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(54) Title: AN LED LIGHTING MODULE

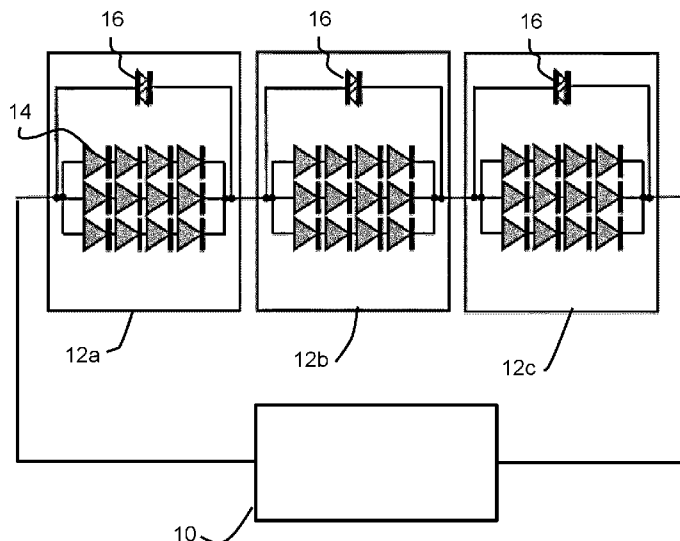


FIG. 1

(57) Abstract: A lighting module comprises a series connection of LEDs having a forward string voltage when driven to a maximum operating current. A protection device is in parallel with the series connection of LEDs with a threshold voltage selected to provide protection against arcing. The protection device is a DIAC or a SIDAC having a threshold in the range 10V to 50V greater than the forward string voltage of the string of LEDs.

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AN LED LIGHTING MODULE

FIELD OF THE INVENTION

This invention relates to lighting modules, in particular having a series connection of LEDs.

5 BACKGROUND OF THE INVENTION

PCBs are commonly used for LED modules. It is known to have several LED strings in parallel on one module. In normal use, the current is divided between each LED string. In the same manner, in normal use the voltage at the terminal of each LED corresponds to the threshold voltage plus the voltage linked to the dynamic resistance of the
10 LED. The nominal voltage at the terminals of the module is equal to the sum the nominal voltages of all the LEDs in a string.

With aging, one LED may become either a short circuit or an open circuit. Another situation is that some unwanted water may create a short or an open circuit on a PCB. A snowball effect may then result due to the fact that the failure of one LED on a
15 module will increase the current in the other LEDs of the modules creating other LED failures increasing the stress on other LEDs until an arcing situation is reached.

Arcing may start when all the current of the module passes through a single string and when one LED of this string becomes an open circuit. At this moment, the voltage at the LED terminals may become equal to the maximum voltage that can be provided by the
20 driver (sometimes a few hundred volts) and the current is maintained to the nominal value by the current-driver for the module (which is several times the nominal current of the LED). Such situation may result in a fire hazard.

The common solution is to detect a critical situation on the driver side and to switch off the driver when a critical situation is detected. Nevertheless, it has been found that
25 driver protection may not work properly. This is the case for example when the driver is oversized and/or when the number of modules connected to the driver is large. Thus, driver-side protection may not be adequate to prevent a fire hazard situation.

There is therefore a need for a module design which provides protection at the LED module side.

US 2006/0220585 discloses an LED circuit in which each LED in a series string is provided with a parallel protection thyristor for providing a conduction path as soon as one LED becomes open circuit. The thyristor provides a bypass path so the other LEDs in the series can continue to operate. The thyristor has a low threshold voltage, so that it is
5 triggered as soon as a voltage just above the forward voltage of its single protected LED is passed.

This means an additional thyristor is needed for each LED and the thyristor has to be selected for the specific LED type.

US2014/0252956 shows another protection made with a thyristor for
10 protecting the LEDs from overvoltage in which a Zener is used for triggering a thyristor. When conducting the Thyristor has a reduced direct voltage but it needs a minimum current but its triggering requires several additional components.

