(19) DANMARK

(10) **DK/EP 3038433 T3**

Patent- og Varemærkestyrelsen

(12) Oversættelse af europæisk patentskrift

(51) Int.Cl.: ***H 05 B 45/12 (2020.01)*** ***H 05 B 45/50 (2022.01)***

(45) Oversættelsen bekendtgjort den: **2022-10-24**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2022-07-13**

(86) Europæisk ansøgning nr.: **15199957.0**

(86) Europæisk indleveringsdag: **2015-12-14**

(87) Den europæiske ansøgnings publiceringsdag: **2016-06-29**

(30) Prioritet: **2014-12-23 DE 102014119623**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

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(54) Benævnelse: **LED-LYSMODUL, SIGNALLYS MED ET SÅDANT LYSMODUL SAMT FREMGANGSMÅDE TIL DRIFT AF ET SÅDANT LYSMODUL**

(56) Fremdragne publikationer:
EP-A1- 0 974 947
EP-A1- 1 992 524
WO-A1-2014/179379
WO-A2-2007/142947
WO-A2-2009/116854
DE-A1- 19 754 222
DE-A1-102005 032 719
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Technical field of the invention

The invention relates to an LED light module, a signal light with such a light module, in particular for rail, water, air or road traffic, and a method for operating such a light module.

Background of the invention

Because of their properties such as low current consumption and high durability, light emitting diodes (LEDs) are increasingly frequently used as replacements for conventional light sources, and indeed also in safety-related lights such as for example traffic signals, position lights and vehicle lights, which can be understood to be lights for all kinds of land, water and airborne vehicles.

In many lights, automatic monitoring of correct functioning is desired or even specified. While monitoring of correct functioning of conventional light sources can usually be performed easily (in general, it is sufficient to monitor whether current is flowing through the light source or not; if no current flows through the light source in spite of applied voltage, it can be assumed that the light source is defective and must be replaced), function monitoring of LEDs is not trivial for various reasons. For example, it might happen that an LED does not come on, even though current flows through it.

Total failure of an LED can be detected by combined current and voltage monitoring. However, this type of monitoring does not allow a change (degradation) of the luminous flux, for example due to ageing of the LEDs, to be detected.

LED light modules, i.e. arrangements usually with several LEDs and other elements such as ballast units for operating the LEDs, are known that are provided with operating time counters, which register the actual service life of the LEDs. If a certain service life is reached, the LEDs are replaced, irrespective of whether the light emitted by them is sufficient or not to meet the respective specified requirements. This approach results in LEDs that still function correctly being regularly replaced.

It has been shown that LED ageing depends not only on their pure service life, but also on other factors, in particular operating current and operating temperature.

An obvious solution of the problem of sensing an age-related reduction of light output is direct

monitoring of the light emitted by the operating LED by means of suitable sensors. For this purpose, DE 197 54 222 proposes a monitoring unit of an LED in which the light radiated by an LED is measured by a photo sensor. If the brightness of the light falls short of a defined limit value, a warning signal is generated that indicates to an operator of the LED that the LED should be replaced.

The type of monitoring known from DE 197 54 222 for the case of so-called line signals for rail traffic is actually potentially linked with very high material costs, as the monitoring unit is supplied with its own operating voltage, whereby the corresponding cables must frequently be routed over a few hundred metres, sometimes even a thousand and more, from a suitable connection point to the monitoring unit.

US 6,078,148 describes a control for a transformer with primary and secondary windings with a plurality of windings and pickups for changing the number of active windings and consequently an LED string light output. In this case, the pickups are controlled according to an operating parameter of the LEDs so as to keep the light output of the LEDs above a predefined level on the basis of a combination of measurements of voltages and currents at the LEDs.

EP 0 974 947 A1 discloses a light signal system with at least one signal transmitter, whose light source is formed as a matrix of arranged LEDs, and with a monitoring device for checking the light emitting diodes for fault-free operating condition, which has a light sensor arranged in the beam path of the LEDs and an evaluation unit connected to same for comparing a light sensor signal generated by the light sensor with a specified nominal value that corresponds to a normal operating condition of the light emitting diode.

