



(11)

EP 1 641 325 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.03.2006 Bulletin 2006/13

(51) Int Cl.:
H05B 37/03 (2006.01) H05B 33/08 (2006.01)

(21) Application number: 05425659.9

(22) Date of filing: 21.09.2005

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: 22.09.2004 IT RM20040448

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(54) Feeding and failure detecting interface for a led optic signaller, particularly for interfacing to railway feeding networks

(57) The invention relates to a feeding and failure detecting interface for a LED optic signaller, particularly for interfacing to railway feeding networks, said optic signaller providing a plurality of LEDs (3) divided into LED (3) clusters (4), LEDs (3) of each cluster being serially connected each other, characterised in that it comprises for each LED (3) cluster (4) a corresponding current generator (5), serially connected with the relevant cluster, each LED (3) cluster (4) and the relevant generator (5) creating a branch, said branches being connected in parallel each other, in that said interface further comprises tension comparator means (6), an oscillator (7) and

switching means (8), said switching means (8) being provided in series with respect to at least one branch, and said oscillator (7) generating a first signal suitable to control said switching means (8), and in that said comparator means compare potential of at least one node of the adjacent branch, so as to generate a second signal, suitable to control switch means (T, T'), said signal being proportional to said first signal, in case all LEDs (3) and the interface components are not in a failure mode, and it is a constant signal suitable to close or to open said switch means (T, T'), when at least one LED (3) or at least a component of said interface is in a failure mode.

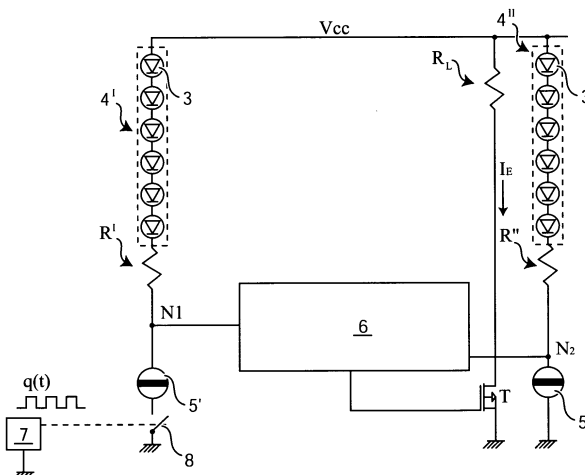


Fig. 3

Description

[0001] The present invention relates to a feeding and failure-detecting interface for a led optic signaller, particularly for interfacing to railway feeding networks.

[0002] More specifically, the invention concerns an interface for making compatible feeding and failure detecting systems of the present railway network with the high efficiency LED signalling systems, particularly studied and realised for revealing every failure, thus allowing a "Safety operation mode".

[0003] As it is well known, railways provide signalling devices suitable to transmit failures along the line or to co-ordinate the traffic. Said devices must be highly reliable since a single signalling error or a malfunction can be fatal. Example of this kind of devices is semaphores. They are usually comprised of three incandescent lamps with different colour, in order to regulate the trains flow along the paths or in order to co-ordinate the give way situations.

[0004] Said incandescent lamps have different problems, among which:

- in case of malfunctioning they do not permit a partial operation, but they completely stop working;
- they have a very short life, with high maintenance costs for replacement of the broken lamps.

[0005] Furthermore, at present, Italian railway lines mainly have failure detecting systems detecting only variations of the current absorbed by the signalling devices. Particularly, along the feeding line, the detection device permits an interpretation of failures based on the reduction or increase of current with respect to pre-set thresholds. If for example one of the semaphore lamps would fail, current would no more flow along the same. Therefore, immediately a reduction of the absorbed current would occur, said reduction being sensed by the failure detection system.

[0006] A further problem relevant to the designing of railway signalling systems is due to the presence of rigid rules concerning reliability. Particularly, reference is made to apparatuses that, to be used, must work under safety conditions according to EN 50129 rules, signalling every failure of components comprising the same. Furthermore, due to the unforeseeability of failure kind, it is not provided the use of integrated devices that, as it is well known, comprise inside a very high number of components.

[0007] As first solution of the above problems, it would be possible using redundant safety circuits. However, also this solution is not sufficient for the above-mentioned rules.

[0008] In order to replace the incandescent lamps, it has been suggested by the same Applicant a solution providing the use of high luminosity LED diode matrix (*light-emitting diode*), for example from the patent application N° RM2002A000331. they have a longer life with

respect to incandescent lamps, so that remarkable advantages exist both under the economic and maintenance point of view.

