Brief Introduction to the LED Driver circuit protection

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Summary ：In this article, issues concerning possible over-voltage and over-current conditions like ElectroStatic Discharge (ESD) and surge that might cause damages to the LED driver circuit are discussed. Suggestions are given on the selection of the surge device and its connection method within the circuit.

Keywords ：LED, MOV, GDT/SPG, TVS, CRD，Surge, ESD, LED Open Circuit Protector

LED, with its high efficiency, high reliability and low power consumption, is widely used in many fields. Typical applications include illumination, display board and traffic signals. LEDs are very vulnerable to over-voltage and over-current conditions especially when used for outdoor applications, causing billions of dollars of economic lost and even human life can be threatened. If proper actions were taken, reliability of LED driver circuit can be greatly enhanced, avoiding unnecessary damages.

Typical LED driver circuit consists of several parts: AC power supply, AC/DC converter and DC/DC Module. Different combinations of surge devices are applied to different parts.

1. On the AC power supply panel, Metal Oxide Varistor (MOV) or combined with Gas Discharge Tubes (GDT/SPG) can be used to protect the circuit. As illustrated in Figure 1, when the AC supply is grounded to PE, common mode and differential mode protection should be adapted at the same time to form the protection circuit. The Varistor connected between L-N can clamp differential mode over-voltage effectively and thus protect the circuit from been damaged. Between L/N and PE, MOV or MOV + GDT/SPG connected in series can guide possible lightening surges to earth, avoiding them from been injected into the lateral circuit. As shown in Figure 2, if the circuit is not grounded, a single Varistor between L/N lines is sufficient. TMOV or PMOV can be used here to prevent possible fire caused by short circuit in case of MOV failure. The continuous operating AC voltage of the Varistor should be about 1.2~1.4 times the maximum AC supply voltage. For GDT/SPG, the lower boundary of DC spark-over voltage should be adequately above the peak voltage of the power supply. Surge current capabilities should be chosen so as to match the surge requirement.

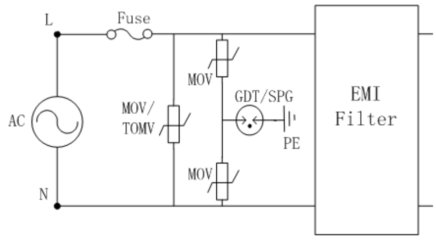

Figure 1: Common&differential protection mode of AC supply

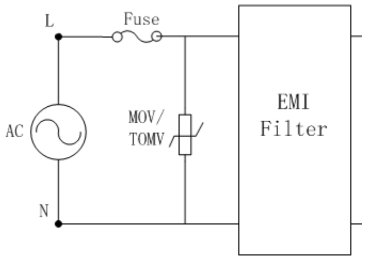

Figure 2: Differential protection mode of AC supply

2. After AC/DC conversion, measures should be taken to protect sensitive IC chips. As shown in figure 3, TVS connected in parallel with the circuit can act within a few pico-seconds in the event of over-voltages, clamping the voltage within a safe level that won't cause damage to the ICs. Over-current can be suppressed by connecting a PTC in series. The resistance of the PTC can become very large when subjected to over-current, blocking the current flow, and return to its normal low-resistance condition after the over-current is removed, thus the circuit returns to normal operation. When selecting TVS device, the reverse stand-off voltage should be about 1.2~1.4 times the peak normal circuit voltage; the power should be chosen based on the surge energy. Factors affecting the selection of PTC include operating current, voltage and environment temperature. The holding current of PTC reduces as the temperature rises. As shown in Figure 3, PTC is usually connected before TVS. In this way, PTC can protect ICs and at the same time, form some certain level of protection to TVS. The service life of TVS can thus be prolonged.

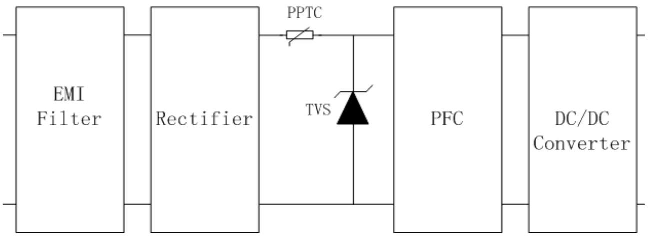

Figure 3: Protection circuit after AC/DC conversion

3. The brightness of LED is controlled by the current flowing through it. Unstable current can cause damage to LED. As shown in Figure 4, a Current Regulative Diode (CRD) can be applied to generate a stable current to drive the LEDs. Drive current for low-power LEDs is usually between 10~30mA, while high-power LEDs can go up to 200~1400mA. CRD should be selected according to the required current value. Since possible over-voltage condition like ESD can occur on this part of the circuit, a TVS can be applied here to suppress these over-voltages.

