TECHNICAL NOTE

2 Surge Protective Devices for LED Lighting

A Technical Supplement from NLS Engineering

SUMMARY AND CONCLUSION:#

Outdoor luminaires are susceptible to transient spikes caused by power system switching, direct lightning strikes, and indirect lightning strikes. The older methods of lighting, such as mercury vapor, metal halide or sodium vapor lights, relied upon their robust construction to suppress any transient voltage spikes. LED lighting isn't afforded that luxury and voltage transients can destroy drivers and the LEDs themselves. Due to the sensitive nature of LED lights, numerous studies have been conducted and resulted in the creation of IEEE C62.41.2-2002 with suggested surge levels. In addition, UL released UL 1449 in 2007which has become the primary safety standard for surge protective devices (SPDs).

The LED driver without external surge protective device is designed to handle surges in the 2-3 kV range. To achieve a system IEEE protection level of **20 kV/10 kA**, the external SPD is required.

It is recommended that 3 levels of SPD protection be offered, see Table 3 for details:

1. ***Standard Protection****: Standard in all fixtures regardless of geographical location*

   or

   Modified Warranty*: If fixtures are sold without at least the standard protection for lightning prone areas as shown in Table 1, the warranty is reduced to 1 year*
2. ***Protection Upgrade 1****: Upgrade option that would offer IP66 and thermal cutoff that would meet UL 1449 requirements for SPDs*
3. ***Protection Upgrade 2****: Upgrade option that would offer IP66, meet UL 1449, thermal fail-safe, disconnect luminaire from circuit to prevent damage during next transient event, failed SPD indicator, and ability to mount the SPD in steel poles*

Nh|#Ibgbjv#

- Parallel SPDs do not protect the fixture from subsequent lightning strikes after it has been subjected to a transient surge
- Series SPDs will protect the fixture from subsequent lightning strikes after it has been subjected to a transient surge
- Series SPDs can be pole mounted if pole is steel
- Indirect lightning strikes several miles away can still create a damaging transient surge
- Power system switching can cause a damaging transient surge
- Top 10 states for lightning strikes: Texas, Florida, Oklahoma, Missouri, Kansas, Arkansas, Louisiana, New Mexico, Illinois, Mississippi
- Most prevalent months for lightning strikes: May, June, July, August
- SPDs need to be disconnected during HiPot testing; this test may damage the SPD and reduce its life and effectiveness
- NLS Non-conforming data for Q1 & Q2 2018 indicate a correlation between increased driver failures and lightning season. Further data analysis should be performed to determine a causal effect

TECHNICAL NOTE

A Technical Supplement from NLS Engineering

1 Introduction

LED fixtures contain electronic components that are sensitive to transient surge events in AC power lines. These can damage lighting fixtures and represents a significant threat to outdoor LED lighting installations.

Power surges in outdoor lighting have various causes:

- Direct lightning strikes to the fixture, the power supply cables or the lighting peripheral equipment
- Indirect lightning strike effects due to capacitive or inductive coupling in the power supply cables
- Switching operations due to ground faults, short-circuits or triggered fuses

Whether a partial or complete failure is produced depends on the energy density of the current pulse and the sensitivity of the components to power surges. Lightning strikes near the lights can generate voltages of up to several tens of thousands of volts in the lines. Transient surge events in AC power lines, which can damage lighting fixtures, represent a significant threat to outdoor LED lighting installations.

2 Regional Differences in Lightning Frequency

Satellite based Lightning Sensor (LIS) observations were used to study lightning activity. This research has shown clear differences in flash frequency in different regions, see Figure 1. The flash activity in different regions shows a clear difference corresponding to local climate, topography, and environment conditions. In addition, lightning season occurs at different months for each state, see Table 1.

