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(54) **Monitoring unit for a high-power LED, and signaling device**

Überwachungseinheit für eine Hochleistungs-LED und Signalisierungsvorrichtung

Unité de surveillance pour DEL haute puissance et dispositif de signalisation

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Description

Background of the Invention

[0001] The invention relates to a monitoring unit for monitoring a high-power LED, driven by a preferably constant electric current, and to a signalling device comprising at least one such monitoring unit.

[0002] For railway signalling purposes, conventional signalling lamps (e.g. 12 VAC, 35 W) are being replaced by high-power light emitting diodes (e.g. 4 V, 350 mA) together with special mirror/lens systems. A major advantage of using LEDs instead of conventional signalling lamps is their superior durability which entails an increased cost-effectiveness of their operation.

[0003] However, in particular when using LED arrays of the above-mentioned type for signalling purposes, for instance in railway systems, some kind of monitoring has to be provided which allows an easy and reliable detection of malfunctions of the LEDs due to short circuits and/or disconnections.

[0004] EP 1 777 533 A1 discloses a monitoring device for an array of LEDs, the LEDs being connected in series and driven by a constant electric current. The monitoring device comprises a bypass means operable to bypass the respective LED in case of a disconnection of the respective LED, and an evaluation unit connected in parallel to the array of LEDs. The evaluation unit is adapted to determine a total voltage of the array and to output a control signal indicative of a function status of the LED array in accordance with a value of the total voltage relative to a predetermined threshold value.

[0005] EP 1 916 879 A1 discloses a secure opto-electronic failure detection of high power LEDs using an electronic circuit having a LED unit with a plurality of LEDs and a photo detection sub-circuit including at least one photo detection unit for providing an output voltage in dependence of the illumination of the at least one photo detection unit by the LEDs of the LED unit.

[0006] US 2005/0140345 A1 discloses a monitoring and redundancy circuit having a messaging line and an input circuit Pd of a coupler Pc, for a diode circuit composed of a plurality of diodes connected in series. The diode circuit comprises a plurality of groups of diodes, each group being connected in parallel to a bypass circuit. The bypass circuit includes a voltage-controlled switching device connected in parallel to the corresponding group, and a detection device which has a constant voltage device and a fusing circuit, both of which are connected in series. The detection device is connected in parallel to a corresponding group, so that, when, because of increased resistance of any diode, a voltage applied to one of the groups exceeds a given voltage defined by the constant voltage device, the constant voltage-controlled switching device is turned on so as to bypass a current that is to pass through the corresponding group, thereby continuing the operation of the whole apparatus even when one or more diodes are broken down. In some

examples, bypass auxiliary circuits are used, allowing to exert redundancy also when one or more of the diodes are short-circuited, i.e. when the internal resistance thereof is lowered.

[0007] DE 10 2007 024 784 A1 discloses a circuit arrangement which has a control circuit for recognition of an electrical failure or a short-circuit in a light emitting diode. The control circuit is connected with a monitoring branch in such a manner that it is impinged with a voltage drop due to all light emitting diodes of the monitoring branch. A bridging member of the control circuit has a switching unit controlled by the control circuit for bridging the monitoring branch.

Object of the Invention

[0008] It is an object of the invention to provide: a monitoring unit for reliably detecting failures of a high-power LED.

Summary of the Invention

[0009] According to one aspect, this object is met by a monitoring unit as described in the introduction, comprising: a coupler, in particular an optical coupler, for coupling the monitoring unit to a messaging line, an input circuit of the coupler being arranged in parallel to the high-power LED, and a bypass unit adapted to bypass the input circuit of the coupler in case of a disconnection of the high-power LED for switching off a switch, in particular an optical switch, in the output circuit of the coupler, the bypass unit comprising a voltage divider and an electronic switch, both being arranged in parallel to the high-power LED, the voltage divider being adapted to produce a control voltage which closes the electronic switch in case that the high-power LED is disconnected, the monitoring unit further comprising a resistance arranged between the voltage divider and the electronic switch and in series to the input circuit of the coupler.

