



# Surge Protection Module LSP05 and LSP10 Series

New Product Introduction  
April 2016





# Transient Surge Threats to Outdoor Devices

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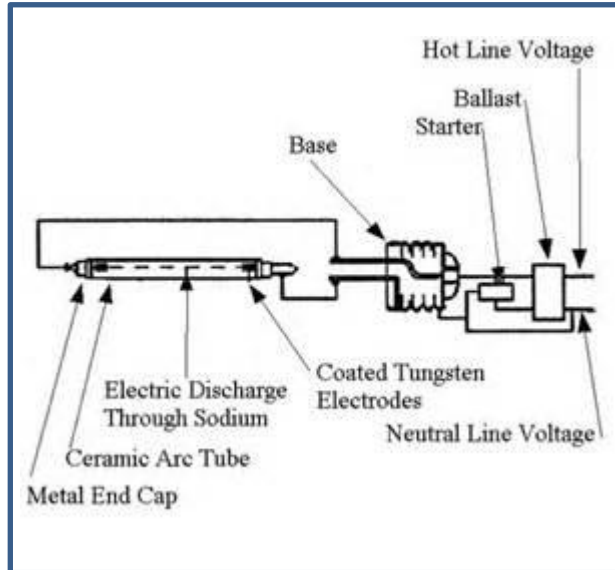
- Lightning strikes are traveling electrostatic discharges, usually coming from clouds to the ground with a magnitude of millions of volts.
- Surges up to thousands of volts are applied to copper wires carrying induced current from lightning strikes occurring up to a few miles away.
- These *indirect strikes usually occur in exposed outdoor wires*, transmitting surges to devices like streetlights or traffic lights.
- The **Surge Protection Module**, at the upstream of the circuitry, is directly facing surge interference coming from the power line. It diverts or absorbs surge energy, *minimizing surge threats to downstream devices* like the AC/DC power supply unit in an LED lighting fixture.





# The Problem with LED Lights Installed Outdoors

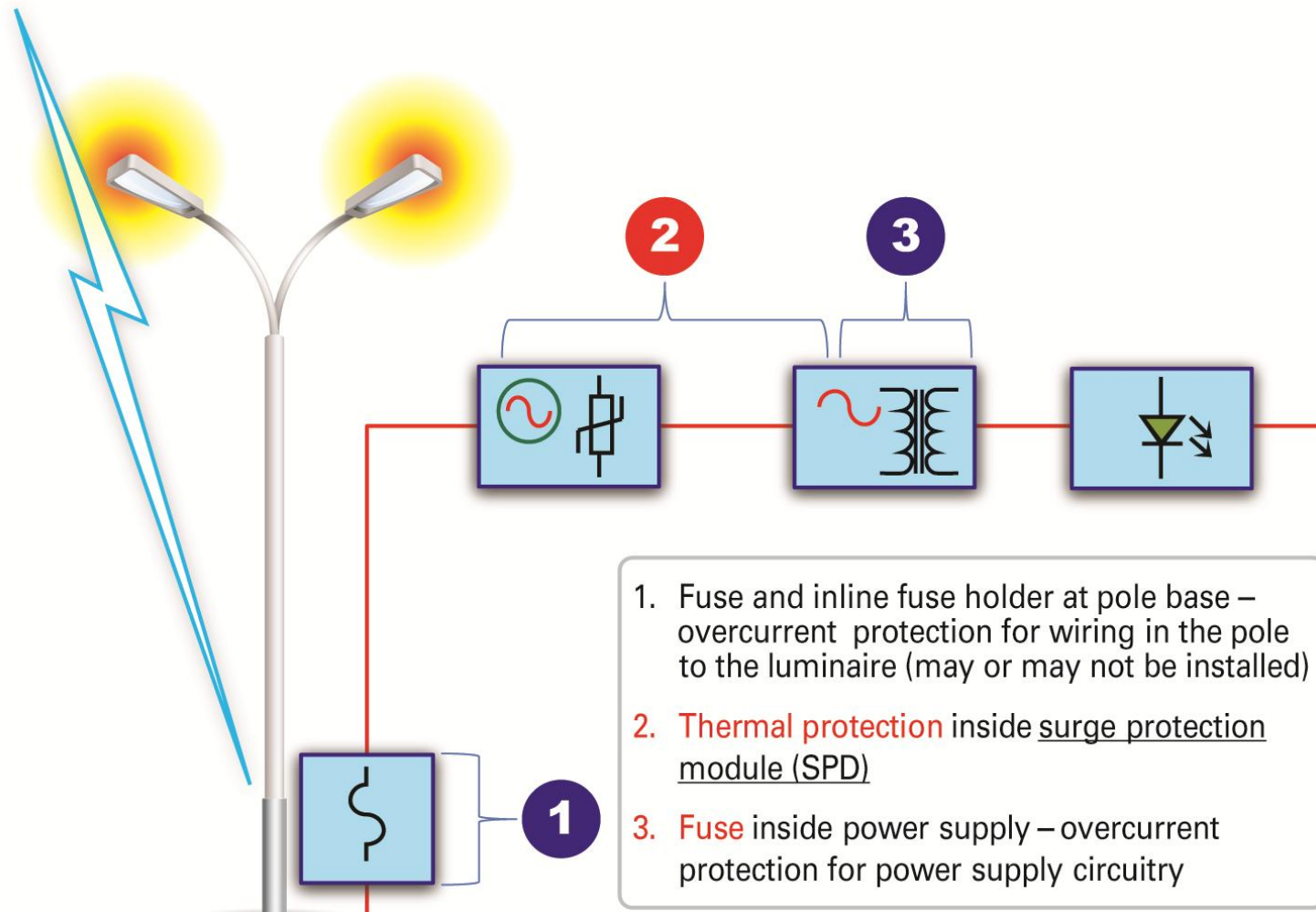
## Comparison High Pressure Sodium vs LED Retrofit Lamp