[0009] According to this technology, each lamp can be replaced by a single LED matrix, serially connected each other. It is possible replacing optic signalling devices providing a plurality of coloured lamps, with a single LED diode matrix by a printed board on which a plurality of LED divided with respect to two or more colours necessary for the specific signalling needing, with a studied distribution for realising a single exit beam for the required colours, as described and claimed in the above mentioned patent application. Obviously, each LED diode cluster of the same colour is independently fed with respect to the others.

[0010] However, in the above described series, in case a LED fails, for example in such a way to have an open circuit, current flowing on the LED series would be annulled, thus allowing detection of failure, but all the signalling device would stop working.

[0011] Therefore, object of the present invention is that of suggesting a feeding and failure detecting interface of a high luminosity LED diode matrix device, allowing operation of said device also only partially failing, but that at the same time permits "safety operation mode", i.e. able detecting every malfunctioning.

[0012] It is still object of the present invention that of permitting the application of said interface on signalling devices comprised of multicolour LED matrix, so that an interface corresponds to each LED cluster with the same colour.

[0013] A further object of the present invention is that of allowing a perfect *pin-to-pin* interfacing with the existing supply network and detection systems.

[0014] It is therefore specific object of the present invention a feeding and failure detecting interface for a LED optic signaller, particularly for interfacing to railway feeding networks, said optic signaller providing a plurality of LEDs divided into LED clusters, LEDs of each cluster being serially connected each other, characterised in that it comprises for each LED cluster a corresponding current generator, serially connected with the relevant cluster, each LED cluster and the relevant generator creating a branch, said branches being connected in parallel each other, in that said interface further comprises tension comparator means, an oscillator and switching means, said switching means being provided in series with respect to at least one branch, and said oscillator generating a first signal suitable to control said switching means, and in that said comparator means compare potential of at least one node of the adjacent branch, so as to generate a second signal, suitable to control switch means, said signal being proportional to said first signal, in case all LEDs and the interface components are not in a failure mode, and it is a constant signal suitable to close or to open said switch means, when at least one LED or at least a component of said interface is in a failure mode.

[0015] Always according to the invention, said inter-

face can comprise a resistive load serially connected with said switch means, in this case, without failure, a first medium current flows, said medium current being comprised between a first threshold I_{MAX} and a second threshold I_{MIN} while, following at least one failure of at least one LED or a component of said interface, a medium current flowing in such a way that total current absorption of said LED and of said interface is higher than said I_{MAX} threshold or minor than said I_{MIN} threshold.

[0016] Furthermore, according to the invention, said interface can comprise a current generator serially connected to said switch means and alternatively actuated by said second signal, and wherein, in case of no failure, said first medium current flows, said medium current being compressed between said first I_{MAX} threshold and said second I_{MIN} threshold, while, following at least a failure of at least a LED or of at least a component of said interface, a medium current flows so that total current absorption of said LEDs and of said interface is higher than said I_{MAX} threshold and lower than said I_{MIN} threshold.

[0017] Still according to the invention, said comparison means can comprise one or more connection units, said connection unit receiving said first signal and transmitting said second signal to said switch means, each one of said one or more units being suitable to compare tension at the ends of said at least one node of at least a first branch with the corresponding node of the adjacent branch, said switching means comprising a commutation device for each one of said one or more units, serially connected to the current generator of a first branch, controlled by the signal received from the possible previous unit or from said oscillator, each one of said one or more units being suitable to transmit to a possible subsequent unit or to said switch means, a signal that is:

- proportional to the signal received from the possible previous unit or from said oscillator, when all LEDs and the components of said unit are not in a failure mode, and
- with constant tension higher than a first threshold value or lower than a second threshold value, when at least one LED or at least a component of said unit is in a failure mode, said first threshold value and said second threshold value being such to respectively activate and not to activate said switching means or said switch means.

[0018] Preferably, according to the invention, said units can comprise photo-couplers, said photo-couplers being comprised of a LED diode and of a phototransistor controlled by said LED diode.

[0019] Always according to the invention, said switch means can comprise a bipolar transistor or a MOSFET.

[0020] Still according to the invention, signal generated by said oscillator can be a square wave.

[0021] Preferably, according to the invention, said switching means can comprise a transistor.

[0022] Furthermore, according to the invention, said current generator can be comprised of two bipolar transistors according to a bootstrap follower connection, that can be polarised by a LED diode.

5 **[0023]** Advantageously, said LED diode can be of the I-Ga-Al-P (Indium — Gallium - Aluminium - Phosphorus) kind.

[0024] Always according to the invention, said interface can be applied to multicolour LED matrix.