[0010] Due to the current-regulating trigger circuit (voltage converter) which is feeding the LED with a constant current, the disconnection of the LED increases the voltage across the bypass unit, respectively, across the voltage divider. The control voltage which is tapped e.g. between two resistances of the voltage divider is now sufficient to switch the electronic switch on, thus bypassing the input circuit of the coupler. Thus, the increase of the voltage drop causes the bypass unit to bridge the input circuit of the coupler (comprising an internal LED for potential-free coupling of the input circuit to a photodiode in the output circuit in case that the coupler is an optical coupler, also known as opto-coupler or optical isolator). The bridging of the input circuit then sets the (optical) switch in the output circuit of the coupler to an open state, causing a break in the messaging line which may be detected in a detection unit which is provided for this purpose. Typically, the electronic switch is implemented as a (bi-polar) transistor.

[0011] It will be understood that instead of opto-couplers, other types of couplers allowing potential-free coupling, such as insulation amplifiers, mechanical relays, etc. may be used. However, as a coupler having low current consumption is of advantage for the present purposes, using an opto-coupler is in general preferred over couplers with higher current consumption, such as mechanical relays.

[0012] As indicated above, the monitoring unit further comprises a resistance arranged between the voltage divider and the electronic switch and in series to the input circuit of the coupler. During normal operation of the LED, the latter provides the input circuit of the coupler with a current which is sufficient for keeping the switch in the output circuit in the active (closed) state. However, when a short-circuit of the LED occurs, the current through the input circuit is no longer sufficient to keep the switch in the active state, such that the short-circuit of the LED may be detected by a disconnection / break of the messaging line. Typically, the monitoring current through the series connection of resistance and input circuit should be less than 20 %, preferably less than 10 % of the lowest current flowing through the LED. For example, with a current through the LED varying between 20 mA and 350 mA, the monitoring current is typically in the order of 2 mA.

[0013] Thus, both a disconnection and a short-circuit of the monitored LED may be observed at the output circuit of the coupler by a change of the switch comprised therein from the active to a passive state, leading to a disconnection of the messaging line. Consequently, both types of failure cause the same result in the output circuit and may be detected using one and the same messaging line.

[0014] A further aspect of the invention relates to a signaling device, comprising: at least one high-power LED, and at least one monitoring unit as described above, the monitoring unit being arranged in parallel to the high-power LED. The monitoring unit allows for an easy detection of faults of the high-power LED using a potential-free coupling to a messaging line. Typically, the signaling device comprises at least two high-power LEDs arranged in series, each high-power LED being arranged in parallel to a respective monitoring unit. In this case, the messaging line is preferably connected to the output circuits of the respective monitoring units in a series connection, such that a malfunction of any one of the high-power LEDs can be detected as a break in the messaging line.

[0015] In one embodiment, the signaling unit further comprises a constant current source for driving the at least one high-power LED with a constant current. Current control of the high-power LED is typically required for safe detection of a disconnection of the high-power LED, as an increase of the voltage drop across the high-power LED is required for this purpose. The person skilled in the art will appreciate that in practical applications, a constant current source may only be approximated. However, it is sufficient when the current source is sufficiently stable to cause an increase of the voltage

drop across the high-power LED which activates the bypass unit when a disconnection of the high-power LED occurs.

[0016] In one embodiment, the signaling device is implemented as a railway signaling lamp. Railway signaling lamps are safety-critical components and their failure may have serious consequences. However, it will be understood that the signaling device described above may also be of advantage in various applications not related to railway systems.

[0017] Further features and advantages are stated in the following description of exemplary embodiments, with reference to the figures of the drawing, which shows significant details, and are defined by the claims. The individual features Further features and advantages are stated in the following description of exemplary embodiments, with reference to the figures of the drawing, which shows significant details, and are defined by the claims. The individual features can be implemented individually by themselves, or several of them can be implemented in any desired combination.

Brief Description of the Drawings

[0018] Exemplary embodiments are shown in the diagrammatic drawing and are explained in the description below. The following are shown:

Fig. 1 shows a schematic circuit diagram for illustrating an inventive signaling device comprising a monitoring unit for monitoring a single LED,

Fig. 2 shows a similar diagram for monitoring two LEDs connected in series,

Fig. 3 shows a simulation circuit used for simulating the arrangement shown in Fig. 1, and

Fig 4 shows voltage and current values measured at different points of the simulation circuit represented in Fig 3.

Detailed Description of Preferred Embodiments

[0019] **Fig. 1** shows a circuit diagram of a signaling device 1 for railway signaling having a high-power light-emitting diode, being referred to as LED in the following. The LED may be part of railway signal lamp, forming a safety-critical system. In order to provide reliable signaling with the LED, it is necessary to monitor its correct functionality and to detect failures, typically disconnections or short-circuits of the LED. For this purpose, a monitoring unit 2 is arranged in parallel to the LED, the monitoring unit 2 having an electro-optical coupler 3 and a bypass unit 4.