Rank	State	Lightning Strikes per Year	Month of Maximum Occurrence
1	Texas	2.878 million	May
2	Florida	1.193 million	July, August
3	Oklahoma	1.088 million	May, June
4	Missouri	1.067 million	May, June, July
5	Kansas	1.022 million	June, July
6	Arkansas	853,135	May, June, July
7	Louisiana	813,234	May, June, July
8	New Mexico	792,932	July, August
9	Illinois	792,479	June, July
10	Mississippi	787,768	July

Table 1) **Lightning Occurrences by State and Month**

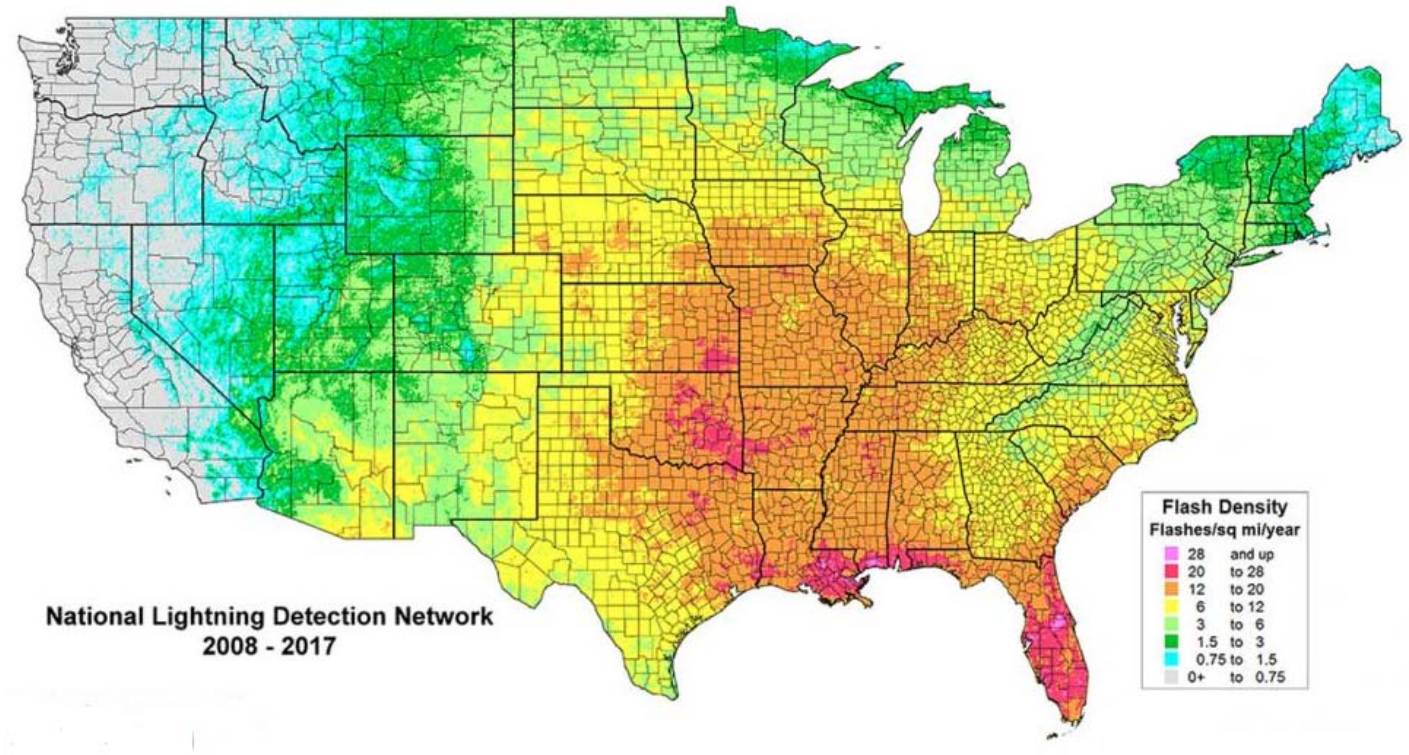

Figure 1) **Lightning Flash Density**