SUMMARY OF THE INVENTION

15 The invention is defined by the claims.

According to examples in accordance with an aspect of the invention, there is provided a lighting module comprising:

a series connection of LEDs having a forward string voltage when driven to a maximum operating current; and

20 a protection device in parallel with the series connection of LEDs, wherein the protection device is in an open circuit state when the voltage across the protection device is below a threshold and switches to a conduction state when the voltage across the protection device is above the threshold,

wherein the protection device is a DIAC or a SIDAC with a threshold is in the
25 range of 10V to 50V greater than the forward string voltage of the string of LEDs.

By adding a protection device across the the LED string, arcing can be prevented because the open circuit voltage can be limited by the protection component. The use of a DIAC or a SIDAC enables to have a single component added which is more reliable than a complex circuit triggering a thyristor. The threshold voltage is selected to be
30 substantially higher than the forward string voltage so that the protection is aimed specifically at preventing high voltage arcing situations.

The protection device bridges the failed LED string in a safe way because the voltage may be limited to a low value while active. For example, the voltage across the protection device in the conduction state is below 5V. It may for example be 1.2V.

The protection devices are available in small surface mount packages, and thus very simple to add to commercial LED (linear) boards. The protection device bypasses the LED string when the voltage threshold is detected between the terminals.

5 The function is equivalent to switching off the failed module to prevent an eventual fire hazard. Other modules can continue to work as well as the driver. The low conduction state voltage of the protection device means the power consumption of a failed module is reduced.

The module may comprise a series connection of 5 to 50 LEDs, for example 5 to 20 LEDs.

10 The forward string voltage is for example in the range 1.5V to 5V per LED in the series connection of LEDs. Thus, the module typically has a voltage across it in the range 20V to 100V, and such voltages can cause arcing when a current driver is used.

By way of example, the string voltage may be in the range 20V to 40V and the threshold voltage for the protection device may then be in the range 30V to 70V.

15 A plurality of parallel branches of series connections of LEDs may be provided in the module, sharing a same protection device.

A lighting system may comprise a plurality of LED boards in series with each other, each LED board comprising a lighting module as defined above. Each board has its own local on-board protection.

20

BRIEF DESCRIPTION OF THE DRAWINGS

Examples of the invention will now be described in detail with reference to the accompanying drawings, in which:

25 Figure 1 shows a lighting system which comprises three modules each in accordance with an example of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

30 The invention provides a lighting module comprising a series connection of LEDs having a forward string voltage when driven to a maximum operating current. A protection device is in parallel with the series connection of LEDs with a threshold voltage selected to provide protection against arcing. The threshold is in the range 10V to 50V greater than the forward string voltage of the string of LEDs.

Figure 1 shows a lighting system comprising a driver 10 which delivers current to a an LED arrangement in the form of a plurality of LED boards 12a, 12b, 12c in

series with each other. Each LED board comprises a lighting module having a series connection of LEDs 14 having a forward string voltage when driven to a maximum operating current.

5 A protection device 16 is placed in parallel with the series connection of LEDs. The protection device 16 is in an open circuit state when the voltage across the protection device is below a threshold and switches to a conduction state when the voltage across the protection device is above the threshold.

The threshold is in the range 10V to 50V greater than the forward string voltage of the string of LEDs.

10 Each module in Figure 1 is shown with a set of parallel branches, each parallel branch having an LED string. Each branch has the same voltage across it. The driver 10 is for example a current-driver for driving a current through the LED arrangement.

By adding a protection device across the LED string (or set of paralleled stings), arcing can be prevented because the open circuit voltage can be limited by the protection component. The threshold voltage is substantially higher than the forward string voltage so that the protection is aimed specifically at preventing arcing situations.

For example each LED string may comprise 11 LEDs in series (rather than the 4 shown schematically in Figure 1) giving approximately a 36V string voltage at the maximum rated current (i.e. the current required for a maximum brightness within the normal operating range of the LEDs). The protection device may then have a threshold voltage of 60V. A threshold voltage of approximately 25V above the string voltage (e.g. 20V to 30V) is found to be particularly suitable.

25 This voltage margin avoids unwanted triggering or unwanted leakage currents through the protection devices. The large margin also means that low cost devices with a large tolerance are suitable and sufficient to prevent arcing.