[0020] The opto-coupler 3 comprises an input circuit 3a and an output circuit 3b, the input circuit 3a being arranged in parallel to the monitored LED, the output cir-

circuit 3b being part of a messaging line 5. The input circuit 3a comprises a further (integrated) LED 6 which emits light which is received by a photodetector being part of an optical switch 7 (including a photodiode) arranged in the output circuit 3b. The opto-coupler 3 provides for a potential-free coupling of the input circuit 3a to the output circuit 3b by electrically insulating the input circuit 3a from the output circuit 3b. It will be understood that instead of the optical coupler 3, other types of couplers allowing for potential-free coupling may be used, for instance mechanical relays or insulation amplifiers.

[0021] When the monitored LED is operable, a current I flows through the LED, causing a voltage drop across the LED which entails a current flow through a resistance R1 which is arranged in series to the input circuit 3a of the coupler 3. The current thus produced is sufficient to make the further LED 6 produce an amount of light which sets the optical switch 7 in the output circuit 3b of the coupler 3 to an active (closed) state. Thus, when the LED operates correctly, the optical switch 7 connects the two parts of the messaging line 4 and no failure is detected.

[0022] In case of a short-circuit of the LED, the voltage drop across the LED decreases, causing a reduction of the current through the input circuit 3a of the coupler 3. The value of the resistance R1 is chosen such that the current through the input circuit 3a, resp., the further LED 6, falls below a threshold value which causes the optical switch 7 in the output circuit 3b to switch from its active (closed) state to a passive (open) state, causing a break in the messaging line 5 which may be observed in a detection unit (not shown) adapted for this purpose.

[0023] For detecting a disconnection of the LED, the bypass unit 4 is used. The bypass unit 4 comprises an electrical switch 8 in the form of a bi-polar transistor and a voltage divider 9 comprising a second and third resistance R2, R3. The voltage in-between the resistances R2, R3 of the voltage divider 9 is tapped and provided as a control voltage to the electrical switch 8. During normal operation of the monitored LED, the control voltage is below a threshold value for switching the electronic switch 8 to its active state. Only when the monitored LED is disconnected, the voltage drop across the monitored LED increases due to the regulated current I which is used for driving the LED, such that the control voltage exceeds the threshold value of the control voltage, thus setting the electronic switch 8 to its active (closed) state. The electronic switch 8 then bridges (short-circuits) the input circuit 3a of the coupler 3, causing the optical switch 7 in the output circuit 3b of the optical coupler 3 to toggle from its active (closed) state to an open state, thus causing a break of the messaging line 5.

[0024] In the way described above, both a disconnection of the monitored LED as well as a short-circuit of the monitored LED may be detected as a change from the active to the passive state of the optical switch 7 in the output circuit 3b of the coupler 3, resp., as a disconnection of the messaging line 5. Thus, only one messaging line 5 can be used for detecting both types of failure.

[0025] Fig. 2 shows a signalling unit 1' which differs from the one shown in Fig. 1 only in that two high-power light-emitting diodes LED1, LED2 are provided, the two of them being arranged in series. For both LEDs, a respective monitoring unit 2a, 2b is provided which allows detection of failures of the respective monitored LED (LED1, LED2) at a common messaging line 5 in the way described above. For this purpose, the messaging line 5 connects the output circuits 3b, 3b' of the respective monitoring units 2a, 2b in a series connection, such that a failure (either disconnection or short-circuit) of any of the high-power LEDs may be detected at the single messaging line 5. It will be understood that for railway signalling, typically an array of high-power LEDs in a series connection is used which comprises more than the two high-power LEDs shown in Fig. 2, however, the monitoring of such an array is a straightforward generalization of the principles described herein with respect to two LEDs.

[0026] For a better understanding of the basic principle of the arrangement shown in Fig. 1, a simulation circuit 10 has been set up, see Fig. 3. The simulation circuit 10 comprises the elements shown in Fig. 1, referred to in the following with the same reference numerals as in Fig. 1.