10 **[0025]** The present invention will be now described, for illustrative but not limitative purposes, according to its preferred embodiments, with particular reference to the figures of the enclosed drawings, wherein:

15 figure 1 shows a block diagram of a railway standard semaphore;

figure 2 shows a graph showing the activation thresholds of the failure detection device with respect to the supply current in function of the time;

20 figure 3 shows a supply and failure detection interface circuit diagram for LED optical signaller according to the present invention;

25 figure 4 shows an embodiment of the supply and failure detection interface according to figure 3; and figure 5 shows a circuit diagram of a current generator.

[0026] In order to better understand the present invention, the operation modes will be described in the following the preferred embodiment of the interface, analogous mode being valid for other embodiments.

[0027] Making reference to figure 1, it is possible observing the block diagram of a three lights conventional railway-signalling device. It provides three signalling incandescent lamps 1, with different colour (green, yellow, red), connected each other to a transformer 2a for transforming the alternate current of the supply, in this case from 150 V to 12 V. Failure detection circuit 2b is present between main supply and transformer 2, said circuit being always preinstalled in the railway network that, as already said, is based on the current measurement. More specifically, said circuit allows detection of a failure when supply current passes an I_{MAX} threshold or is below an I_{MIN} threshold, if for example current passes I_{MAX} threshold, switch 2c is actuated, interrupting supply to lamp.

[0028] It is possible observing in greater detail the operation feature of figure 2, wherein it is shown the supply current in function of the time, putting into evidence the above mentioned thresholds. In case current is not included between I_{MAX} and I_{MIN} , railway network failure detection circuit 2b considers the lamp failed.

[0029] In figure 3 it is shown the principle scheme of supply interface according to the invention, suitable to permit the pin-to-pin replacement of a standard signalling lamp by a high luminosity LED matrix. Said LEDs 3 shown in the figure have all the same colour and can be mounted on a single support or they can be distributed in a matrix wherein LEDs 3 with different colours are present, ac-

cording to the signalling needing. In this case, each monochromatic LED 3 cluster will be suitably connected with its own supply interface.

[0030] Monochromatic LEDs 3 are divided into clusters 4, provided in parallel (in the figure it is possible individuating two clusters 4). Each cluster 4 provides a similar number of LEDs 3, provided in series. Furthermore, serially provided with respect to said LEDs 3, for each diode cluster 4, beside a resistance R, it is provided a current generator 5, suitable to set current that must flow on the LEDs 3 of each diode cluster 4. They are also provided a comparator 6 and an oscillator 7. the latter, by a square wave $q(t)$ periodically switches the switch 8, provided in series with the current generator 5', that is the reference.

[0031] Signal on the node N_1 , being node N_1 between LED 3 cluster 4' and current generator 5', is a wave proportional to $q(t)$.

[0032] Comparator 6 makes a comparison between the tension at the ends of the nodes N_1 and N_2 , transmitting, if the operation of all the components is proper, a suitable equalisation signal. Having a square wave shape proportional to $q(t)$, o the gate of the transistor T, absorbing a current I_g , or equalisation current, such that the total absorption of current of the whole interface and of the two LED clusters 4 is within the range between I_{MAX} and I_{MIN} . In case of failure of every component, consequent variation of the equalisation signal on the base of transistor T interdicts or saturate the same. This respectively involves a sharp reduction or a sharp increase of current in drain of T, making varying the total current absorbed respectively under threshold I_{MAX} or above threshold I_{MIN} . this allows to the railway failure detection systems individuating the failure.

[0033] As it can be noted, interface allows even partial operation of diode matrix, always indicating the failure, while in the known solutions providing incandescent lamps 1 this does not occur.

[0034] In case only the comparison of tension on nodes N_1 and N_2 is made by comparator 6, acting on polarisation of transistor T, it would not have been possible detecting possible failures of the same transistor T, operating as a switch. In fact, if for example, for standard operation I_E is zero, in case T fails and it can be replaced by an open circuit, current I_E would be always null, independently from the presence of failures along the circuit.

[0035] As to the essential operation of the interface, if a LED diode 3 of one of the diode clusters 4 or 4' would be damaged, for example remaining as an open or closed circuit, a reduction or an increase of tension would occur on the corresponding node N_1 or N_2 . In this way it is obtained an interruption of the pilot square wave on the base of transistor T that, as already said, is saturated or interdicted permitting that current I_E flows along resistance R_L and at the entrance on its drain, so as to activate the failure detection circuit 2b (not shown in the present figure).