More generally, each module may comprise a series connection of 5 to 50 LEDs, for example 5 to 20 LEDs. The forward string voltage for LEDs is generally in the range 1.5V to 5V per LED in the series connection of LEDs. Overall, the module for example has a voltage across it in the range 20V to 100V, and such voltages can cause arcing when a current driver is used. A preferred string voltage range is for example 20V to 40V and a threshold voltage for the protection device in the range 30V to 70V.

The invention makes use of a high voltage based surge protection component for providing a bypass current path. Some specific examples will now be presented.

A first example is a DIAC ("diode for alternating current") type device, which is a diode that conducts electrical current only after its breakover voltage, V_{BO} , has been reached momentarily. The DIAC is a three layer device.

When breakdown occurs, the diode enters a region of negative dynamic resistance, leading to a decrease in the voltage drop across the diode and, usually, a sharp increase in current through the diode. The diode remains in conduction until the current through it drops below a value characteristic for the device, called the holding current, I_H . Below this value, the diode switches back to its high-resistance, non-conducting state. This behavior is bidirectional, meaning typically the same for both directions of current.

DIACs have no gate electrode, and they are for example used to trigger other gated thyristors, such as TRIACs. Because DIACs are bidirectional devices, their terminals are not labeled as anode and cathode but as A1 and A2 or main terminal MT1 and MT2.

Most DIACs have a three-layer structure with a breakover voltage of approximately 30 V. Thus, higher voltage devices are typically required for this application.

A second example is a SIDAC ("silicon diode for alternating current") which is electrically similar to the DIAC, but has, in general, a higher breakover voltage and greater current handling capacity. The SIDAC is thus particularly suited to this higher voltage LED lighting application.

The SIDAC is also a bilateral voltage triggered switch. Its operation is similar to that of the DIAC, but the SIDAC is a five-layer device with low-voltage drop in the latched conducting state, more like a voltage triggered TRIAC without a gate.

In general, SIDACs have higher breakover voltages and current handling capacities than DIACs. The SIDAC remains non-conducting until the applied voltage meets or exceeds its rated breakover voltage. Once entering this conductive state going through the negative dynamic resistance region, the SIDAC continues to conduct, regardless of voltage, until the applied current falls below its rated holding current. At this point, the SIDAC returns to its initial nonconductive state to begin the cycle once again.

These devices once again operate as bidirectional voltage-controlled TRIACs without gate. Rather than using the natural breakdown voltage of the device, an extra region is fabricated within the device to form a Zener diode. This allows a much tighter control of the breakdown voltage.

Trisil devices are commonly used to protect circuits from overvoltage. They act faster and can handle more current than SIDACs. By way of example, this type of

crowbar protector is widely used for protecting telecommunications equipment from lightning-induced transients and induced currents from power lines.

The voltage across the protection device in the conduction state is preferably below 5V and may for example be between 1V and 2V such as 1.2V.

5 Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent
10 claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. A lighting module comprising:
 a series connection of LEDs (14) having a forward string voltage when driven
 to a maximum operating current; and
 a protection device (16) in parallel with the series connection of LEDs,
5 wherein the protection device is in an open circuit state when the voltage across the
 protection device is below a threshold and switches to a conduction state when the voltage
 across the protection device is above the threshold,
 wherein the protection device is a DIAC or a SIDAC with a threshold in the
 range of 10V to 50V greater than the forward string voltage of the string of LEDs.
10
2. A module as claimed in claim 1, wherein the voltage across the protection
 device in the conduction state is below 5V.
3. A lighting module as claimed in claim 1 or 2, comprising a series connection
15 of 5 to 50 LEDs, for example 5 to 20 LEDs.
4. A lighting module as claimed in any preceding claim, wherein the forward
 string voltage is in the range 1.5V to 5V per LED in the series connection of LEDs.
- 20 5. A lighting module as claimed in any preceding claim, comprising a plurality of
 parallel branches of series connections of LEDs (14), sharing a same protection device.
6. A lighting module as claimed in any preceding claim, wherein the threshold is
 in the range 20V to 30V greater than the forward string voltage of the string of LEDs.
25
7. A lighting system comprising a plurality of LED boards (12a, 12b, 12c) in
 series with each other, each LED board comprising a lighting module as claimed in any
 preceding claim.