Structure	Simple	Highly complex
Cost	Low	High – larger investment
Reliability/Lifetime	Medium	Very high
Overcurrent / Short Circuit	Robust assembly	May cause fire or explosion / safety risk
Overvoltage (Surge, EFT, ESD)	Ballast is robust	Sensitive Semiconductor Components can fail

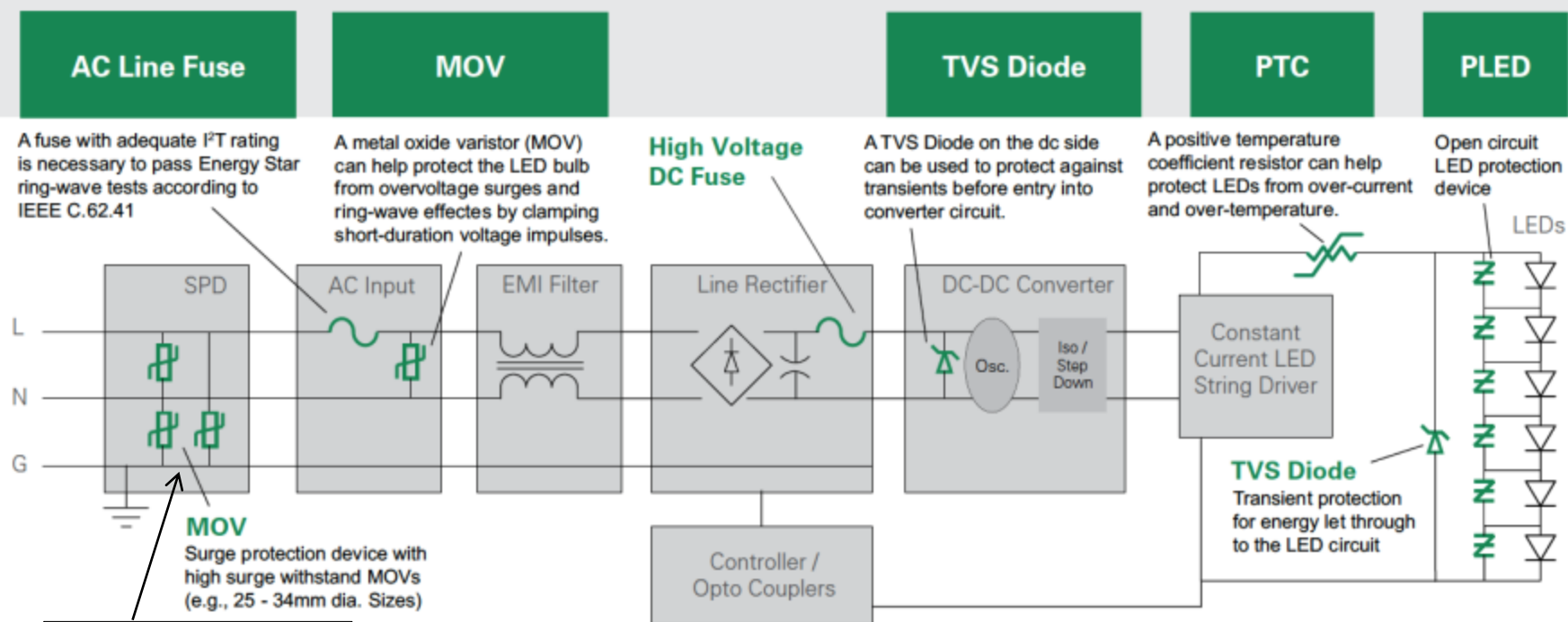


# Street Light Protection Scheme





# Protecting LED Luminaire in Product Design



**Figure 3. Typical LED luminaire driver circuit with transient and surge energy protection devices**



**SPD Module**  
Also known as Surge Arrestor



# Product Overview

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- Protection Module Maximum Lightning Surge Current
  - LSP10 Series - 20,000 Amps
  - LSP05 Series - 10,000 Amps
- Meets ANSI 136.2/IEEE C62.41.2 Location **Category C High Exposure**
- **Thermally protected** Varistor technology
- Parallel connected and **series connected** SPD options
- IP66 water-proof and dust-proof
- **Indication wire lead options** for parallel connected modules
- Certified to meet **UL1449/IEC61643-11**
- Compact form factor (**48x48x30mm**) with mounting tabs