DE 10 2005 032 719 A1 discloses a light signal system with at least one signal transmitter having light emitting diodes for emitting a light signal, with a control unit for controlling, evaluating and monitoring the signal transmitters, with wiring for the power supply and wiring for data transmission between the control unit and the signal transmitters, and with a circuit device for controlling the signal transmitters, and for each signal transmitter a circuit device arranged in its immediate vicinity, wherein the signal transmitters are connected to the control unit by means of a wiring section having the power supply wiring and the data transmission wiring.

According to DE 10 2010 026 012 A1, for generating different coloured light points with RGB LEDs, a signal transmitter has an optical sensor for secure signalling monitoring of the colour point and the light intensity of the signal transmitter.

To operate a fan, DE 10 2010 013 310 A1 discloses an output circuit connected to an output of a ballast unit for supplying a light module with electrical energy, wherein both the fan and a control circuit for supplying electrical energy are connected to the output circuit.

WO 2014/179379 A1 and WO 2009/116854 A2 respectively disclose an LED light module according to the generic term of claim 1. US 8,159,146 B1 discloses an LED driver with pulse width modulation.

Disclosure of the invention

The invention is based on the aim of providing an LED light module with a monitoring unit and a signal light provided therewith, in which the monitoring unit can be made at minimum material cost and consequently be particularly affordably operational.

The invention is also based on the aim of providing a method for operating an LED light module, which can be embodied in a cost-saving way, while at the same time ensuring high operating reliability.

The aims are achieved by an LED light module with the characteristics of claim 1, a signal light with the characteristics of claim 4, and a method with the characteristics of claim 3.

The LED light module according to the invention does not require a separate power supply to the monitoring unit, but this can be of use to the light module with pulse width modulation of the delivered current so as to monitor the luminous flux emitted and thereby dispense with a costly elimination of stray light portions, which are sensed by conventional monitoring units. These and further advantages emerge from the following description, purely exemplary and not limiting, of embodiment examples in conjunction with the drawing, which consists of two drawing figures.

Brief description of the drawing

Fig. 1 shows a highly diagrammatic block diagram for basic understanding of the way the invention works.

Fig. 2 highly diagrammatically shows an embodiment example of a light module according to the invention.

Description of preferred embodiments

Fig. 1 highly diagrammatically shows the basic idea of the invention according to which a string 10 of series-connected LEDs of a corresponding LED light module, in particular a light module for signal lights of road and rail traffic, a current with a defined voltage is delivered in a manner known per se via a wire 12 and then a part of the delivered current is used via a circuit parallel to at least some of the LEDs of the string so as to operate a monitoring unit 14. The monitoring unit 14 can sense defined operating parameters of the light module, such as for example the current flowing through the string during operation, the voltage dropping across the string, the temperature in the surroundings of the string and the luminous flux generated by the string and can output characteristic values for these operating parameters to a higher-order evaluation unit 16.

The monitoring unit 14 can be supplied entirely via the power supply of the LED string, so that a separate power supply is advantageously dispensed with, and therefore monumental quantities of cable can be partially saved, in particular when the light module is used in signal lights for rail traffic. Means can be provided such as voltmeters for the LED forward voltage, which are connected in parallel to one or more LEDs 18 of the string 10. These means can be supplied with current via the current supply 20 of the LEDs when the light module is operating.

The higher-order evaluation unit 16 is supplied via the current supply of the LED string, therefore avoiding stray light sensing, in an LED string disconnected in particular in a pulsed manner. The modern components required for this, such as for example temperature or photo sensors, as well as micro controllers, have such a low current consumption that there are no noticeable effects on the luminous flux of the LED string, when a part of the current supplying the units 14 and 16 is channelled off via the said parallel circuit.

An LED string 10 typically is of the type in question here, for example eight series-connected LEDs

with a current consumption of 350 mA, while a photo sensor as a means for sensing a further operating parameter and a corresponding micro controller for evaluating the signal from the photo sensor have a current consumption in the region of about 1 to 2 mA. It has been shown that a circuit according to the invention functions excellently in particular when the current consumption of the units 14 and 16 is more than 20 times lower than the current consumption of the LED string, preferably about 50 to 100 times lower.

