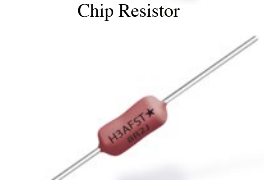
Overcoming Reliability Challenges in LED Streetlight Applications

APPLICATION NOTE

LSP Series LED
Shunt Protector

PTVS Diode

Current Sense
Chip Resistor



Fusible Power
Resistor

BACKGROUND

Light Emitting Diodes (LEDs) are seen as a beneficial emerging technology in the established streetlight market. Mature technologies for this market are sodium and metal halide lighting, which are well-understood and reliable. In recent years, however, these existing technologies have been scrutinized from an economical as well as an environmental point of view. The global economic slowdown has increased pressure on funding of public services, and is prompting the examination of not just the installation and maintenance costs of streetlights, but also the ongoing costs of operating them. Coupled with incentives for reduction of CO_2 emissions, LED lighting is beginning to show its broad benefits for more widespread adoption.

BENEFITS OF LED TECHNOLOGY

The cost of ownership of streetlights encompasses their installation, maintenance and the ongoing cost of electricity. LED technology experienced false starts when light output, reliability or temperature effects have produced disappointing results. With a reported 20 % of global energy used for lighting, advantages of both a reduction in energy cost and CO_2 emissions have resulted in a more positive acceptance of LED technology for streetlights.

One of the crucial hurdles to LED acceptance is reliability, where ENERGY STAR and similar standards set the bar high in terms of light output and life expectancy. Where high-pressure sodium lighting would easily provide up to 30,000 hours of expected life, LED lighting offers double the lifespan at 60,000 hours. By taking advantage of improved LED light output for a given input power (efficacy) and improved light delivery where it is needed with less light spill or pollution, LED lighting has been shown to deliver energy savings of up to 50 % compared to existing technologies.

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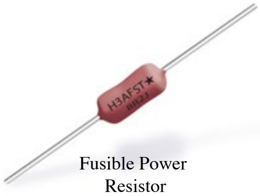

Fusible Power Resistor

LUMINAIRE RELIABILITY

An important consideration is that streetlight and industrial lighting luminaires often differ from domestic 'plug and play' modules. Sub assemblies for streetlight luminaires need careful commissioning on-site as part of an overall fixture, which introduces potential problems. Electricians typically need to have direct contact with boards, subsystems and connectors during installation. Streetlight designs normally have a control unit or power supply at the pole base, and the luminaire remote at the top.

Because of the variety of streetlight luminaire components involved, there are numerous areas where the luminaire can be potentially exposed to stress from the moment of installation. The first is the possibility of miswiring while the LED module is being installed, and miswiring can be as simple as reversing polarity. The luminaire can also be exposed to Electrostatic Discharge (ESD) from the craftsperson handling the sub assemblies and while an exposed LED module is being handled before being mounted into the lens fixture. When the lamp enclosure is sealed, temperature extremes of -40 °C to +125 °C are not uncommon with contributing environmental and self-heating LED factors. Industrial fixtures for public spaces such as fuel station lighting often face similar or greater stress challenges due to the environment in which they are placed.

ENSURING RELIABILITY WITH LED SHUNT PROTECTORS

Most LED designs include solid-state lighting luminaries configured in series strings of twenty or more LEDs. In this configuration, an open LED can cause the entire LED string to go dark, resulting in reduced performance and possible maintenance calls and costly warranty returns. Adding an LED Shunt Protector (LSP) device to an LED design allows the unaffected lights in the string to remain illuminated by shunting current around the inoperable LED.

In addition, compared to low-power LED string designs typically incorporating zener diodes, high-power LEDs used for streetlights require very large and expensive zeners. LSP devices present a more cost-effective solution to ensure reliability of the remaining LEDs in a string when an LED fails open circuit. Further, it has been shown that LSP devices in active mode dissipate less power than the LEDs.

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STREETLIGHT LUMINAIRE EXAMPLE

An optimal configuration for a streetlight luminaire is shown in the circuit diagram example in Figure 1 below. In this configuration, if the power is accidentally reversed during installation, the forward diode characteristic will protect the LED string from damage, while also protecting against fast transients at the power terminals. Also important, is the fact that in highly stressed LED strings, LEDs can develop an open circuit state, often as a result of cooling and heating stresses inside an LED package. Using LSP devices in this design example helps to maintain illumination in the remaining LEDs in a string if an LED goes into an open circuit state as a result of electrical or thermal damage.