# LSP05 & LSP10 Features and Benefits

## Key Features

- Maximum Lightning Surge Current 20kA
- Thermally protected varistor technology
- Wide operation voltage 120Vac~480Vac
- Ingress protection IP66
- Series connected and parallel connected SPD options
- Certified to meet UL1449/IEC61643-11



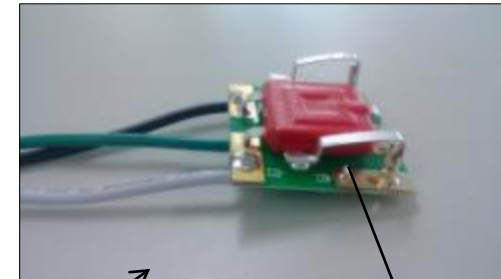
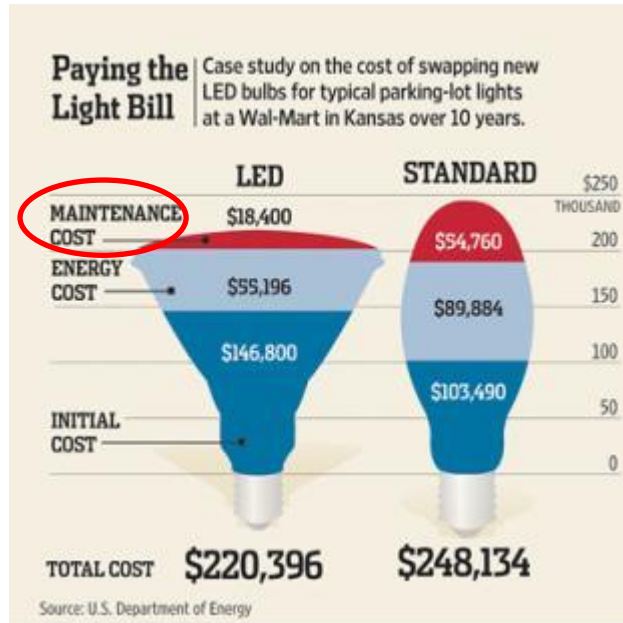
## Benefits

- Optimized surge immunity solution to protect the outdoor LED fixture investment to get the long term reduction in maintenance costs and energy savings. Without surge protection, the value proposition of LED lighting is at risk
- Thermal fail-safe protection to prevent a hazard to the light or facility due to 'end-of-life' or extreme failure conditions of internal components
- Flexibility to select optimal protection for each lighting installation input voltage
- Surge protector is less susceptible to damage from water or environment
- Series – Clear indication for SPD module replacement by turning luminaire off when the thermal fail-safe protection is activated
- Parallel – External wire option for LED indication or adaptive lighting circuit
- Confidence in the quality and integrity of specifications will be met since it is subjected to regular, independent 3rd party analysis

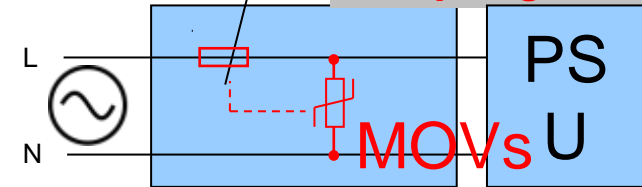




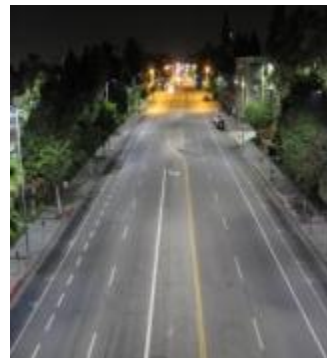
# LED SPD Module Value Proposition



**Thermal disconnect springs**



**Before and after the conversion to LED street lighting. Credit: Los Angeles Bureau of Street Lighting**



## Technology

- Up to 20kA lightning surge protection
- MOV thermal protection for end of life
- SPD replacement indication
- **LED fixture investment protected**



Expertise Applied | Answers Delivered

PROTECT | CONTROL | SENSE



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# Value Proposition Explained

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## ■ **SAFETY**

- LED lights are electronic appliances – failures in electronic appliances are the number one reason for fire in households
- Carefully selected **FUSES** provide the necessary **SAFETY**

## ■ **RELIABILITY**

Customer expectations are very high

- LED Lights promise extremely long lifetimes (20,000 to 50,000 hours)
- Suitable overvoltage protection MOV technologies help increase reliability

## ■ ***External, replaceable, surge protection modules***

- ⇒ **Protect** the overall LED lighting fixture **investment**
  - ⇒ Municipality is paying 2-4X the price when replacing legacy lighting; they need to recoup the investment but cannot accomplish this if LED lighting fixture is damaged by surge event during its prescribed lifetime.
- ⇒ **Reduce maintenance costs** by providing real-time, clear indication that protection module needs to be replaced due to end of life.