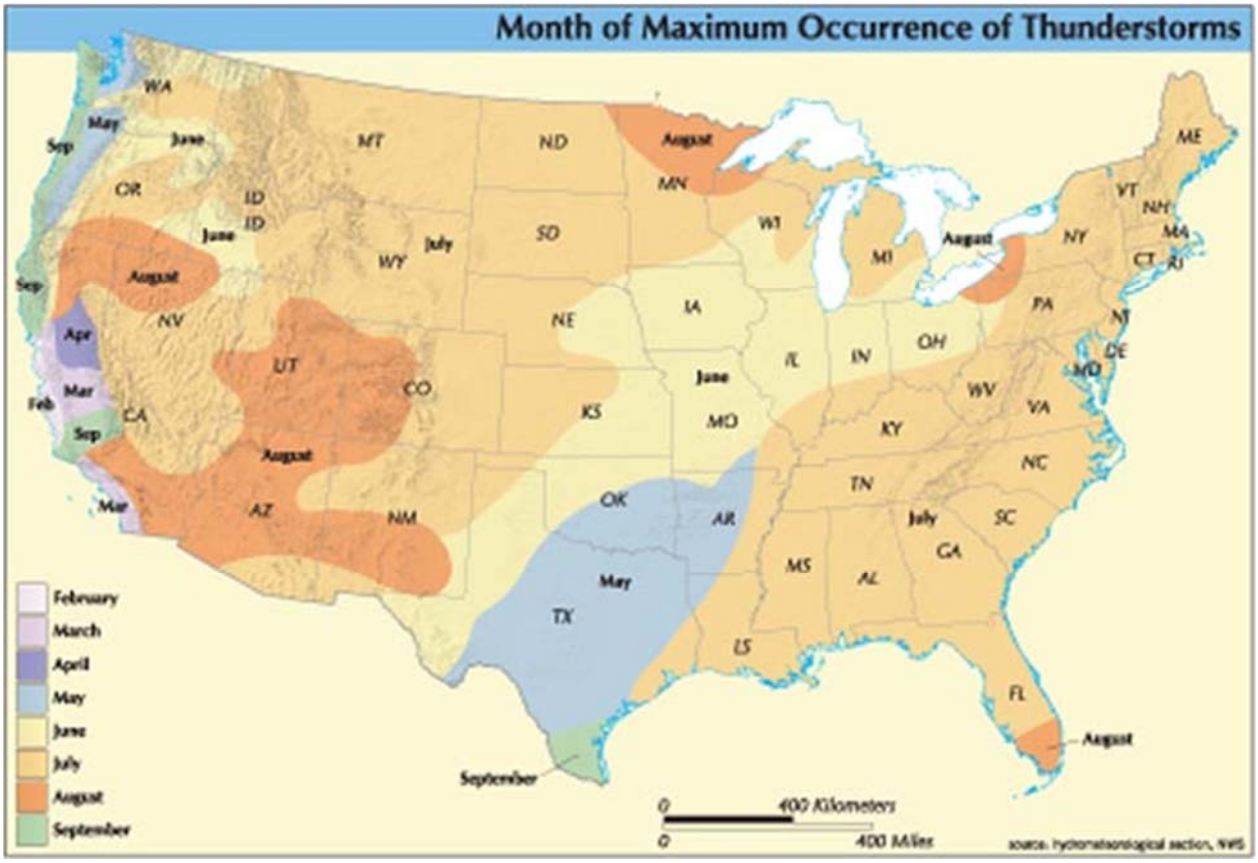

Figure 2) **Month of Maximum Lightning Occurrence**

3 Correlation with NLS Reported Driver Failures

Data collected and analyzed from the Non-Conforming Smartsheet from March 2017 to July 2018 shows no correlation between lightning season 2017 and driver failures, se Figure 3. There does appear to be a significant increase in driver failures for the beginning half of lightning season 2018. The dramatic change in 2018 may be due to increased sales in lightning prone states.