Fig. 2 shows an embodiment example of the invention, wherein two operating parameters are sensed here and are used to monitor and control the LED string in the manner according to the invention. The units corresponding to the units of Fig. 1 are provided with the same reference numbers also used in Fig. 1.

The illustrated light module in this embodiment example forms a unit, which is installed in particular in a signal light and can be supplied externally with current via a wire 12. The LED string is formed by a number of series-connected LEDs 18, only some of which are shown here, wherein the supply voltage and the current are controlled by a ballast unit 20. The ballast unit 20 in this embodiment example is part of the light module like the evaluation unit 16, but, like the evaluation unit 16, can also be arranged outside the actual light module. The evaluation unit 16 and the ballast unit can be part of a single control unit.

As indicated by the wire 22, current is supplied to a monitoring unit 14 at a first point via a circuit parallel to the series connection of the LEDs 18, wherein the different square wave signals symbolically shown in the figure are meant to indicate that the current is pulse width modulated.

As indicated by the relevant circuit diagram, the monitoring unit 14 in this embodiment example comprises a photo sensor 24, which is arranged in the light module and senses a value proportional to the luminous flux generated during operation of the LEDs. In light modules of the type in question here, the LEDs are typically arranged rotationally symmetrically, and the light module is provided with a viewing or diffusing disc, whereby a part of the emitted light is reflected back, which can then be sensed by the photo sensor 24.

The monitoring unit 14 in this embodiment example further comprises two voltmeters 26, which,

together with corresponding shunt resistors 28 and wires 30 enable indirect current measurement of the current flowing through the LED string in operation.

Not illustrated, but provided in a preferred embodiment, is a voltmeter, which measures the total voltage dropping across the LED string, which can be advantageous in particular in light modules for use in signal lights for rail traffic. The advantages of combined current and voltage monitoring when monitoring LED strings are known and disclosed for example in EP 1 992 524 A2, whose content is integrated herewith by reference. In an embodiment variant of the invention, means provided for sensing the current and/or voltage can be supplied in a pulsed manner with current via the current supply of the LEDs.

The values from the voltmeter 26 representative of the actual current, therefore the current actually flowing through the LED string and a value measured by the photo sensor 24, proportional to the luminous flux emitted during operation of the LEDs, are delivered to the evaluation unit 16, which in this embodiment example comprises a micro controller 32 and a regulator 34, which is designed to output a control value to the ballast unit 20. It can be noted that the evaluation unit 16 does not have its own current supply as in previously known light modules, but is advantageously supplied, like the monitoring unit 14, by the current delivered to the LEDs 18. If the photo sensor now senses that the luminous flux emitted during operation is decreasing for example due to a degradation of the LEDs 18, the evaluation unit 16 can generate an appropriate control signal, by means of which the ballast unit 20 is triggered to increase the current delivered to the LEDs so that the desired luminous flux is provided. With the boundary condition mentioned above, that the current consumption of the monitoring unit 14 and the evaluation unit 16 is significantly lower than the current consumption of the LEDs, the reduction in brightness of the LEDs due to the current being channelled off can be disregarded particularly such sensed anyway by the photo sensor (24) and resulted in a readjustment of the current.

The evaluation unit 16 is designed to control the current delivered to the LED string directly or indirectly as a function of the so-called “further operating parameter”, here therefore the luminous flux, therefore either directly influencing the current as part of a complex control circuit or else communicating with a separate unit, in this case the ballast unit 20, and transmitting this information, which is a basis for controlling the current, and thus indirectly controlling the current.

In the embodiment example shown in Fig. 2, the actual current sensing is designed as double channel, consequently with redundancy, so that incorrect measurements are practically eliminated, because the micro controller 32 can be designed such that it can generate a corresponding fault report in the event of discrepancies between the two signals representative of the actual current, which can then be communicated in a manner known per se to a higher-order location, for example a maintenance centre.