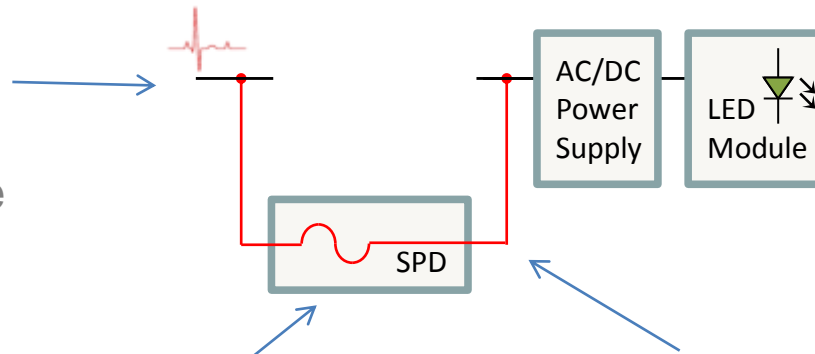


# LSP10

## Series Connection

*The world's first series connected, 20kA capable indicating surge arrestor*

Transient voltage from lightning or load switching in the neighborhood



Thermal protection prevents MOV fire hazard caused by unstable line voltage and end-of-life failure

If SPD that has activated its thermal protection is not replaced, subsequent surge events can damage luminaire. Series connected SPD cuts luminaire power off to provide a clearly visible indication that SPD replacement is required.





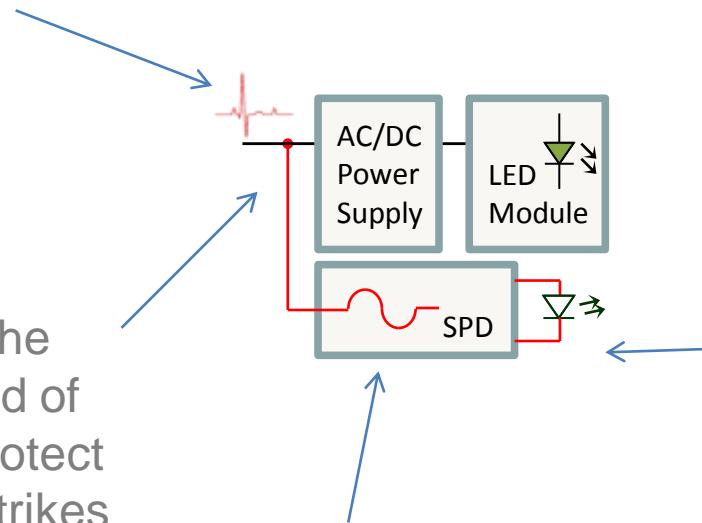
# LSP05 & LSP10

## Parallel Connection

Transient voltage from lightning or load switching in the neighborhood

Parallel connection, the most common method of SPD installation to protect PSU from transient strikes

Thermal protection prevents MOV fire hazard caused by unstable line voltage and end-of-life failure



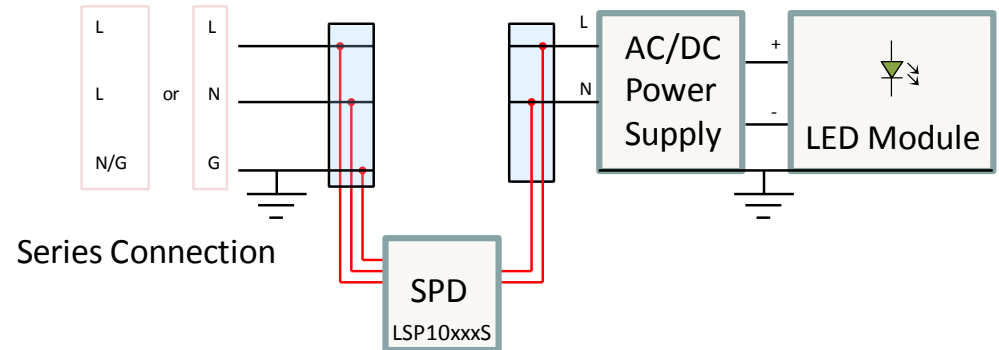
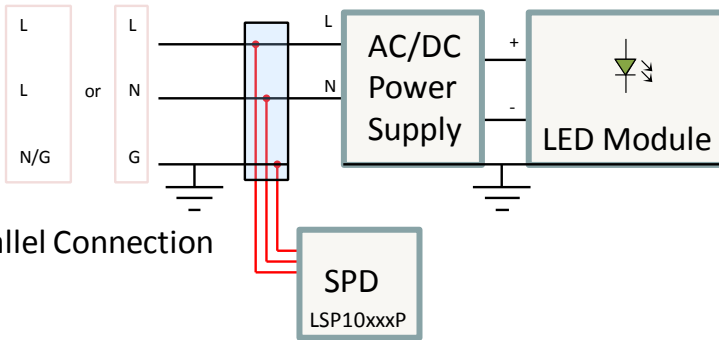
LED indicator shows when to replace the SPD