[0027] For simulating a failure of the high-power LED, the simulation circuit 10 further comprises a disconnecting unit 11 and a short-circuiting unit 12 arranged in series resp. in parallel to the high-power LED. The disconnecting unit comprises an electrical switch (relay) 13a, the input of which is connected to an input line 14a having a voltage supply 15a. In a similar way, the short-circuiting unit 12 comprises an electrical switch 13b, being connected to an input line 14b which also includes a voltage supply 15b. The voltage supply 15a of the disconnecting unit 11 is arranged in series to an input circuit of the electrical switch 13a, whereas the voltage supply 15b of the short-circuiting unit 12 is arranged in parallel to the input circuit of the electrical switch 13b. The simulation circuit also comprises a constant current source 16 with a further voltage supply 17 and a further resistance R4.

[0028] In the following, the operation of the simulation circuit 10 will be explained with reference to Fig. 4, showing current and voltage values at four different points of the simulation circuit 10, namely a voltage value "A" at the voltage supply 15a of the disconnecting unit 11, a voltage value "B" at the voltage supply 15b of the short-circuiting unit 12, the current "I" at the output of the current source 16, and a voltage value "C" measured at the messaging line 5 at the output of the optical coupler 3, the messaging line 5 comprising a further resistance R5 being arranged between the output of the optical coupler 3 and ground. In the following, the resistance values which have been used for the simulation will be given for the sake of completeness: R1= 1kΩ, R2 = 27,4 kΩ, R3 = 3,92 kΩ, R4 =100 Ω, and R5=10kΩ.

[0029] The values at the points "A", "B", "I", and "C" will be evaluated in the following at three different points of time M1 to M3 represented in Fig. 4.

[0030] At the first point of time M1, the high-power LED is in normal operation, i.e. neither disconnected nor short-circuited. In this case, the values at the respective points are as follows "A": 0 V, "B": 0 V, "I" = 102 mA, and "C": 4,6 V. Apparently, the current I through the high-power LED is sufficient to cause a voltage drop across the monitored LED which generates a current through the LED 6 of the input circuit 3a of the coupler 3 which is sufficient to close the optical switch 7 in the output circuit 3b of the coupler 3, not generating a break in the messaging line 5.

[0031] At the second point of time M2, the voltage at point "A" raises to 1 V, thus closing the relay 13a of the disconnecting unit 11 for disconnecting the high-power LED. The disconnection leads to a reduction of the (regulated) current I to 11,1 mA, increasing the voltage drop across the voltage divider R2, R3, thus closing the electrical switch 8 which leads to a bypassing of the input circuit 3a of the coupler 3. Consequently, the LED 6 in the input circuit 3 of the coupler 3 does not generate a sufficient amount of light for keeping the optical switch 7 in the output circuit 3b in a closed state, the latter causing a break in the messaging line 5 and disconnecting the resistance R5, leading to a voltage drop at point "C" of about 0 V.

[0032] In a similar way, at the third point of time M3, the voltage at point "B" raises to 1 V, thus short-circuiting the high-power LED, leading to an small increase of the current I to 120 mA at the output of the current source 16. The short-circuit leads to a reduction of the voltage drop across the high-power LED, thus reducing the current through the further LED 6 in the input circuit 3a of the coupler 3, causing the optical switch 7 to change from its active (closed) to its passive (open) state. Thus, a break in the messaging line 5 is caused which disconnects the resistance R5 from the voltage reference (5V) of the messaging line 5, such that the voltage at point "C" is reduced to about 0 V.

[0033] In summary, the arrangements described above allow for an easy detection of both disconnections and short-circuits of one or a plurality of (high-power) LEDs using a single potential-free messaging line. In particular, the monitoring units described above can be designed with only a few components, thus providing a low-cost solution for the monitoring of the high-power LEDs of the signaling devices as described herein.

[0034] The above description of the preferred embodiments has been given by way of example. From the disclosure given, those skilled in the art will not only understand the present invention and its attendant advantages, but will also find apparent various changes and modifications to the structures and methods disclosed. The applicant seeks, therefore, to cover all such changes and modifications as defined by the appended claims, and equivalents thereof.