[0036] Oscillation circuit 7, acting on switch 8, provided in series with the reference current generator 5', can be

a standard square wave generator. It is suitable observing that even in case oscillator does not properly work, always leaving open or closed switch 8, interface would automatically permit indication of failure. In fact, a sharp increase (or reduction) of medium tension would occur on node N_1 and circuit would saturate (or would interdict) transistor T.

[0037] Use of current generator allows that current flowing along LEDs 3 does not depend on current supply tension and therefore also their luminosity does not depend on this value. Furthermore, possible short-circuit of a LED 3 leaves unmodified current flowing on the corresponding diode cluster 4. finally, their use allows a faster monitoring of failures.

[0038] In order to maintain unmodified the total current absorbed by the whole circuit, it is suitable replacing R_L with a current generator, also alternatively activated by the signal coming from the comparator 6.

[0039] Figure 4 shows a particular embodiment of the interface according to the invention.

[0040] It particularly provides four LED diode 3 clusters 4. it is possible making the analyses of the interface operation in case of proper operation and of failure.

Failure less operation mode

[0041] In case all components of the circuit do not have failures, oscillator 7, generating square wave $q(t)$, by the switch 8, switches the current generator 5'. Therefore, current flowing on cluster 4', set by said current generator 5', has a run in the time proportional to $q(t)$, as well as potential on node N_1 .

[0042] LED diode 9a of photo-coupler 9, connected between nodes N_1 and N_2 of two clusters 4, 4' is directly and inversely polarised according to the run of potential on node N_1 , making photo-transistor 9b transmitting the signal on switch 8'.

[0043] The same comparison of potentials made between nodes N_1 and N_2 is carried out between nodes N_3 and N_4 , by coupler-coupler 10.

[0044] Due to the transmission of a square wave signal proportional to $q(t)$ by the photo-transistor 3b on switch 8', potential on node N_3 has a run proportional to $q(t)$, directly or inversely polarising LED diode 10a of photo coupler 10, sending the signal proportional to $q(t)$ on the base of bipolar transistor T'. the latter absorbs current I_E on collector, passing through the resistance R_L . as already said equalisation current I_E is calculated in such a way that the whole interface absorbs a medium current between I_{MIN} and I_{MAX} thresholds mentioned din the above, to which the railway failure detection device is sensible.

[0045] Furthermore, as already said, in order to maintain the equalisation current between the above limits, it is possible replacing resistance R_L with a current generator, saving the total absorption of the interface after possible VCC variations.

[0046] As it can be noted, pairs of diode clusters 4

make comparison of potential on nodes. It is in fact possible providing a plurality of branch pairs. In case no failure occurs, signal proportional to $q(t)$, or equalisation signal, is transmitted to the following diode cluster 4 pair, and so on, until the last pair, transmitting the above equalisation signal to the transistor T', absorbing current useful to set the total absorption of the whole interface.

Failure operation mode

[0047] In case of failure, the operation mode is based on the principle that it is not possible transmission of the equalisation signal. Therefore, a square wave signal is no more present on the base of transistor T', said signal allowing an absorption of medium current equal to I_E , but a continuous tension is present so as to interdict or to saturate the same, this involving a reduction or a remarkable increase of the absorbed current, so that the total current absorbed by interface is minor than I_{MIN} or higher than I_{MAX} , permitting to the railway failure detection device, as already said, to activate.

[0048] Observing now figure 4, if a LED diode 3, e.g. of the diode cluster 4", would fail, i.e. short-circuit, a potential increase would occur on node N_2 of at least about 2 Volts. This implies that diode 10a of photo-coupler 10 would steady remain conductive. Phototransistor 10b of photo-coupler 10 would be as well always conductive and, on the base of T' a signal proportional to $q(t)$ would not be present. Transistor T' would be continuously saturated. Current absorbed by I_E collector would increase, thus causing a total absorption of interface and of LED diodes higher than I_{MAX} , thus signalling the failure.

[0049] As it can be easily noted, although interface detects the failure, remaining diodes 3 of the diode clusters 4 still operate, ensuring the illumination service.

[0050] Assuming that the diode 3 failure mentioned in the above can be realised as an open circuit, potential on node N_3 would increase, thus constantly interdicting diode 10a of photo-coupler 10. Phototransistor 10d would be interdicted as it is transistor T'. current I_E would reduce to zero, thus causing a total absorption of interface and Led diodes lower than I_{MIN} , thus obtaining the failure indication.

[0051] Unlike the previous case, the whole diode cluster 4"" switches off for this kind of failure, not being present current flowing along the branch. However, the other diode clusters 4, although partial, ensure illumination.