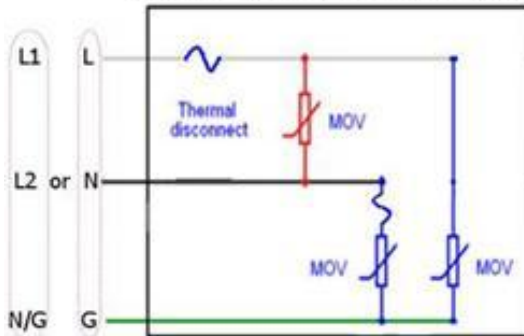
# LSP10 Series

## Parallel Connection & Series Connection

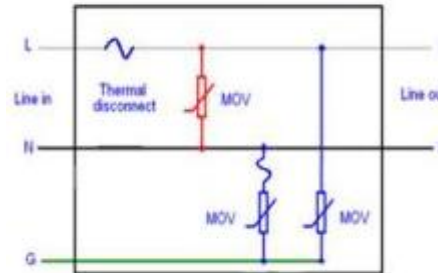
### Design Schematic Circuit and Application Examples



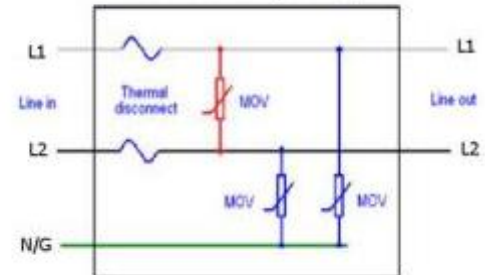
Parallel Connection (L-N-G and L1-L2-N/G)



Series Connection (L-N-G)



Series Connection (L1-L2-N/G)

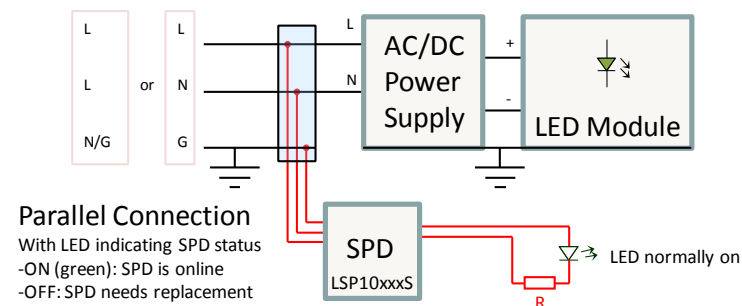
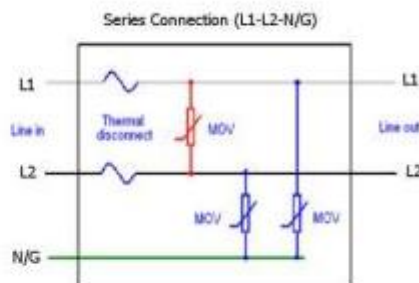
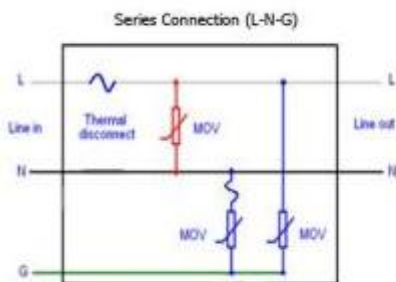




# LSP10

## Parallel Connection with End-of-Life Indication

- Take series connection models (with suffix S) and apply as parallel connection in the lighting fixture.
- Use the output wires as end-of-life indication.
- Connected to a current limiting resistor and a green LED to form an external indicator of module status. When green LED is on, the module is working normally. When green LED is off, the module is disconnected from power circuit and not providing surge protection to downstream devices. It must be replaced with a new one.