Claims

1. Monitoring unit (2, 2a, 2b) for monitoring a high-power LED (LED, LED1, LED2) driven by a preferably constant electric current (I), comprising:

a coupler, in particular an optical coupler (3), for coupling the monitoring unit (2, 2a, 2b) to a messaging line (5), an input circuit (3a) of the coupler (3) being arranged in parallel to the high-power LED (LED, LED1, LED2), and

a bypass unit (4) adapted to bypass the input circuit (3a) of the coupler (3) in case of a disconnection of the high-power LED (LED, LED1, LED2) for switching off a switch, in particular an optical switch (7), in the output circuit (3b) of the coupler (3), wherein the bypass unit (4) comprises a voltage divider (9) and an electronic switch (8) both being arranged in parallel to the high-power LED (LED, LED1, LED2), the voltage divider (9) being adapted to produce a control voltage which closes the electronic switch (8) in case that the high-power LED (LED, LED1, LED2) is disconnected, the monitoring unit (2, 2a, 2b) further comprising a resistance (R1) arranged between the voltage divider (9) and the electronic switch (8) and in series to the input circuit (3a) of the coupler (3).

2. Monitoring unit according to claim 1, wherein the electronic switch is a transistor (8).

3. Signaling device (1, 1'), comprising:

at least one high-power LED (LED, LED1, LED2) and at least one monitoring unit (2, 2a, 2b) according to any one of the preceding claims, the monitoring unit (2, 2a, 2b) being arranged in parallel to the high-power LED (LED, LED1, LED2).

4. Signaling device according to claim 3, comprising at least two high-power LEDs (LED1, LED2) arranged in series.

5. Signaling device according to claim 4, wherein the messaging line (5) is connected to the output circuits (3b, 3b') of the respective monitoring units (2a, 2b) in a series connection.

6. Signaling device according to any one of claims 3 to 5, further comprising a constant current source (16) for driving the at least one high-power LED (LED, LED1, LED2) with a constant current.

7. Signaling device according to any one of claims 3 to 6, implemented as a railway signaling lamp.

Patentansprüche

1. Überwachungseinheit (2, 2a, 2b) zum Überwachen einer Hochleistungs-LED (LED, LED1, LED2), die von einem vorzugsweise konstanten elektrischen Strom (I) angesteuert wird, umfassend:

einen Koppler, insbesondere einen optischen Koppler (3), zum Koppeln der Überwachungseinheit (2, 2a, 2b) an eine Nachrichtenleitung (5), eine Eingangsschaltung (3a) des Kopplers (3), die parallel zu der Hochleistungs-LED (LED, LED1, LED2) angeordnet ist, und eine Bypasseinheit (4), die so angepasst ist, dass sie die Eingangsschaltung (3a) des Kopplers (3) umgeht im Falle einer Unterbrechung der Hochleistungs-LED (LED, LED1, LED2) zum Abschalten eines Schalters, insbesondere eines optischen Schalters (7), in der Ausgangsschaltung (3b) des Kopplers (3), wobei die Bypasseinheit (4) einen Spannungsteiler (9) und einen elektronischen Schalter (8) aufweist, die beide parallel zu der Hochleistungs-LED (LED, LED1, LED2) angeordnet sind, wobei der Spannungsteiler (9) so ausgebildet ist, dass er eine Steuerspannung erzeugt, die den elektronischen Schalter (8) schließt, wenn die Hochleistungs-LED (LED, LED1, LED2) unterbrochen ist, wobei die Überwachungseinheit (2, 2a, 2b) weiter aufweist: einen Widerstand (R1), der zwischen dem Spannungsteiler (9) und dem elektronischen Schalter (8) und in Reihe mit der Eingangsschaltung (3a) des Kopplers (3) angeordnet ist.

2. Überwachungseinheit nach Anspruch 1, wobei der elektronische Schalter ein Transistor (8) ist.

3. Signalvorrichtung (1, 1'), umfassend:

mindestens eine Hochleistungs-LED (LED, LED1, LED2) und mindestens eine Überwachungseinheit (2, 2a, 2b) nach einem der vorhergehenden Ansprüche, wobei die Überwachungseinheit (2, 2a, 2b) parallel zu der Hochleistungs-LED (LED, LED1, LED2) angeordnet ist.

4. Signalvorrichtung nach Anspruch 3, umfassend mindestens zwei Hochleistungs-LEDs (LED1, LED2), die in Reihe angeordnet sind.

5. Signalvorrichtung nach Anspruch 4, wobei die Nachrichtenleitung (5) mit den Ausgangsschaltungen (3b, 3b') der entsprechenden Überwachungseinheiten (2a, 2b) in einer Reihenschaltung geschaltet ist.

6. Signalvorrichtung nach einem der Ansprüche 3 bis 5, weiterhin umfassend eine Konstant-Stromquelle

(16) zum Ansteuern der mindestens einen Hochleistungs-LED (LED, LED1, LED2) mit einem konstanten Strom.