Other than the aforementioned securing of a stable colour point, the pulse width modulated operation envisaged in a preferred embodiment of the invention has two important further advantages. Consequently, in those cases in which the means for sensing at least one further operating parameter comprise a photo sensor as in Fig. 2, costly elimination of the stray light portion, since the sensor is only in operation due to the supply according to the invention via the LED current when the LEDs are also switched on, whereby stray light portions can then be disregarded. Light falling onto the sensor when the LEDs are switched off between two current pulses, is not included by the sensor in the usual summation, so that affordable standard photo sensors can be used advantageously, which sum light over a determined period of time so as to output a measurement value.

A further advantage of pulse width modulated operation is that the evaluation unit 16 can check whether the photo sensor 24 or the voltmeter 26 deliver signals during the time between two current pulses, which can then lead to deducing defective functioning of the photo sensor and/or the voltmeter, and can generate a corresponding fault report in a manner known per se. The evaluation unit 16 thereby virtually disposes of a function for testing the means for sensing the at least one further operating parameter. The signals emitted by the voltmeter and/or the photo sensor are therefore checked as to whether they display a pattern corresponding to the pattern of the pulse width modulated current.

Many variations and further developments relating in particular to the type and number of the means for sensing operating parameters of the LEDS are possible within the framework of the concept of the invention. Sensing the temperature in the surroundings of the LEDs of the string is envisaged in a preferred embodiment of the invention, wherein a fan for example can be switched on at this value via the evaluation unit. Such a fan can also advantageously be supplied with current via the operating

current of the LEDs, since in typical cases of application, the fan only needs low power.

For the first time, in a particularly simple and affordable way, the invention allows a particularly secure monitoring to be performed of the correct functioning of an LED light module, since three different monitoring methods – monitoring the voltage dropping across the LED string, monitoring of the current flowing through the string and sensing a value proportional to the luminous flux emitted – can be combined.

Reference signs list

10	LED string
12	Wire
14	Monitoring unit
16	Evaluation unit
18	LEDs
20	Ballast unit
22	Wire
24	Photo sensor
26	Voltmeter
28	Shunt resistors
30	Wires
32	Micro controller
34	Regulator

Patentkrav

1. LED-lysmodul, navnlig til vej- og skinnetrafiks lyssignaler, omfattende

- mindst en streng (10) af serieforbundne LED'er (18),
- midler til overvågning (26, 28, 30) af strømmen, der strømmer gennem strengen under strengens drift, og/eller spændingen, der falder over strengen,
- en strømforsyning (20) til LED'erne,
- en overvågningsenhed (14), omfattende midler til registrering af mindst ét yderligere driftsparameter for LED'erne, der omfatter en sensor (24) til registrering af en værdi, der er proportional med en under lysmodulets drift afgivet lysstrøm, og til afgivelse af et signal på basis af værdien, og

en evalueringsenhed (16), der er konfigureret til at styre strømforsyningen (20) til LED'erne for en strøm tilført LED-strengen ved pulsbreddemodulation som en funktion af signalet,

kendetegnet ved, at

overvågningsenheden (14) under lysmodulets drift ligeledes forsynes via LED'ernes (18) strømforsyning (20) med strøm svarende til pulsbreddemodulationen.

2. LED-lysmodul ifølge krav 1, kendetegnet ved, at evalueringsenheden (16) har en funktion til test af midlerne til registrering af det mindst ene yderligere driftsparameter.

3. Fremgangsmåde til drift af et LED-lysmodul, navnlig til vej- og skinnetrafiks lyssignaler, hvor

- lysmodulet har en streng (10) af serieforbundne LED'er,
- strømmen, der strømmer gennem strengen under drift, og/eller spændingsfaldet over strengen overvåges,
- en værdi proportional med en afgivet lysstrøm under drift af lysmodulet registreres, og et signal på basis af værdien afgives til en evalueringsenhed (16) på højere niveau ved hjælp af en sensor (24) fra en overvågningsenhed (14), og

den til strengen tilførte under drift styres af en pulsbreddemodulation for LED'ernes strømtilførsel som en funktion af værdien,

kendetegnet ved, at

ligeledes overvågningsenheden (14), under lysmodulets drift, forsynes via LED'ernes strømforsyning med strøm svarende til pulsbreddemodulationen.

