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TE Circuit Protection solutions for LED lighting applications

The LED based lighting is one of the most popular and fastest developing area, targeted by today's electronic R&D activities. Although this technology is not new, the applied new materials, the growth of the achieved light intensity and the extended lifetime will have the highest impact of the lighting industry in the coming years. It is very important to keep in mind, that external circumstances, like the ambient temperature, the maximum applied voltage and the forward current have huge impact on these factors, therefore it is essential to keep them within satisfactory limits by using circuit protection solutions.

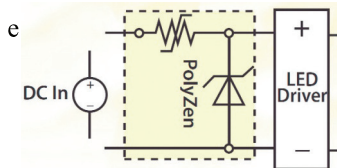
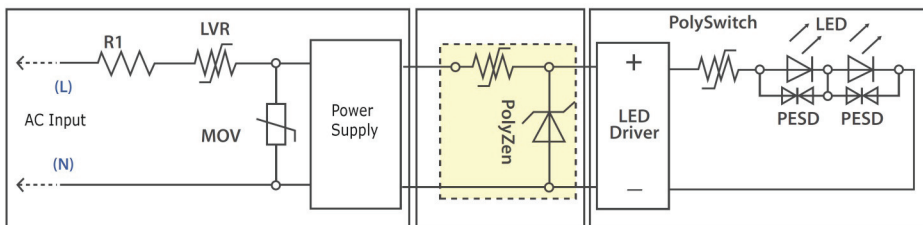
Obviously, LED based lighting solutions provide longer lifespan than traditional lighting, but this is only true, when all factors having affect on lifetime, like LED junction temperature, voltage and forward current, are kept between the defined limits.

As of the longer lifespan, the spare parts are subjected to more environmental affects also for longer time; on the other hand for economical operation it is essential to avoid the need of maintenance. In order to enjoy same trust and acceptance as the traditional lighting solutions, LED based devices should have circuit protection applied to meet also the international safety standards and regulations. Circuit protection could target directly to avoid the failure of the light source (LED), but could also provide the protection against overheating, risk of fire or other overstress caused by the inadequate operation of the power supply circuit.

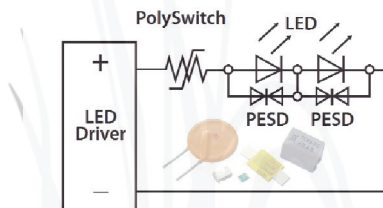
Protection solutions to maximize LED lifespan

As the LED lifetime highly depends on the applied heat management, designers target the adequate cooling. These solutions are normally satisfactory for the normal operation, however the extra heating caused by unexpected

APPLICATION	FUNCTION
Input protection against transient overvoltage and overcurrent events	Safety, circuit protection
Battery protection of safety lighting systems against overheating and overcurrent	Battery protection
Overvoltage protection of low voltage LED sockets' Class 2-power supplies	Safety
Overheat protection to provide long lifetime for LED	LED lifetime
Protection against electrostatic discharge (ESD)	LED lifetime



Environmental affects should also be considered or prevented. TE Circuit Protection offers the PolySwitch devices against over current and over heat events, and should be connected in series with the protected element. During normal operation these devices are in low impedance state, therefore are invisible for the circuit. During overcurrent failure situation, partly



because the growing ambient temperature, partly due to the internal heating caused by the unexpected overcurrent (I^2R), the internal structure changes, the impedance starts to grow, limiting the fault current and protecting the circuit behind. This solution could also be used on the output of the LED driver to provide satisfactory protection against overcurrent and overtemperature generated by anomalies in the circuitry.

The white LEDs used in the general lighting applications are usually containing blue chips that are very sensitive for electrostatic discharges, so it is also advised to use ESD protection.

There are number of producers include tanning diodes into the LED package, but when it is not applicable, external protection, like parallel PESD devices could be used.

Protection of power supply and LED driver circuit

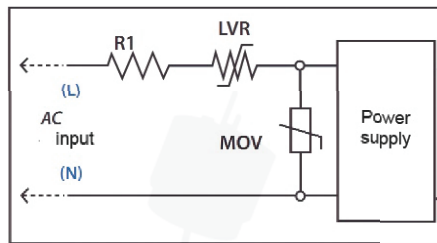
Without adequate circuit protection, transients (like spikes, neutral line break etc) of the power net decrease the lifetime of the complete light source.

To minimize the damage, it is possible to use PolySwitch LVR and MOV (metal-oxide varistor) elements in combination.

The appearing overvoltage is handled by MOVs, while the growing current activates the LVR, which goes into high impedance state and starts to limit it.

The R_1 resistor of the figure is not a protection device, it only helps to limit the current to the value, which could be safely handled by the LVR.

In some cases, LED driver inputs are



subject to non-transient overvoltage events, that are caused by accidentally connected higher than nominal voltage or reverse polarity power supply.

An example can be a LED based table lamp, which should be energized with an external power supply, and a wrong device is used. In these cases a semiconductor based fast clamping device should be used for protection, like the PolyZen device of TE Circuit protection. PolyZen is designed as a

combination of Zener diode provided overvoltage protection and a PolySwitch device for current limiting in closed thermal coupling. The PolySwitch device will protect the Zener diode from overheating and burning down, by providing effective current limiting once the Zener is activated and its current grows.

AC2Pro protection for line voltage LED based lighting systems

As mentioned above, the overvoltage events caused by transients and spikes of the line voltage, could be effectively handled by using metal oxide varistors (MOV) in LED based lighting devices. Lightning, sudden switching of huge inductive or capacitive load, breaking of neutral line can induct such high transient voltages, which cannot be handled by the varistor, the device would suffer from thermal runaway, can blow or burn. Recently there are hybrid devices appearing on the market, which incorporate effective overtemperature protection to the clamping overvoltage device. These devices could be used – among others – for input protection of power supplies of LED based lighting systems. During normal circumstances, the voltage appearing on the MOV does not exceed the maximum permitted voltage of the device, and even the extra energy generated by handling the fast overvoltage events caused by e.g. spikes, will also be handled. The abnormal

cases, like for instance the neutral cable loss will result however long transient overvoltage events, and without effective overtemperature protection, the MOV would suffer from thermal runaway.

Usual solution was using a serial TCO, and an extra overcurrent protection element, like a fuse in order to limit the generated transient overcurrent. Instead of using discrete circuit elements, it is better to use an integrated solution. TE Circuit Protection's AC2PRO devices offer this kind of hybrid protection, being a combination of a metal oxide varistor and a thermally coupled PPTC device. During abnormal operation, the MOV goes to low resistance state and

starts to conduct current to the ground, that can grow fast to a value, which would lead to thermal runaway, burning down the MOV and result fire.

The integrated PPTC however would also warm up partly because the thermal coupling with the hot MOV, partly because the I^2R self heating of the growing current. This warming up will activate the current limiting ability of the PolySwitch, which then would go into high resistance state and save the MOV from burning down. A further advantage of the device is its reset ability, when the problem is gone, after a certain cooling time, the AC2PRO resets to normal state

and is ready to function normally. Maintenance costs could be minimized as no replacement is needed.

The figure left below shows the operation of the AC2PRO device during a transient event caused by neutral loss. The AC2PRO is available at the moment in 150 mA, 350 mA and 700 mA hold current versions, with 400V MOV nominal voltage. Using these hybrid protection devices the LED based lighting systems can easier meet the requirements of the industry a well as the concerning (safety) standards (IE61000-4-5 and IEC60950).

