of the pulsed current 14 the LEDs 2 are on and produce light, whereas at a minimum level 13 they are off and do not produce light.

[0011] The frequency of the pulsed current 14 may be set as required for a particular place and/or purpose of use of the illuminator. Moreover, the amplitude of the pulsed current 14, which represents the intensity of the current supplied to the LEDs 2, may be selected as required in each case. It is also possible to change the pulse ratio of the current to be supplied to the LEDs 2 by adjusting the ratio of the duration of the maximum level 15, i.e. when the LEDs 2 receive current, to the duration of the minimum level 13, i.e. when the LEDs 2 do not receive current. By changing the pulse ratio it is possible to adjust the brightness of the illuminator so that the duration of the maximum level 15 increases in relation to the duration of the minimum level 13. In this embodiment the pulsed current 14 is generated by means of a pulse oscillator, although any other device capable of producing pulsed current can be used as well. It is also possible to set the current impulse supplied to the LEDs 2 so that also at the minimum level 13 the LEDs 2 receive current, which due to its pulsed nature is lower than the current supplied at the maximum level 15. The following example, however, assumes that at the minimum level 13 there is zero current.

[0012] According to the present invention, the LED illuminator is provided with a light sensor 4 installed therein to measure light intensity inside the illuminator. The intensity of light inside the illuminator is always the sum of ambient light, i.e. that coming from outside the illuminator, and the light output produced by the LEDs 2. At the minimum level 13 of the pulsed supply current 14 the light output of the LEDs 2 is zero because the LEDs 2 are off and thus do not emit light, the light intensity inside the illuminator consisting only of the ambient light. At the maximum level 15 of the pulsed supply current 14 the LEDs emit light and therefore light intensity inside the illuminator is the sum of the ambient light and the light output produced by the LEDs 2. At the minimum level 13 of the pulsed current 14 the light sensor 4 thus automatically measures ambient light, whereas at the maximum level 15 it measures both the ambient light and the light produced by the LEDs 2.

[0013] From the measurement results obtained from the sensor 4, two separate measurement signals are separated, one of which corresponds to the measurement result obtained at the maximum level 15 of the pulsed current 14 and the other to the measurement result obtained at the minimum level 13. These two separate measurement signals are separated by means of separating means 18 provided in comparison means 8. The separating means 18 may consist of a switch, for example, that operates in response to a pulsed current signal received from current supply means 6, as shown Figure 1.

[0014] Having been supplied to the comparison means and separated there, the light intensity measurement signals corresponding to the maximum level 15 and the minimum level 13 of the pulsed current 14 are compared with each other. The comparison preferably takes place by calculating the difference between the two separate measurement results in subtraction means 16. In practice this is carried out by taking voltage samples from the separated measurement signals of the light sensor 4 and by supplying the samples to what are known as memory capacitors 10, 12. The voltage sample of the measurement signal representing the minimum level 13 of the pulsed current 14, i.e. when the LEDs are off, is stored in memory 10. The voltage sample of the measurement signal representing the maximum level 15 of the pulsed current 14, i.e. when the LEDs are on, is stored in memory 12. Next, to compare the voltage values stored in memories 10, 12, the difference between them is calculated. Another alternative is to temporally average these two separate signal levels stored in memories 10, 12 by means of suitable averaging means whereby sudden changes of short duration are filtered off from the measurement results. When comparison means 8 of Figure 1 are used, the switch 18 operating in response to pulsed current 14 guides the measurement signal obtained from the light sensor 14 to memory 12 when the LEDs are on and to memory 10 when the LEDs are off.

[0015] Since the measurement signal representing the minimum level 13 of the pulsed current 14 contains ambient light intensity alone and the signal representing the maximum level 15 contains both ambient light intensity and light output created by the LEDs, the ambient light intensity is filtered off from the measurement results when the difference between these two separate measurement signals is calculated. As a result, only the values of the light output produced by the LEDs are left, and in this embodiment the value representing the minimum current level 13 is zero, i.e. the LEDs do not receive current. Thus by calculating the difference between these two measurement results, it is possible to determine the light output and thereby also the condition of the LEDs and/or the LED illuminator on a continuous basis.

[0016] The value obtained from the subtraction means 16, which represents the operating condition of the LEDs 2 or the LEDs of the LED illuminator as a whole, can be compared with a predetermined limit val-

ue. Since LEDs tend to become dimmer in long-term use, the comparison with the predetermined limit value enables fully automated monitoring of the operating condition of the LEDs. Thus, when the value obtained from the subtraction means 16, which represents the operating condition of the LEDs, drops, an alarm can be raised by means of an alarm device (not shown) connected to the comparison means 8. After the alarm the operating condition of the LED illuminator can be restored by means of service operations or by replacing the illuminator with a new one.

