Selecting open LED protectors for lighting strings

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High-power LEDs are finding increasing use in traffic lights, illuminated billboards, streetlights, runway markers, railroad crossings, medical/surgery lighting and vehicular signals. They offer long life — lifetimes of 35,000 to 50,000 hours for high-power white LEDs are typical — and low power consumption. But LEDs are easily damaged by overvoltages caused by nearby lightning strikes, electrostatic discharge (ESD), by overtemperature, or even by inadvertently being plugged in backwards.

Because LEDs are generally connected in series strings, if one LED in a string fails open-circuit then all the LEDs in that string will go dark. (If one LED shorts out then the rest of the string will be unaffected.) What's needed is some way to keep all the other LEDs in a string operating if one fails open circuit, and at the same time protect against electrical threats.

Fortunately there is such a device: the open LED protector. One protector can be connected in parallel with each LED in a string; it will shunt current around an open-failed LED to keep the rest of the string lit. It will also turn on when an overvoltage attempts to drive too much current through the string or when the polarity is reversed.

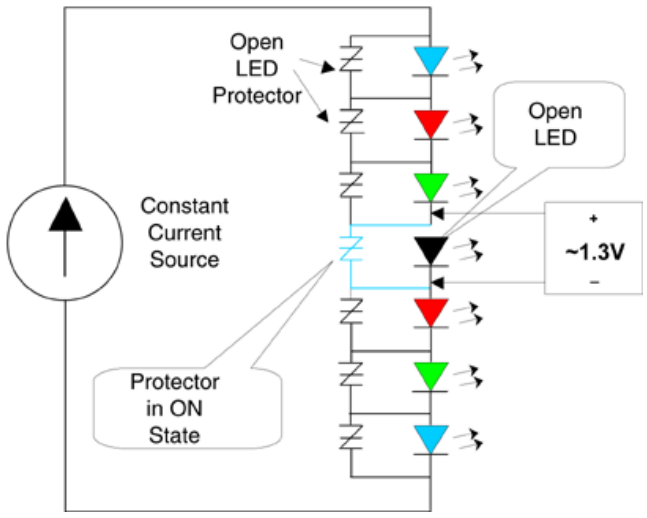

Fig. 1: When an LED fails open-circuit, the open LED protector goes into conduction, limiting its voltage drop to about 1.3V and keeping the rest of the string operating.

Designers have tried a number of devices to do this — zener diodes, MOVs and SCRs, for example — but open LED protectors are best, because they are designed specifically for this application. As shown in Fig. 1, when an LED fails open the voltage across it tries to rise to the compliance voltage of the power supply. The open LED protector senses this voltage rise and goes into conduction, limiting its voltage drop to about 1.3V and keeping the rest of the string operating.

Open LED protectors are available with different features and voltage ratings. Some devices are designed to protect individual LEDs in a string; others allow designers to protect two, three, four or five LEDs with a single device, as a means of cost savings. The first open LED protectors, introduced a couple of years ago, protected against open LEDs and lightning surges, but they did less well against ESD events and reverse polarity. The newest generation of open LED protectors protect against both of these. Designers should select the device based on the threats and needs of the application.

ESD and lightning protection

ESD can find its way to a LED string during assembly or field installation. This could be from machine to LED string or from human contact to the LED string. Lightning can get into the LED string in two ways: a nearby lightning strike could cause a transient in the power supply which could get coupled through to the LED driver and into the string, or a nearby strike could induce an electrical transient in the LED driver power rails and/or wiring leading to the LED string.

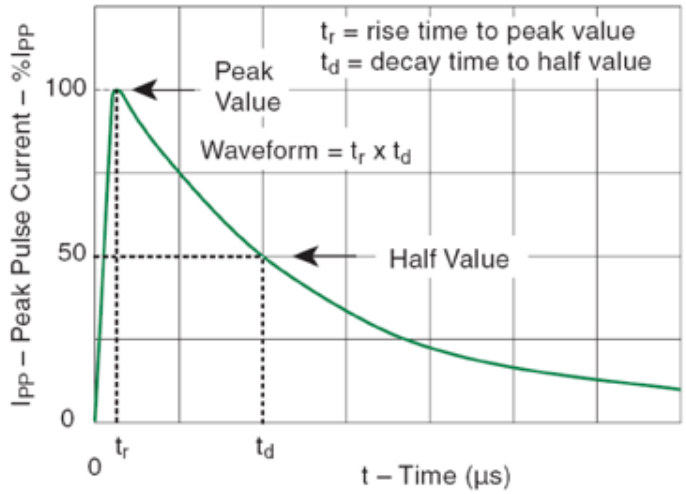

Fig. 2: Lighting surges have risetimes of between 8 and 10 microseconds.