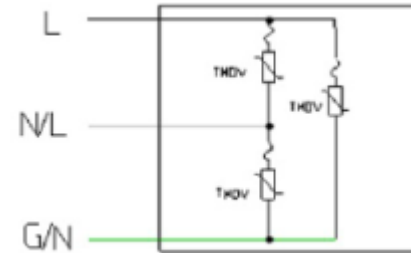
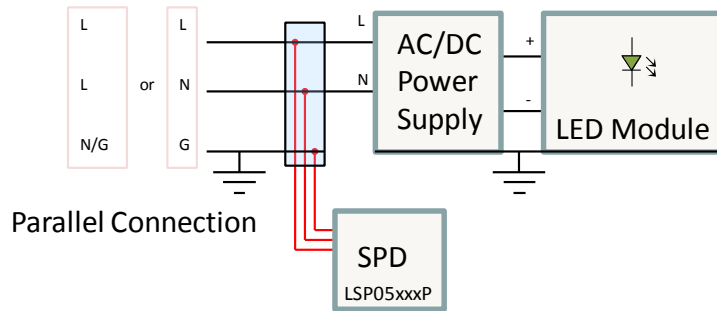




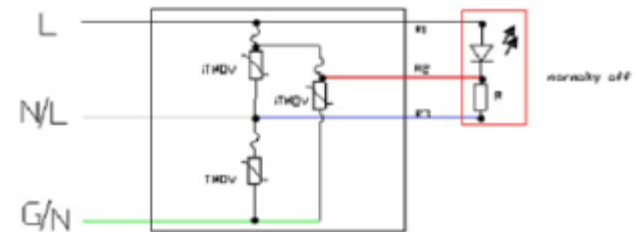
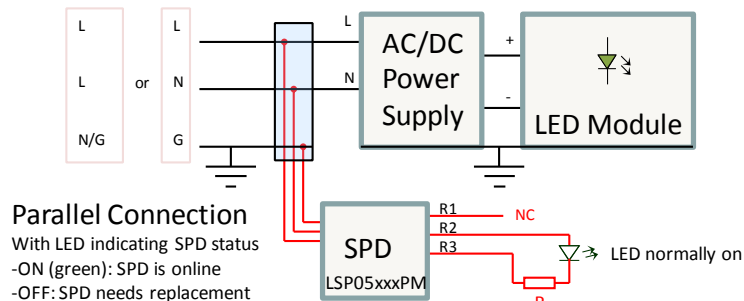
# LSP05

## Parallel Connection and Indication Options

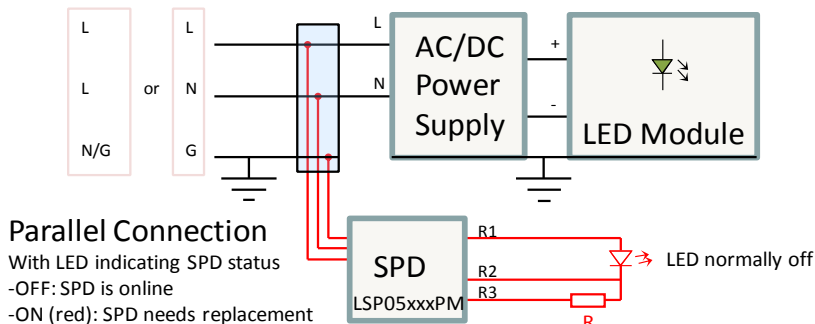
### Design Schematic Circuit and Application Examples



- Indication wires (R1/R2/R3) could be connected to current limiting resistor and LED to form normally-on or normally-off indicator.



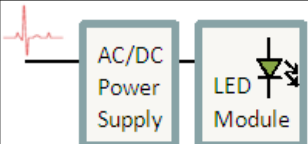
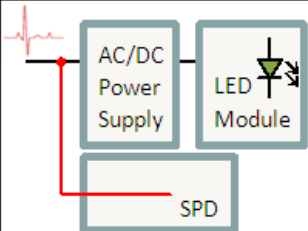
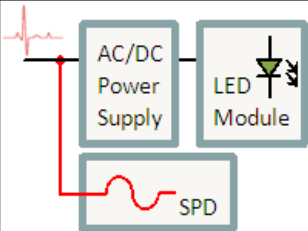
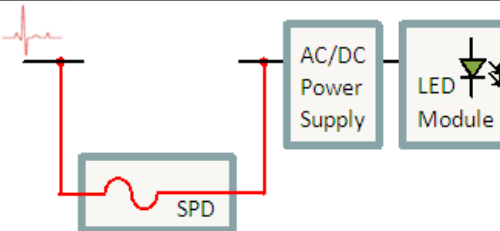
\*LED and Resistor are assembled by customer