[0017] The monitoring of the operating condition of the LEDs can be further facilitated and simplified by connecting the pulsed current 14 supply means 6 and the light sensor 4 to a microprocessor and/or a computer, which then functions as the comparison means 8. The processing of the measurement signal obtained from the light sensor 4 may be carried out totally or partly by the microprocessor. In that case the separation of the measurement signals corresponding to the minimum level 13 and the maximum level 15 of the pulsed current 14, their storage to memories 10, 12, their comparison, and the raising of the alarm in response to a predetermined limit value may be carried out easily by means of the microprocessor and/or computer and a software, if any.

[0018] With the apparatus described above the method of the present invention for monitoring the operating condition of a LED illuminator can be carried out. According to the method the light output of a LED illuminator controlled by pulsed current 14 is measured by means of a light sensor 4 installed inside the illuminator. Due to the pulsed current, light output varies in accordance with variations in the current, the frequency of a measurement signal obtained from the light sensor 4 substantially corresponding to the frequency of the pulsed current. The measurement signal is further supplied to the comparison means 8 to separate two separate measurement signals from the signal obtained, one of the signals corresponding to the light intensity of the LED illuminator at the minimum level 13 and the other one to its intensity at the maximum level 15 of the pulsed current 14. These two separated measurement signals are stored in their respective memories 10, 12 and temporally averaged to eliminate temporally sudden variations in ambient light. The averaged measurement signals are then compared by calculating the difference between them, the difference being further compared with a predetermined limit value. When the difference between the signals drops below the predetermined limit value, an alarm is raised to indicate that the operating condition of the LED illuminator has dropped below an accepted value.

[0019] It is apparent to a person skilled in the art that as technology advances, the basic idea of the invention can be implemented in various ways. Therefore the invention and its embodiments are not restricted to the above examples, but may vary within the scope of the accompanying claims.

Claims

1. A method for monitoring the condition of a LED illuminator comprising one or more light emitting diodes, **characterized in that** the method comprises the following steps:

   controlling the LEDs (2) by means of pulsed current (14) comprising a minimum level (13) and a maximum level (15);
   measuring the light output of the LEDs (2) or the LED illuminator by means of one or more light sensors (4) during the minimum (13) and maximum (15) levels of the pulsed control current (14);
   separating two separate measurement signals from the light outputs measured during the minimum (13) and maximum (15) levels of the pulsed control current (14); and
   making conclusions on the operating condition of the LEDs or the LED illuminator by comparing the measurement signals corresponding to the minimum (13) and maximum (15) levels of the control current (14) with each other.

2. A method according to claim 1, **characterized in that** the comparison of the measurement signals corresponding to the minimum (13) and maximum (15) levels of the control current (14) is carried out by calculating their difference.

3. A method according to claim 1 or 2, **characterized in that** it further comprises a step of averaging the measurement signals corresponding to the minimum (13) and maximum (15) levels of the control current (14) for a predetermined period before making conclusions about the operating condition of the LEDs or the LED illuminator.

4. A method according to any one of the preceding claims, **characterized in that** it further comprises a step of setting a predetermined limit value for the result obtained on the basis of the comparison/difference of the measurement signals corresponding to the minimum (13) and maximum (15) levels of the control current (14).

5. A method according to claim 4, **characterized in that** the method further comprises a step of raising an alarm when the result obtained on the basis of the comparison/difference of the measurement signals corresponding to the minimum (13) and maximum (15) levels of the control current (14) is below the predetermined limit value.

6. A method according to any one of the preceding claims, **characterized in that** the measurement signals received from the light sensors (4) are processed totally or partly by means of a microprocessor for determining the operating condition of the LEDs and/or the LED illuminator.

7. An apparatus for monitoring the condition of a LED illuminator comprising one or more light emitting diodes (2), **characterized in that** the apparatus comprises current supply means (6) for supplying pulsed control current to the LEDs and/or the LED illuminator, one or more light sensors installed inside the LED illuminator for measuring the light output of the LEDs and/or the LED illuminator, and signal processing means (8) for processing signals received from the light sensor (4).

8. An apparatus according to claim 7, **characterized in that** the current supply means (6) for supplying pulsed control current to the LEDs and/or to the LED illuminator comprise a pulse oscillator.

9. An apparatus according to claim 7 or 8, **characterized in that** the comparison means (8) comprise separation means (18) for separating light intensities measured by the light sensor (4) during the minimum (13) and maximum (15) levels of the pulsed control current (14) from one another.

10. An apparatus according to any one of claims 7 to 9, **characterized in that** the comparison means further comprise memory (12) for storing a measurement signal received during the maximum level (15) of the pulsed control current (14) and memory (10) for storing a measurement signal received during the minimum level (13) of the pulsed control current (14).