Fixtures may be in the field for 9-10 months before a reported problem since lightning season is between May and August.

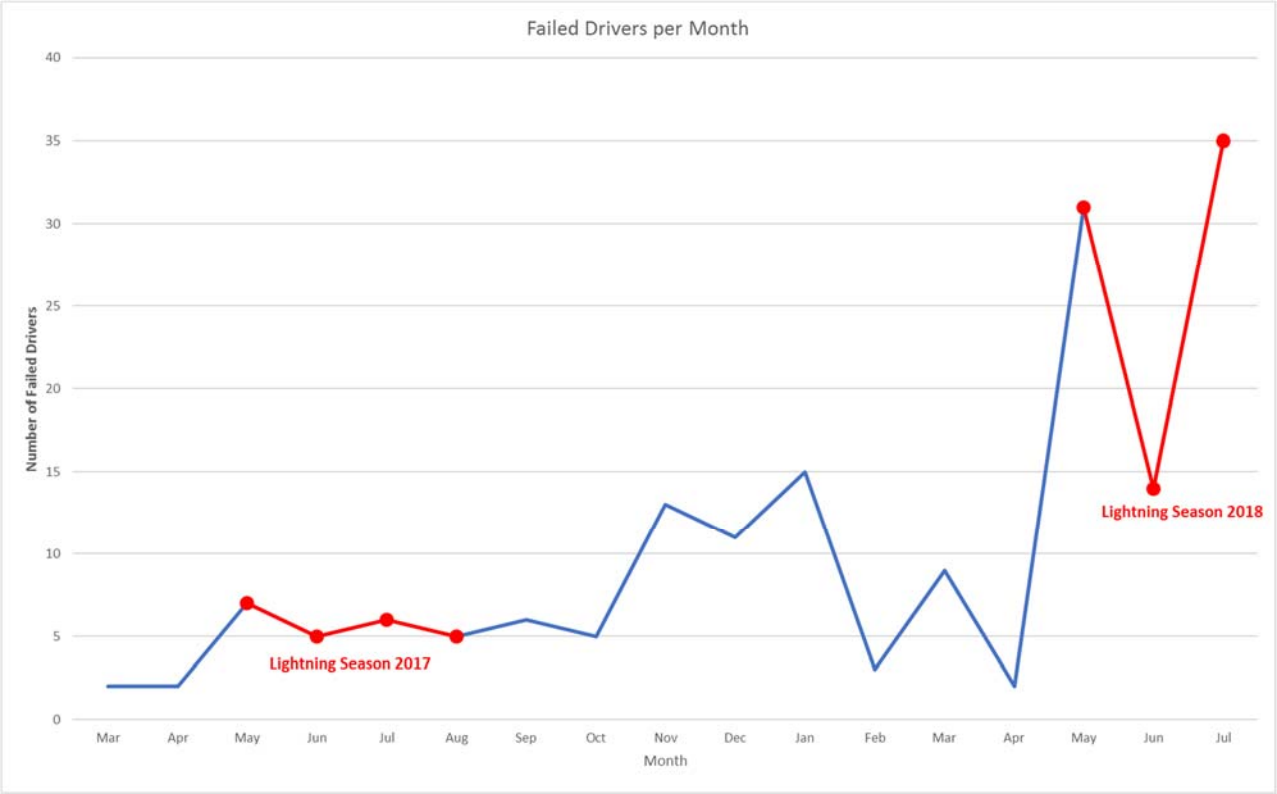

Figure 3) **NLS Failed Drivers per month**

4 Protecting Against Induced Surge Events

Protecting outdoor LED lighting from lightning induced surges requires diverting high voltage/current transient interference away from sensitive electronics in the lighting fixture, see Figure 4. The most common type of surge protective device (SPD) for outdoor LED fixtures is the metal-oxide varistor (MOV). This is designed to remain at standby in the circuit under normal conditions. When an abnormal high-voltage transient occurs, it activates to absorb the transient energy, then return to standby mode. However, after MOVs absorb a certain number of surge strikes, they will begin to degrade and no longer provide surge protection. The SPD is considered to be a sacrificial or disposable device in that any potentially harmful electrical surges may cause the low-cost SPD to fail, thereby protecting the LED fixture.