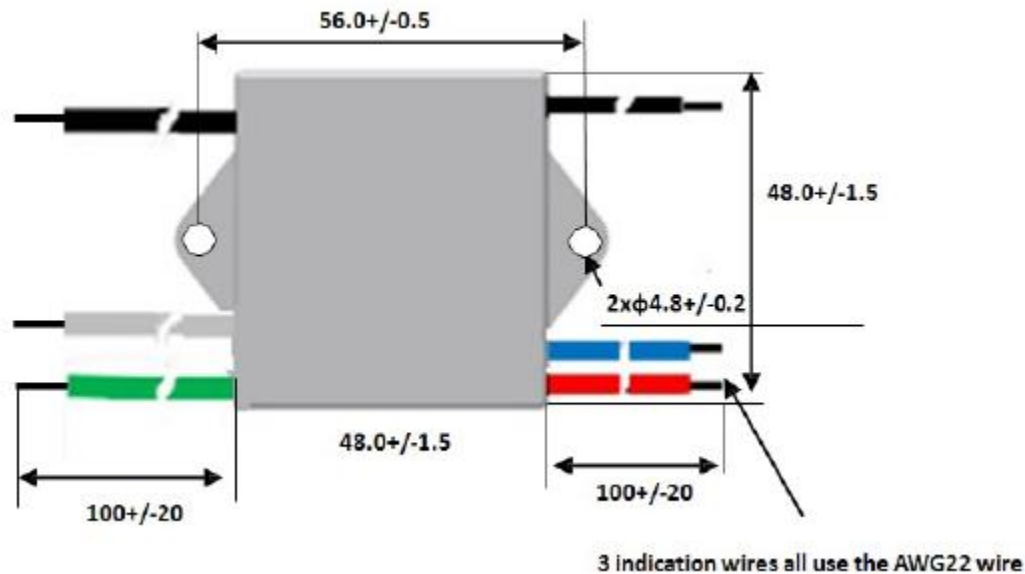
# Series Connection Provides More Value

- Series connection **turns lighting off** as an obvious indication to maintenance personnel of the need for surge protection module replacement
- Until the end-of-life surge protection module is replaced, the lighting fixture is separated from the power line and **immune to subsequent surge events**

	No SPD connected	SPD parallel connected	Thermally protected SPD parallel connected	Thermally protected SPD series connected
				
Surge protection to absorb overvoltage transient from power source	no	yes	yes	yes
Thermal disconnect to cut off damaged SPD from circuit to reduce risk of fire	-	no	yes	yes
UL1449 certificated for SPD safety	-	no	yes	yes
Indication for damaged SPD maintenance	-	no	no	yes, light turns off
Prevent luminaire from subsequent surges after SPD is damaged	-	no	no	yes

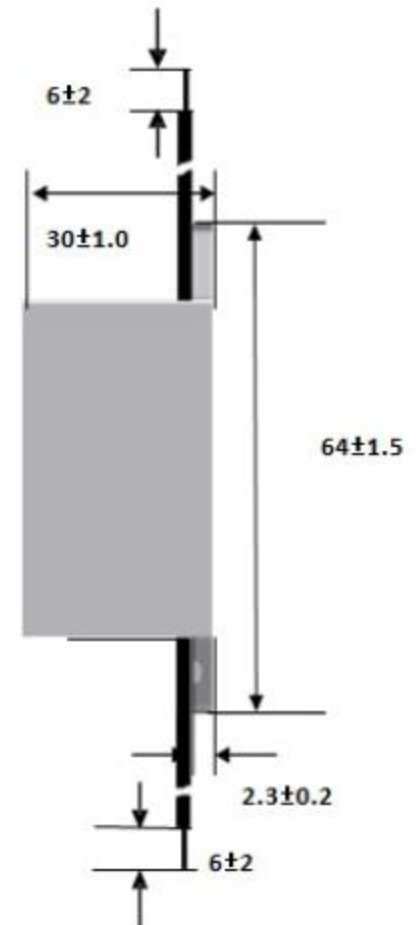


# LSP05 & LSP10 Outline Dimension



NOTE: 1.Black: Line; White: Neutral; Green: Ground

2.Wire Gauge: AWG14; Wire Line in, AWG22 wire for indication wire





# LSP05 & LSP10 Series

## Surge Protection Module Key Applications



Roadway Lighting



Parking Garage Lighting



Wash wall Lighting



Traffic Lighting



Flood Lighting



Digital Signage



Street Lighting



Tunnel Lighting



# Product Availability & Contacts

- Samples and pricing are available by contacting your Littelfuse sales representative
- Standard lead time: 10 weeks
- Please contact your local Littelfuse sales representative for fast support.
- Additional Contacts:
  - Product Manager – Johnny Chang ([Jchang@littelfuse.com](mailto:Jchang@littelfuse.com)); Contact for sample availability & initial pricing
  - Product Engineer: Kite Hou ([Khou2@littelfuse.com](mailto:Khou2@littelfuse.com)); Contact for general technical issues, qualification data
- Commercial and Industrial LED Lighting Sample Kit
  - Ivy Spidale ([ispidale@littelfuse.com](mailto:ispidale@littelfuse.com))







