Choosing the Right Circuit Protection for LEDs

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Approximately 25 percent of global energy consumption goes to lighting applications, so making lighting more energy-efficient could have a dramatic impact on overall energy usage or make more power available for other uses. Legislation designed to discourage the use of incandescent lamps has been a significant factor in the growth in demand for LED lighting equipment. At the same time, both consumers and industrial users are increasingly interested in energy-efficient lighting options, further stimulating the demand for LED lighting.

Technical innovations that impact LED efficiency (more lumens per watt), secondary optics (better lenses/reflectors), and thermal dissipation are increasingly allowing LED lighting to replace legacy light sources like mercury vapor, metal halide, and sodium vapor lights in outdoor applications. However, outdoor LED lighting can be very expensive to install; payback must be determined based on lower wattage demands, lower maintenance costs, and a longer operating life. To prevent outdoor LED lighting from experiencing failures within an investment payback period of about five years, high durability and reliability are essential. Transient surge events in AC power lines represent a serious threat to outdoor LED lighting fixtures.

Indirect Lightning-Induced Surges

Whenever electrical devices are switched on or off, overvoltage transient surges can affect nearby AC power lines. Similarly, lightning strikes **(Figure 1)** can generate transient surges in AC power lines, especially in outdoor environments.

Indirect lightning energy can affect outdoor LED lighting installations adversely. Transient voltage protection is crucial to eliminate field failures driven by the electrical environment. Luminaires are vulnerable to damage both in the differential and common modes:

- **Differential mode:** High voltage/current transient between the L-N or L-L terminals of a luminaire could damage components in the power supply unit or LED module board.
- **Common mode:** High voltage/current transient between the L-G (earth) or N-G (earth) of the luminaire could break over safety insulation in the power supply unit or LED module board, including the LED to heat-sink insulation.

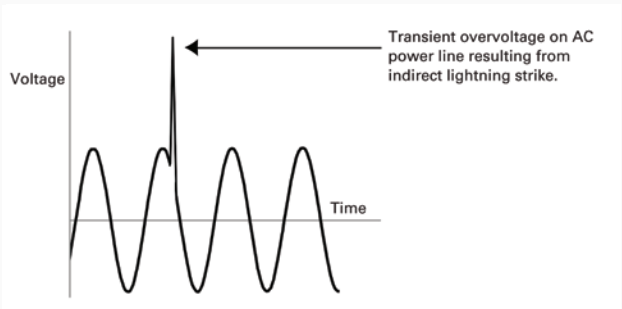

Figure 1. Effects of indirect lightning strike on AC power line.

LED lighting equipment manufacturers rely on carefully chosen fuses, metal oxide varistors (MOVs) and transient voltage suppression (TVS) diodes to meet important regulatory and safety standards related to overvoltage transients. The United States is leading the way in establishing uniform performance and safety standards for both indoor commercial lighting and outdoor roadway, parking lot and garage illumination.

Overvoltage transient surge testing per IEC 61000-4-5 is a global requirement for LED lighting assemblies, except in the United States, which has its own set of standards. In addition, part of IEC61547, "Equipment for General Lighting Purposes," requires electromagnetic compatibility (EMC) immunity testing. **Figure 2** shows two waveforms that define rise time and duration of the test voltage and current. The test waveform is a combination 1.2×50µs open circuit voltage and 8×20µs short circuit current waveform. To conduct this test, the specified peak current is calibrated on the surge generator by shorting the output to ground prior to connecting to the luminaire.

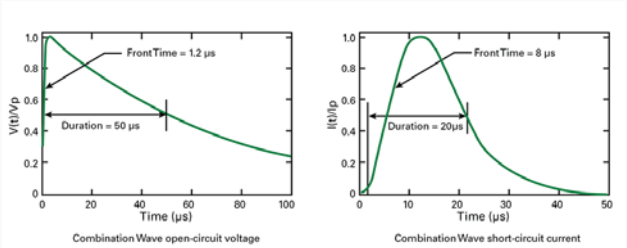

Figure 2: IEC 61000-4-5 surge immunity test waveforms: 1.2×50µs open circuit voltage and 8×20µs short circuit current.

To prevent damage caused by surge energy, enhance reliability, minimize maintenance, and extend the useful life of an outdoor lighting installation, a robust surge suppression circuit is essential. **Figure 3** illustrates the various elements often incorporated into a street light surge protection circuit.

Thermally Protected Metal Oxide Varistors (MOVs)

MOV technology is an affordable, highly effective method for suppressing transients in power supplies and other applications, such as the SPD modules often located in front of an LED driver.