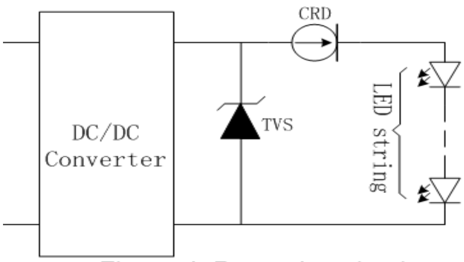

Figure 4: Protection circuit for direct LED drive part

4. When multiple LEDs are connected in series as shown in Figure 5, open-circuit malfunction of one LED can cause the entire LED string to turn off. To solve this issue, we can connect an open circuit protector, Tx, in parallel to every individual LED. In case of open-circuit of one LED, the Tx connected in parallel will break-down and start to conduct, maintaining a smooth flow of the current. In this way the other LEDs will not be affected and continue to operate normally. To achieve such a protection level, the cost is relatively high, too.

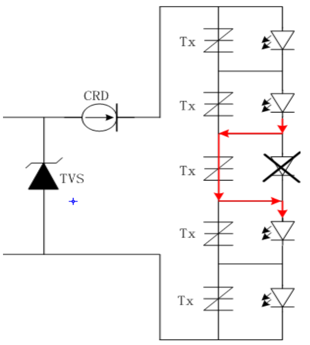

Figure 5: Protection of LED string

To summaries, typical LED drive circuit consists of several parts: AC power supply, AC-DC converter and DC/DC Module, and the overall protection design can be illustrated as shown in Figure 6:

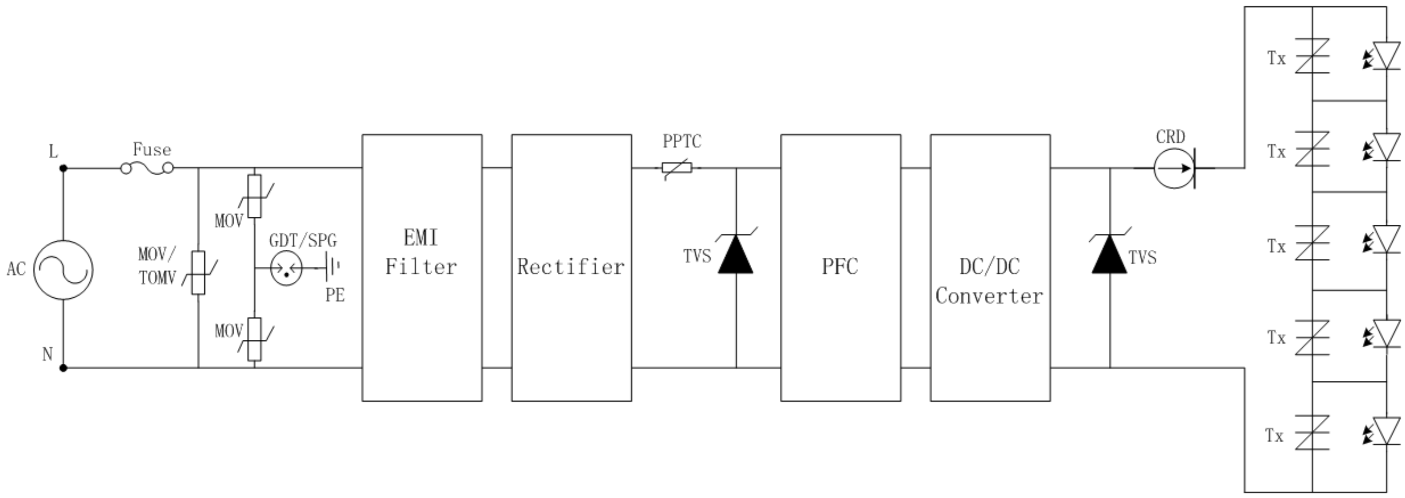

Figure 6: Overall protection design for LED drive circuit

In the actual selection of surge protection devices, factors including circuit voltage/current, adopted surge test standard and level, operating environment, and IC chip data, should all be considered and evaluated in order to achieve required protection level.