7. Signalvorrichtung nach einem der Ansprüche 3 bis 6, ausgeführt als eine Eisenbahnsignallampe.

Revendications

1. Unité de surveillance (2, 2a, 2b) destinée à surveiller une LED haute puissance (LED, LED1, LED2) alimentée par un courant électrique, de préférence un courant constant (I), comprenant :

un coupleur, en particulier un coupleur optique (3), en vue de coupler l'unité de surveillance (2, 2a, 2b) à une ligne de messagerie (5), un circuit d'entrée (3a) du coupleur (3) étant agencé en parallèle à la LED haute puissance (LED, LED1, LED2), et une unité (4) adaptée pour contourner le circuit d'entrée (3a) du coupleur (3) en cas de déconnexion de la LED haute puissance (LED, LED1, LED2) afin de mettre hors tension un commutateur, en particulier un commutateur optique (7), dans le circuit de sortie (3b) du coupleur (3), dans lequel l'unité (4) comprend un diviseur de tension (9) et un commutateur électronique (8), tous deux étant agencés en parallèle à la LED haute puissance (LED, LED1, LED2), le diviseur de tension (9) étant adapté pour générer une tension de commande qui ferme le commutateur électronique (8) lorsque la LED haute puissance (LED, LED1, LED2) est déconnectée, l'unité de surveillance (2, 2a, 2b) comprenant en outre une résistance (R1) agencée entre le diviseur de tension (9) et le commutateur électronique (8) et en série vers le circuit d'entrée (3a) du coupleur (3).

2. Unité de surveillance selon la revendication 1, dans laquelle le commutateur électronique est un transistor (8).

3. Dispositif de signalisation (1, 1'), comprenant :

au moins une LED haute puissance (LED, LED1, LED2) et au moins une unité de surveillance (2, 2a, 2b) selon l'une quelconque des revendications précédentes, l'unité de surveillance (2, 2a, 2b) étant agencée en parallèle à la LED haute puissance (LED, LED1, LED2).

4. Dispositif de signalisation selon la revendication 3, comprenant au moins deux LED haute puissance (LED1, LED2) agencées en série.

5. Dispositif de signalisation selon la revendication 4,

dans lequel la ligne de messagerie (5) est connectée aux circuits de sortie (3b, 3b') des unités de surveillance respectives (2a, 2b) dans une connexion série.

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6. Dispositif de signalisation selon l'une quelconque des revendications 3 à 5, comprenant en outre une source de courant constant (16) pour alimenter ladite au moins une LED haute puissance (LED, LED1, LED2) avec un courant constant.

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7. Dispositif de signalisation selon l'une quelconque des revendications 3 à 6, mis en oeuvre sous la forme d'une lampe de signalisation ferroviaire.

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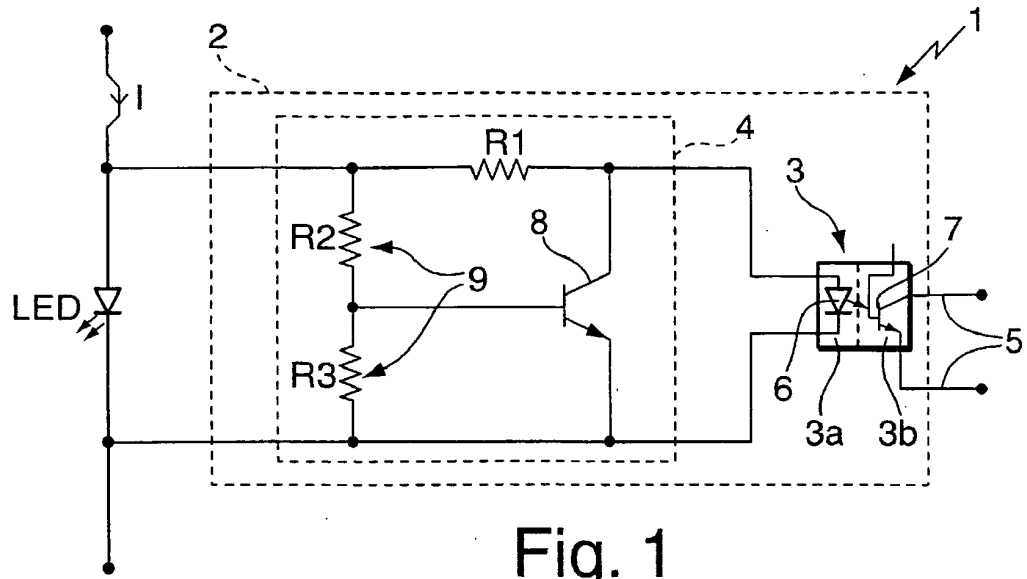