MOVs are designed to clamp overvoltage transients within microseconds. However, when built into SPD modules, MOVs can be subject to temporary overvoltage conditions caused by loss of neutral or by faulty installation wiring. These conditions can severely stress an MOV and cause it to experience thermal runaway, resulting in smoke, overheating, and possibly fire. North American safety standards for SPDs (including UL 1449) define atypical conditions under which devices must be tested to ensure SPD safety. Robust SPD designs feature thermal disconnects to protect the MOVs from thermal runaway.

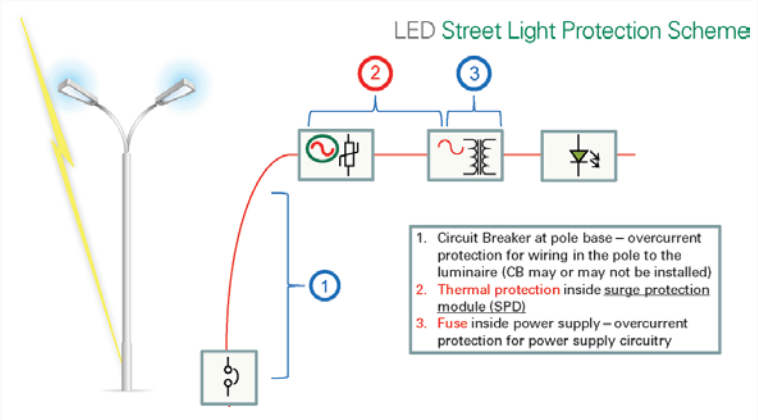

Figure 3: LED street light protection scheme

MOVs tend to degrade steadily after exposure to a large surge or several small surges, which leads to increasing MOV leakage current. Even under normal conditions (e.g.,120Vac/240Vac operating voltage), this degradation will increase the MOV's temperature. A thermal disconnect placed next to the MOV can be used to sense the increase in MOV temperature as it continues to deteriorate. When the MOV reaches the end of its operating life, the thermal disconnect will open the circuit, remove the degraded MOV from the circuit, and prevent its catastrophic failure.

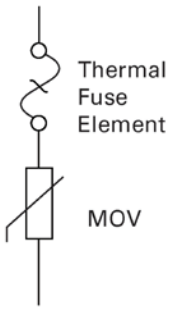

Figure 4: A thermal disconnect can open a circuit and prevent catastrophic failure of a degraded MOV.

End-of-Life/Replacement Indication

Once an MOV is disconnected from the circuit, the SPD no longer provides surge suppression. To prevent subsequent surges from damaging the fixture, the circuit designer should implement a method that alerts maintenance personnel that the SPD requires replacement. Luminaire designers have two main types of SPD module configurations from which to choose, depending on their maintenance and warranty strategies: parallel- and series-connected surge protection subassemblies.

- **Parallel connection:** The SPD module is connected in parallel with the load. Here, an SPD module that has reached end-of-life condition is disconnected from the power source while the AC/DC power supply unit remains energized. The lighting fixture still operates, but the power supply unit and LED module are no longer protected from the next surge. Today, SPD modules are available with small LEDs that serve as replacement indicators, such as a green LED that indicates an online SPD module or a red LED that indicates an offline SPD module. It's also possible to indicate the need for SPD module replacement remotely by using a light management center with SPD module end-of-life indication wires connected to a networked smart lighting system rather than placing indicators at each lighting fixture.

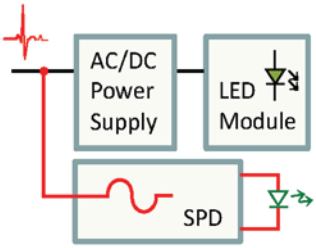

Figure 5. Parallel-connected SPD module.

- **Series connection:** In this configuration, the SPD module is connected in series with the load. An SPD module at the end of its life is disconnected from the power source, which turns off the light, indicating the need for a maintenance call. The disconnected SPD module not only turns the light off but isolates the AC/DC power supply unit from future surge strikes. This configuration is growing in popularity because it protects the luminaire investment while the SPD module is awaiting replacement. It is also much more economical to replace a series-connected SPD module than to replace the whole luminaire, as in the case of a parallel-connected SPD module.

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Conclusion

Installing a SPD module in front of the LED power supply unit provides effective protection for lighting systems. Placing thermal disconnects in these modules improves their overall safety and helps them to achieve UL 1449 certification. To allow LED fixtures to pay back their initial investment, designers must include mechanisms to indicate their SPD modules require replacement.

For more information, visit **http://www.littelfuse.com/industries/led-lighting.aspx**

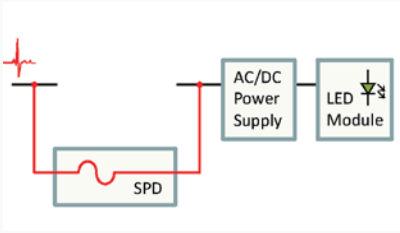

Figure 6. Series-connect SPD module

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