[0052] In figure 4 it is shown a block 11, provided on the supply coming from the railway network, said block rectifying the tension.

[0053] Said current generators 5 are shown in figures 3 and 4 as ideal. Really, design constraints, due to the limited power and the minimum luminosity to be guaranteed under perfect operation conditions, involve the needing of using a stabile current generator scheme with a large compliance also for low tension. In the present embodiment it is used the solution shown in figure 5. This allows obtaining many advantages.

[0054] A bipolar transistor 12 of the n-p-n kind, is polarised having in parallel the base junction and the polarisation resistance 13 the p-n junction of a LED diode 14. The latter is of the I-Ga-Al-P (Indium - Gallium - Aluminium - Phosphorus). Choice of said LED diode instead, for example, of a zener diode, has been made since:

- it allows an optimum coupling between the two junctions, allowing obtaining the same temperature coefficient between said two junctions so that tension on resistance 13 is almost constant of temperature variations;
- provides a dynamic resistance very lower with respect to a zener diode;

[0055] In fact, zener diodes are not very stable with low tensions (about 2 - 3 Volts), with respect to temperature and have a very high dynamic resistance.

[0056] Bipolar transistor 12 is further coupled with bipolar transistor 16 (p-n-p) in a configuration known as "bootstrap follower". Transistor 12 collector is connected with the transistor 16 base. Collector of said transistor 16 is coupled to the transistor 12 emitter. Load 15 on which the current to be flowed is connected to the transistor 16 emitter. Obviously, the diode clusters 4 represent load 15 of figure 3 for each current generator.

[0057] Arrangement described has the advantage of increasing the current gain resulting from the two coupled transistor (beta coefficient), as an arrangement of the *Darlington* type, but with respect to this solution has the advantage of a base - emitter tension drop reduced at half.

[0058] On the basis of the previous specification, it can be noted that basic feature of the present interface is the fact that it can partially operate in case of failure of one or more LED diodes, and at the same time signalling every failure according to EN 50129 Rule, thus permitting a "safety operation mode".

[0059] An advantage of the present invention is that high efficiency diodes last much longer with respect to the incandescent lamps.

[0060] The present invention has been described for illustrative but not limitative purposes, according to its preferred embodiments, but it is to be understood that modifications and/or changes can be introduced by those skilled in the art without departing from the relevant scope as defined in the enclosed claims.

Claims

1. Feeding and failure detecting interface for a LED optic signaller, particularly for interfacing to railway feeding networks, said optic signaller providing a plurality of LEDs divided into LED clusters, LEDs of each cluster being serially connected each other, **characterised in that** it comprises for each LED cluster a corresponding current generator, serially connected

with the relevant cluster, each LED cluster and the relevant generator creating a branch, said branches being connected in parallel each other, **in that** said interface further comprises tension comparator means, an oscillator and switching means, said switching means being provided in series with respect to at least one branch, and said oscillator generating a first signal suitable to control said switching means, and **in that** said comparator means compare potential of at least one node of the adjacent branch, so as to generate a second signal, suitable to control switch means, said signal being proportional to said first signal, in case all LEDs and the interface components are not in a failure mode, and it is a constant signal suitable to close or to open said switch means, when at least one LED or at least a component of said interface is in a failure mode.

2. Interface according to claim 1, **characterised in that** said interface comprises a resistive load serially connected with said switch means, in this case, without failure, a first medium current flows, said medium current being comprised between a first threshold $I_{\max}$ and a second threshold $I_{\min}$ while, following at least one failure of at least one LED or a component of said interface, a medium current flowing in such a way that total current absorption of said LED and of said interface is higher than said $I_{\max}$ threshold or minor than said $I_{\min}$ threshold.
3. Interface according to one of the preceding claims, **characterised in that** said interface comprises a current generator serially connected to said switch means and alternatively actuated by said second signal, and wherein, in case of no failure, said first medium current flows, said medium current being compressed between said first $I_{\max}$ threshold and said second $I_{\min}$ threshold, while, following at least a failure of at least a LED or of at least a component of said interface, a medium current flows so that total current absorption of said LEDs and of said interface is higher than said $I_{\max}$ threshold and lower than said $I_{\min}$ threshold.
4. Interface according to one of the preceding claims, **characterised in that** said comparison means comprise one or more connection units, said connection unit receiving said first signal and transmitting said second signal to said switch means, each one of said one or more units being suitable to compare tension at the ends of said at least one node of at least a first branch with the corresponding node of the adjacent branch, said switching means comprising a commutation device for each one of said one or more units, serially connected to the current generator or a first branch, controlled by the signal received from the possible previous unit or from said oscillator, each one of said one or more units being suitable to trans-

mit to a possible subsequent unit or to said switch means, a signal that is:

- proportional to the signal received from the possible previous unit or from said oscillator, when all LEDs and the components of said unit are not in a failure mode, and
- with constant tension higher than a first threshold value or lower than a second threshold value, when at least one LED or at least a component of said unit is in a failure mode, said first threshold value and said second threshold value being such to respectively activate and not to activate said switching means or said switch means.