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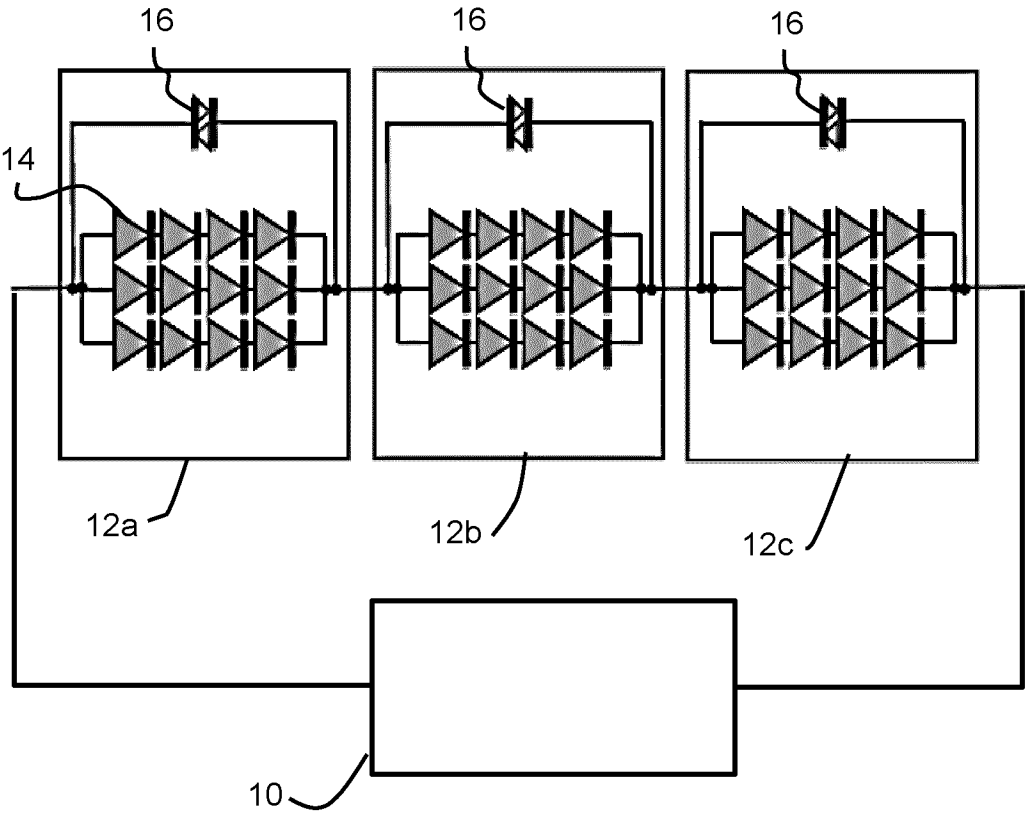


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B33/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013/160400 A1 (ZUMTOBEL LIGHTING GMBH [AT]) 31 October 2013 (2013-10-31) figures 1-4 page 9, line 25 - page 10, line 23; figure 5	1-7
Y	----- US 2014/252956 A1 (SCHMITT HARALD [DE]) 11 September 2014 (2014-09-11) paragraph [0031] - paragraph [0037]; figure 1	1
Y	----- EP 2 161 969 A2 (EXCLARA INC [US]) 10 March 2010 (2010-03-10) paragraph [0076]; figures 8,12 -----	1-7



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/071722

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013160400 A1	31-10-2013	DE 102012206888 A1 EP 2842388 A1 WO 2013160400 A1	31-10-2013 04-03-2015 31-10-2013
US 2014252956 A1	11-09-2014	CN 104039034 A DE 102013203732 A1 US 2014252956 A1	10-09-2014 11-09-2014 11-09-2014
EP 2161969 A2	10-03-2010	CN 101686591 A EP 2161969 A2 TW 201012300 A US 2010060175 A1 US 2012299483 A1 US 2014265860 A1 US 2017019961 A1	31-03-2010 10-03-2010 16-03-2010 11-03-2010 29-11-2012 18-09-2014 19-01-2017