4. Signallys, navnlig til vej- og skinnetrafik, kendetegnet ved, at det omfatter et LED-lysmodul ifølge krav 1 eller 2.

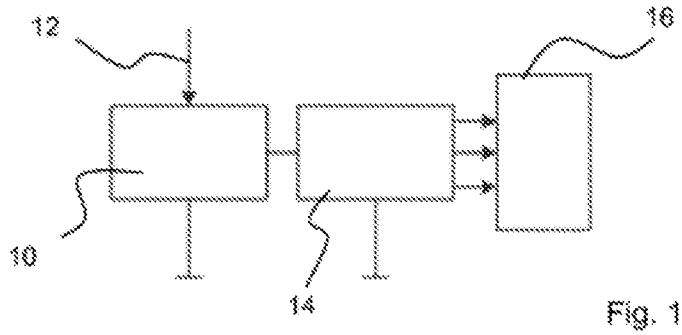

Fig. 1

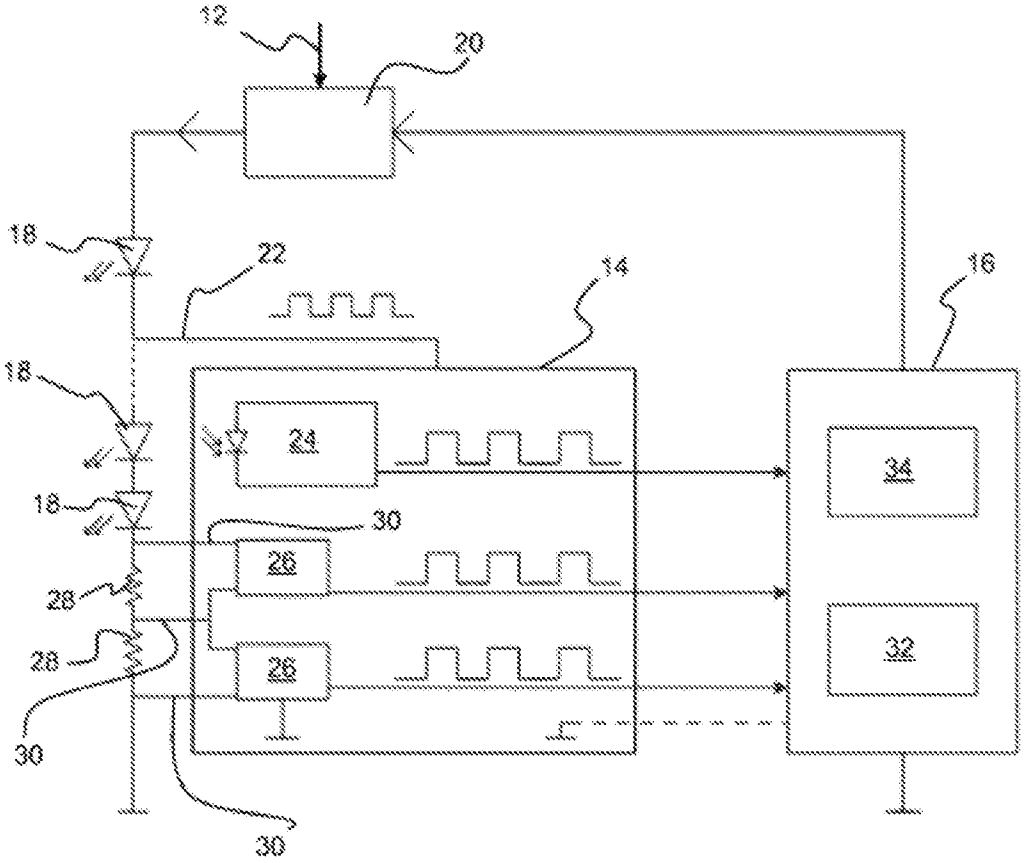

Fig. 2