5 Discussion and Recommendations

- Due to the sensitivity of LED lighting all outdoor fixtures should have some level of surge protection. A $4 - $9 device can save a $1000 fixture and associated field and labor costs.
- Three levels of SPD can be offered:
    - **Standard Protection**: standard in all fixtures regardless of geographical location usage, see Table 4

      or

      Modified Warranty: If fixtures are sold without at least the standard protection for lightning prone areas as shown in Table 1, the warranty is reduced to 1 year
    - **Protection Upgrade 1**: Upgrade option that would offer IP66 and thermal fail-safe that would meet UL 1449 requirements for SPDs, see Table 4
    - **Protection Upgrade 2**: Upgrade option that would offer IP66, meet UL 1449, thermal fail-safe, disconnect luminaire from circuit to prevent damage during next transient event, failed SPD indicator, and ability to mount the SPD in steel poles, see Table 4
    - SPDs shown are from Little Fuse but other SPD suppliers offer similar products
- SPDs should be disconnected from the fixture during HiPot testing. The test overvoltage can damage the SPD and decrease its life and effectiveness
- Built-in driver SPDs are designed to withstand the HiPot testing overvoltage with no damage

SPD Feature(s)	LSP-10HST	LSP-10P Module	LSP-10S Module
Protection Level	Standard Protection	Protection Upgrade 1	Protection Upgrade 2
Connection Type	Parallel	Parallel	Series
DOE MSSLC based on IEEE C62.41.2, Cat C High **20kV/10kA**	Yes	Yes	Yes
Ingress Protection IP66	No	Yes	Yes
UL 1449/IEC61643-11	No	Yes	Yes
Thermal fail-safe protection to prevent a hazard due to 'end-of-life'	No	Yes	Yes
Indication for SPD module replacement by turning luminaire off when the thermal fail-safe protection is activated	No	No	Yes
Mount SPD in fixture	Yes	Yes	Yes
Mount SPD in pole – Steel pole only	No	No	Yes

Table 4) **Recommended SPD Standard and Upgrade Options**

6 Notes

1 Little Fuse, Inc. *"LED Lighting Surge Protection Modules Design and Installation Guide."* www.littelfuse.com. 2016

2 ASCO Power Technologies. *"Avoiding Damages to SPDs from Electrical HiPot Testing."* www.surge.ascopower.com. 2018

3 IEEE, McCombs, Curtis. *"What You Need to Know About Surge Protection."* 2015

4 Inventronics. *"Inventronics HiPot Testing."* www.inventronics-co.com. 2017

5 OBO BettermannGmbh & Co. *"Guide: Lighting and Surge Protection for LED Lighting."* www.obo-bettermann.com. 2014

6 Advanced Protection Technologies. *"Surge Protective Device."* www.aptspd.com. 2011.

7 DEHN. "Surge Protection for LED Mast Lights." www.dehn-international.com.

8 Vertivco. "What Causes "Dirty Power?". www.vertivco.com

9 Thomas Research Products. *"Problem: Hi Pot Testing LED Drivers?"*. www.trpssl.com

10 Philips. *"The Challenges of Surge Protection."* www.lighting.philips.com. 2015

11 GE Digital Energy, Grosz, Fred. "Transient Voltage and Surge Protection." www.gedigitalenergy.com. 2011

12 Philips. "Protecting LED systems in accordance with IEEE & ANSI C62.41.2." www.lighting.philips.com. 2011