Fig. 1

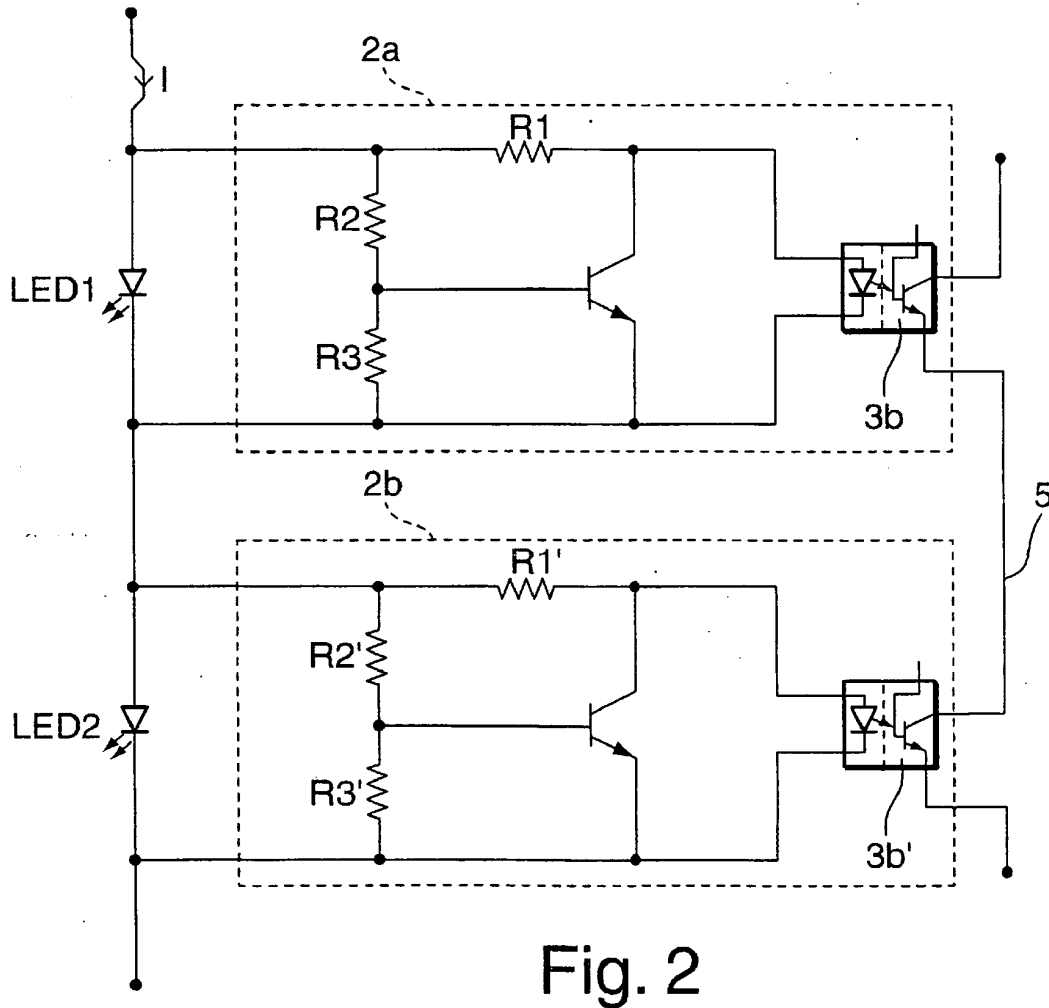


Fig. 2

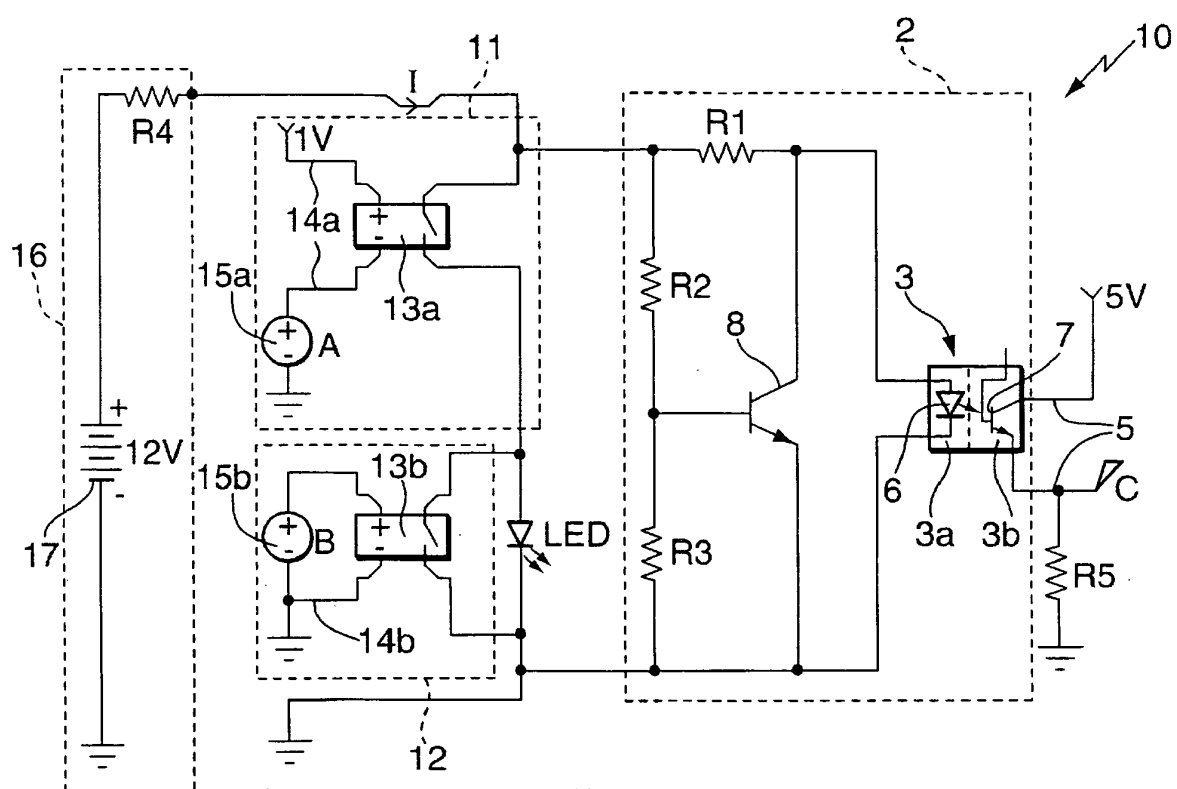


Fig. 3