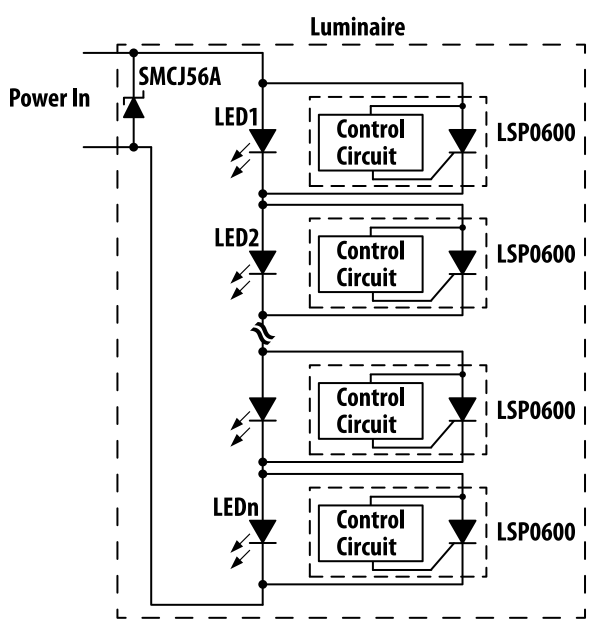

Figure 1. | *Optimal Configuration for a Streetlight Luminaire*

EFFECTIVE CURRENT CONTROL

The inverter for an LED module has to perform multiple functions. A sodium lamp typically requires a simple 50/60 Hz magnetic ballast and starter, whereas a modern switching inverter used to drive a multi-LED lamp fixture has to meet many new challenges. LEDs must have effective current control to maximize life expectancy while also maintaining the expected light output. LED ballasts may also need to control light output for motion detection or dimming for periods when the space is unused. An entire street is many times interconnected in zones to illuminate when pedestrian or vehicle activity is detected.

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EFFECTIVE CURRENT CONTROL *(Continued)*

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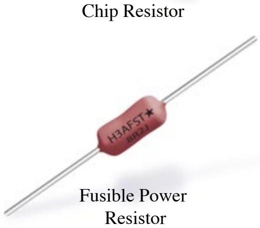

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LED streetlight applications require new high-frequency switching inverters to perform power factor correction and precise current control while typically constrained to a small form factor and a hostile installation environment. Adding to the challenge are recent developments that interconnect streetlights either by RF radio links or wired control lines for a system control approach. This new interconnection scheme with built-in intelligence results in more sensitive high value circuits, which need to be protected from lightning, AC events and faults.

Bourns® Power TVS (PTVS) diodes offer an effective circuit protection solution for high current LED streetlight applications. Bourns® PTVS diodes offer bidirectional protection from 58 volts to 470 volts, and are UL recognized while also meeting IEC 61000-4-5 8/20 µs surge requirements. The use of silicon technology in the PTVS products offers lower clamping voltage under surge compared to competing varistor technology.

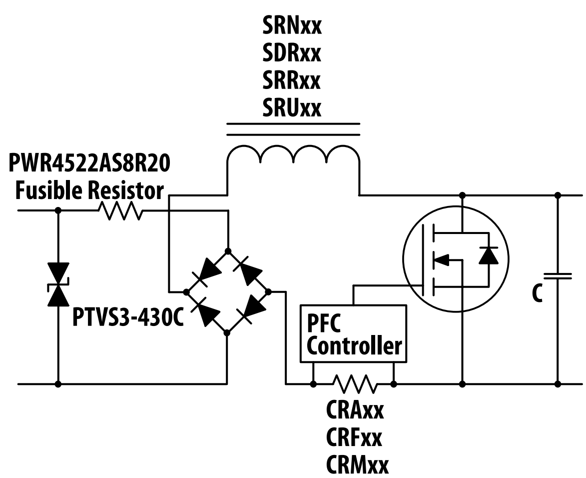

Figure 2. Streetlight LED Power Supply using a Power TVS Diode

Figure 2 is a representation of how a typical streetlight LED power supply may be configured using a Power TVS diode (PTVS) instead of a more common varistor to protect against transients in this electrically-exposed environment. Completing the power supply design, Bourns has a broad selection of inductors available in high current, flat wire, semi-shielded and fully shielded options to maximize performance.

In addition, tight current sensing control can be achieved with Bourns' CRx range of current shunts. This current sense resistor series cover the full range of requirements with very high accuracy, as well as high power density and a broad operational temperature.

Incorporating the Bourns® PWR4522 family of fusible resistors can be an efficient combined inrush and overcurrent protection solution that helps save valuable board space.

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SOLUTIONS FOR RELIABILITY DESIGN CHALLENGES

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Developers faced by many of the reliability challenges of streetlight or industrial LED lighting applications can find optimal solutions in Bourns' broad selection of products. Open LED failure can be addressed with a range of LSP devices, and Power TVS diodes offer effective protection for applications in an electrically-exposed environment where varistors may not be able to offer the required performance.

The Bourns® LSP Series of open LED shunt protectors includes four models: LSP0600, LSP0900, LSP1300 and LSP1800. Customers can maximize their level of protection by selecting Bourns® Model LSP0600 and using one device per LED. Alternatively, customers can reduce their protection costs by selecting Bourns® Models LSP0900, LSP1300 or LSP1800 which have the capability of isolating groups of two, three or four LEDs respectively.

When more precision is desired, Bourns® CRx current sense resistors provide tight tolerance and high precision over a wide range of resistance values. These highly specialized resistors are capable of withstanding surges without a material change in the characteristics of the resistor, and offer total resistance values lower those required by industry standards, giving engineers enhanced design flexibility.

The Bourns® PTVS diode products offer a wide voltage range, low clamping voltage under surge, standards compliance, and consistent performance for a variety of designs. Matching an extensive range of application requirements, Bourns® inductors are available in high current, flat wire, semi-shielded, shielded and non-shielded options. The Bourns® PWR4522A series of axial leaded wirewound resistors in a flame retardant silicone coating are designed to fuse under abnormal conditions such as sudden surges in voltage or circuit malfunctions. The resistor will fuse instantly upon the application of 220/240 mains voltage without flame or incandescent particles.

ADDITIONAL RESOURCES

For more information visit Bourns online at:

www.bourns.com

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