11. An apparatus according to any one of claims 7 to 10, **characterized in that** the signal processing means (8) comprise subtraction means (16) for determining the difference between the light output results measured during the minimum (13) and maximum (15) levels of the control current.

12. An apparatus according to claim 11, **characterized in that** the apparatus further comprises an alarm device for raising an alarm when the difference between the light output results measured during the minimum (13) and maximum (15) levels of the control current is below a predetermined limit value.

13. An apparatus according to any one of claims 7 and 9 to 12, **characterized in that** the microprocessor comprises signal processing means (8, 18, 10,12,16).

14. An apparatus according to any one of claims 7 and 9 to 13, **characterized in that** the computer and/or computer software comprise signal processing means (8, 18, 10, 12, 16).

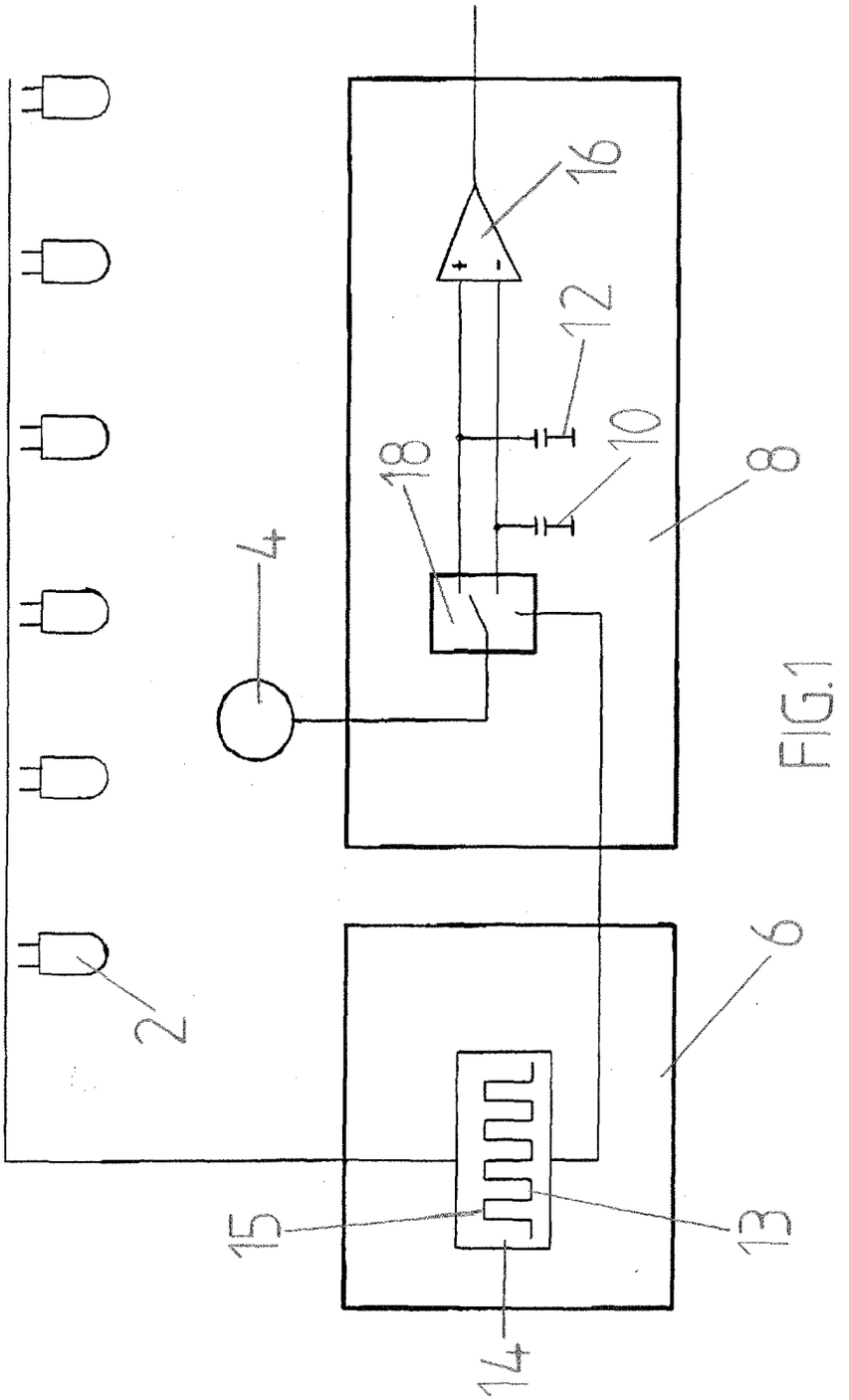

FIG.1

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EUROPEAN SEARCH REPORT

Application Number
EP 05 10 0565

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 April 2005	Burchielli, M

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X : particularly relevant if taken alone
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