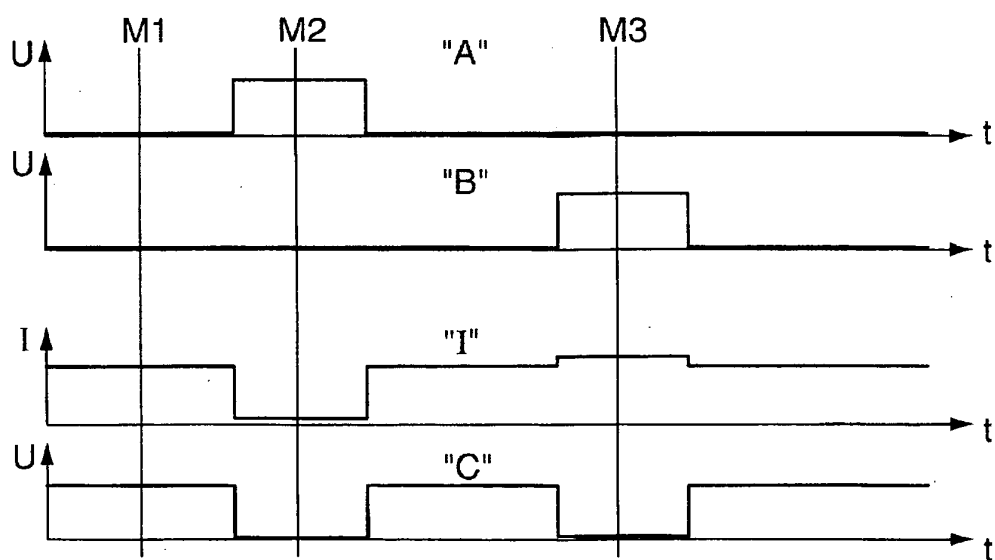


Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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