5. Interface according to claim 4, **characterised in that** said units comprise photo-couplers, said photo-couplers being comprised of a LED diode and of a phototransistor controlled by said LED diode.
6. Interface according to one of the preceding claims, **characterised in that** said switch means comprise a bipolar transistor or a MOSFET.
7. Interface according to one of the preceding claims, **characterised in that** signal generated by said oscillator is a square wave.
8. Interface according to one of the preceding claims, **characterised in that** said switching means comprise a transistor.
9. Interface according to one of the preceding claims, **characterised in that** said current generator is comprised of two bipolar transistors according to a bootstrap follower connection.
10. Interface according to one of the preceding claims, **characterised in that** said current generator is polarised by a LED diode.
11. Interface according to one of the preceding claims, **characterised in that** said LED diode is of the I-Ga-Al-P (Indium - Gallium - Aluminium - Phosphorus) kind.
12. Interface according to one of the preceding claims, **characterised in that** said interface is applied to multicolour LED matrix, each interface being connected to a cluster of LED of same colour.

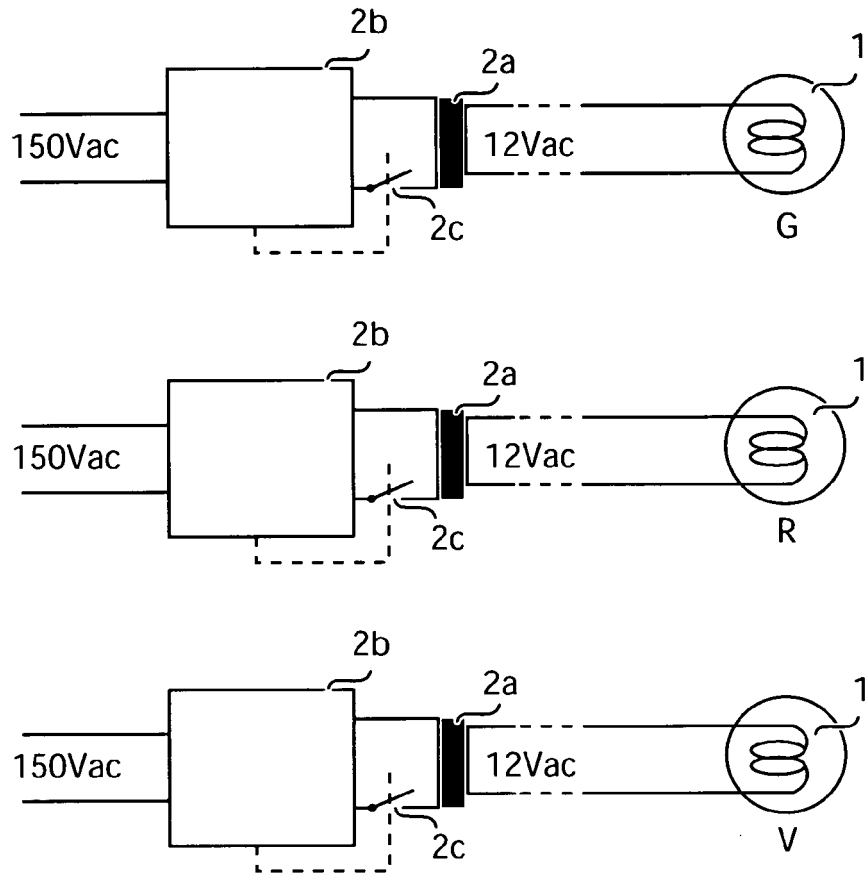


Fig. 1

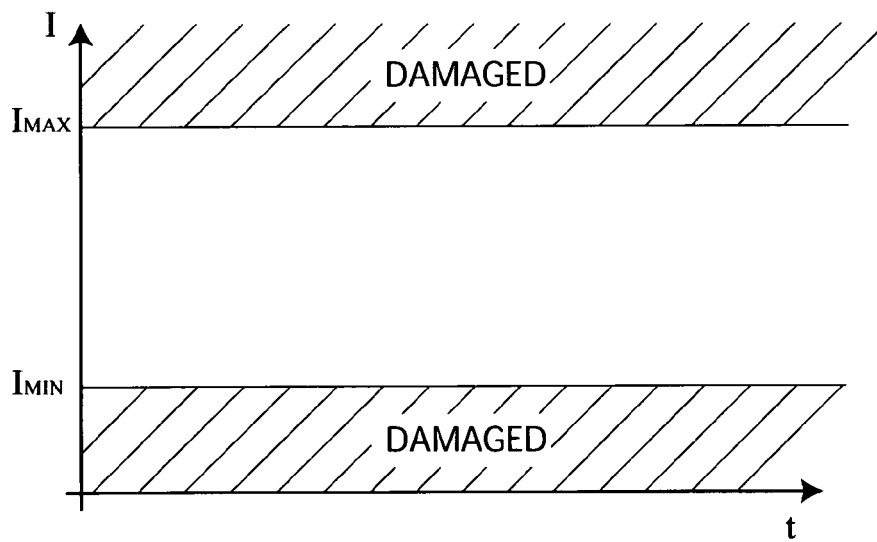


Fig. 2

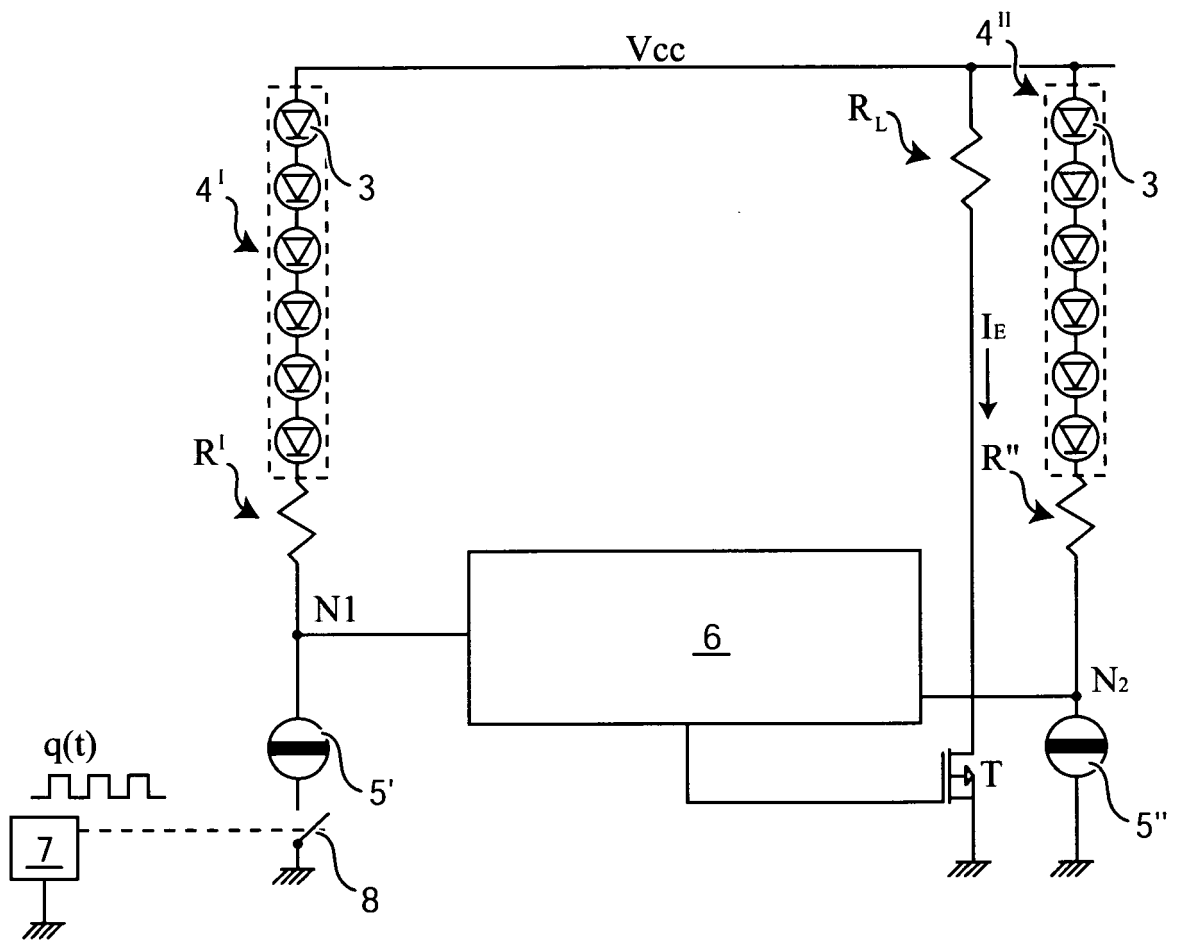


Fig. 3

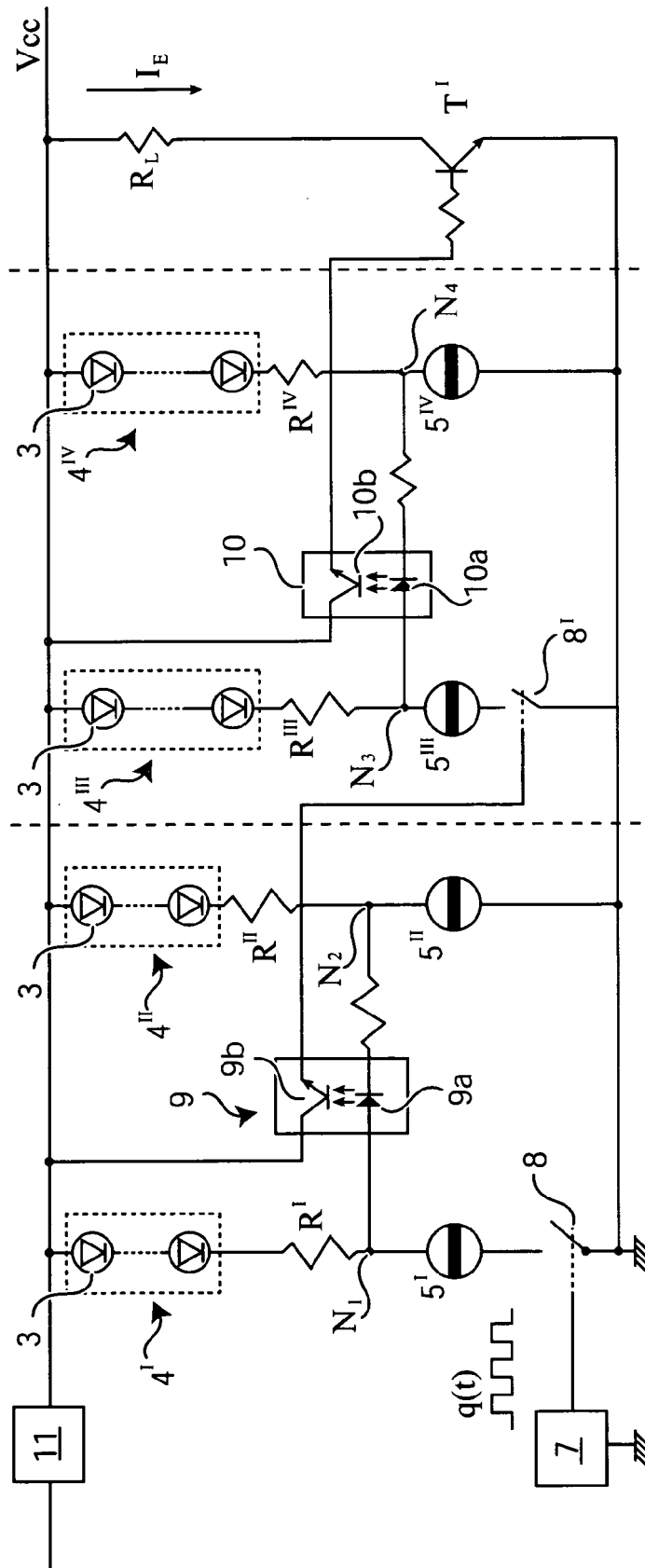


Fig. 4

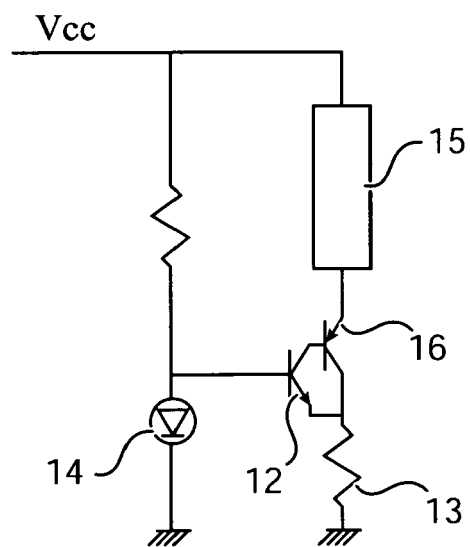


Fig. 5