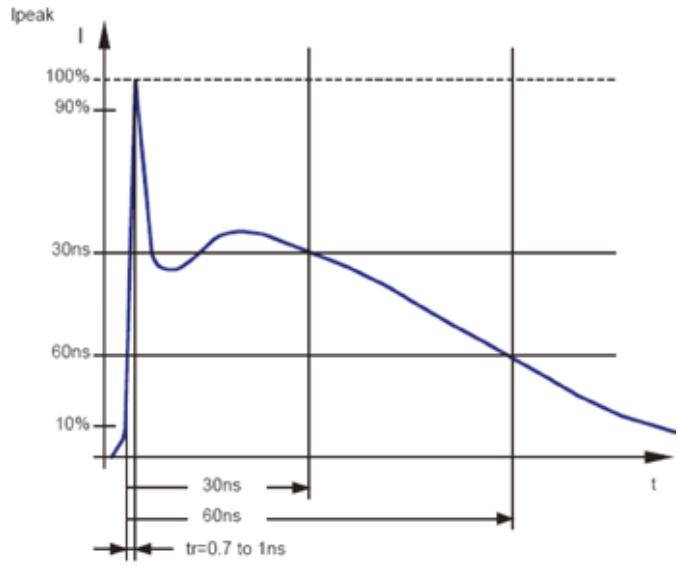

Fig. 3: ESD events have risetimes of a few nanoseconds. New-generation open LED protectors can handle ESD at ±15 kV air discharge, ±8 kV contact discharge and EFTs (electrically fast transients) of ±40A 5/50 ns.

Lighting surges have risetimes of between 8 and 10 microseconds (Fig. 2), while ESD events have risetimes of a few nanoseconds (Fig. 3), depending on the test method. Earlier generations of open LED protectors could defend against the former, but not the latter. New-generation open LED protectors such as the Littelfuse PLED 5 Series can handle ESD at ±15 kV air discharge, ±8 kV contact discharge and EFTs (electrically fast transients) of ±40A 5/50 ns.

Reverse polarity protection

The most common way LED strings are subjected to reverse polarity is through incorrect string placement or orientation during field installation: the LED strings are plugged in backward.

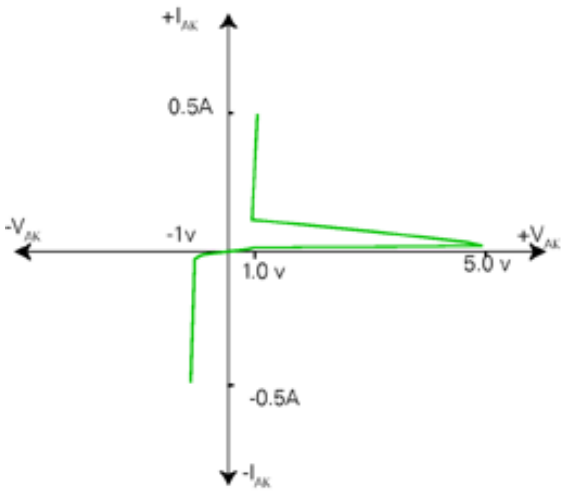

Fig. 4: The Littelfuse PLED 5 open LED protectors have a reverse-bias turn-on voltage of 1.1 to 1.6 V, which provides protection against reverse polarity.

Some models of open LED protectors (for example the Littelfuse PLED5 Series) have a reverse-bias turn-on voltage (Fig. 4) of 1.1 to 1.6 V, which is much less than the reverse breakdown voltage of a typical high-power LED (in contrast to other devices, whose reverse-bias turn-on voltage is similar to their forward-biased turn-on voltage). When power is applied in reverse to an LED string with PLED5s all the protectors go into conduction, shunting the current around the LEDs and protecting them from harm. When the reversed polarity is corrected, the protectors turn off and the LEDs come on normally.

Selecting an open LED protector

The process of selecting the appropriate open LED protector begins with three preliminary evaluations:

- *Cost* — Is initial price critical? Some devices, such as the Littelfuse PLED 9-18 Series, reduce cost by protecting two, three, four or five LEDs with a single device. The tradeoff is that if one LED fails open then all the LEDs protected by that device will go out. For applications such a street lighting this may well be acceptable. But if dark spots in a string will be a problem (as for example in lighted advertising signs) then designers should use the PLED 5 or PLED 6 which protects each individual LED.
- *Hazard profile* — Will the installation be outdoors, where it is likely to be subjected to nearly lightning strikes? Will those doing the installation be sure to use proper ESD protection measures (grounding, etc.) or will they be less fully trained in such matters? If the answers to these questions are yes, then use a protector that offers lightning, ESD, and reverse polarity protection.
- *Criticality of the application* — Will complete or partial failure of an LED string endanger human life and property, or will it be simply an inconvenience? For critical installations, use a protector in parallel with each LED in the string.

Once the type of open LED protector has been selected, it is time to do the analysis of voltages and currents to come up with a good design. For advice on this, contact your Littelfuse representative or go to www.littelfuse.com/PLED.