# *Commercial and Outdoor LED Lighting Application Reference*



Expertise Applied | Answers Delivered

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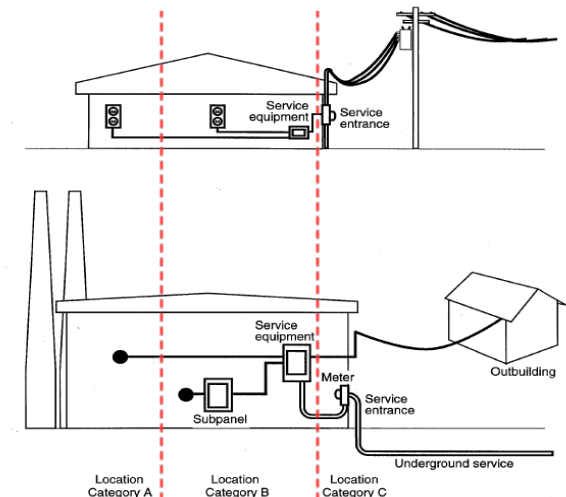
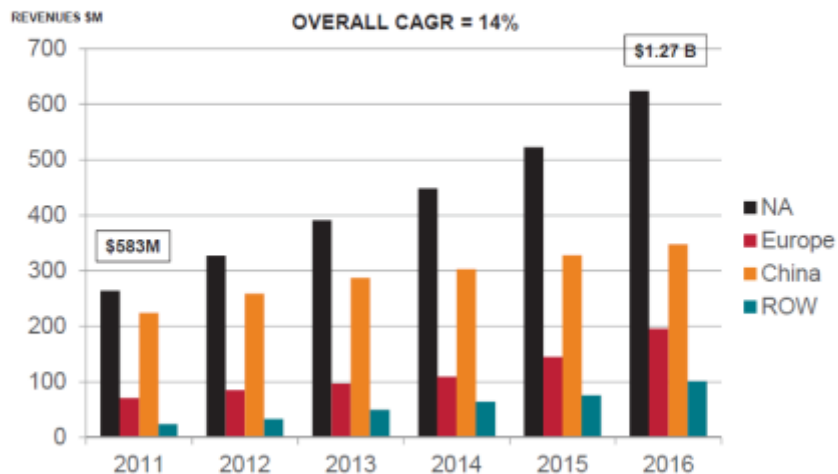
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# Background

Rapidly increasing demands for LED-based light sources for outdoor applications bring new challenges to system **durability**. In order to maximize the durability and **reliability** of LED lighting systems, it is critical to protect them from damage due to high current surges on the main lines.

LED Luminaires in Outdoor Lighting  
(Street & Area)



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Expertise Applied | Answers Delivered

PROTECT | CONTROL | SENSE



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# Global Regulatory Overview

Surge Immunity (Combo wave) 1.2x50us Voc/ 8x20us Isc	United States	Europe South America Asia
Integrated LED light bulbs (E27 Base Europe / E26 Base USA) LED Luminaires (indoor commercial)	Energy Star (Based on IEEE C62.41.2 Category A) Ring wave 2.5kV 100kHz	IEC/EN 61547 IEC/EN 61000-4-5 500V/250A 1kV/500A
LED Outdoor Luminaires (Street Lighting, Parking Lot Lighting)	DOE MSSLC V1.0 (Based on IEEE C62.41.2) Cat C Low 6kV/3kA Cat C High 20kV/10kA ANSI/NEMA C136.2	IEC/EN 61643-11 IEEE C62.41.2 6kV/3kA 10kV/5kA
Safety	UL 8750, UL 1310, UL 1993, UL 1598	IEC/EN 62560 bulb IEC/EN 60598 general IEC/EN 61347 control IEC/EN 62031 general



# US Dept of Energy (DOE) New Model Specification for LED Roadway Lighting

## *Municipal Street Solid State Lighting Consortium*

- LED roadway lighting model specification, effective from December 2011, calls out surge immunity requirements for outdoor lighting systems.
- Model specification may become mandatory ANSI/NEMA requirement.
- Cities, municipalities and utilities in North America are adopting this model specification in their Requests for Quotes (RFQs) for lighting retrofit projects.

- F. Institute of Electrical and Electronics Engineers (IEEE)
  - 1. IEEE C62.41.2-2002 (or latest), IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits
  - 2. ANSI/IEEE C62.45-2002 (or latest), IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
- G. National Electrical Manufacturers Association (NEMA)
  - 1. ANSI/NEMA/ANSI C78.377-2008 (or latest), American National Standard for the Chromaticity of Solid State Lighting Products
- H. National Fire Protection Association (NFPA)
  - 1. 70 – National Electrical Code (NEC)
- I. Underwriters Laboratories (UL)
  - 1. 1449, Surge Protective Devices
  - 2. 1598, Luminaires
  - 3. 8750, Light Emitting Diode (LED) Equipment for Use in Lighting Products



# North America - Commercial and Industrial Outdoor LED lighting

## Dept of Energy Surge Requirements with reference to IEEE C.62.41-2002

Location Category	Pk Voltage (kV)	Pk Current (kA)	Source	Application
Waveform	1.2/50 $\mu$ s	8/20 $\mu$ s	Impedance (Ohms)	
A (Indoors)	6	0.5	12	Indoor Commercial Bldg/ Offices/ Retail
B	6	3	2	Lighting near Service Entrance
C Low	6	3	2	Commercial/ Industrial/ Parking Garage
C High (Outdoors)*	20	10	2	Street/ Hwy/ Parking Lot/ Area Flood/ Outdoor

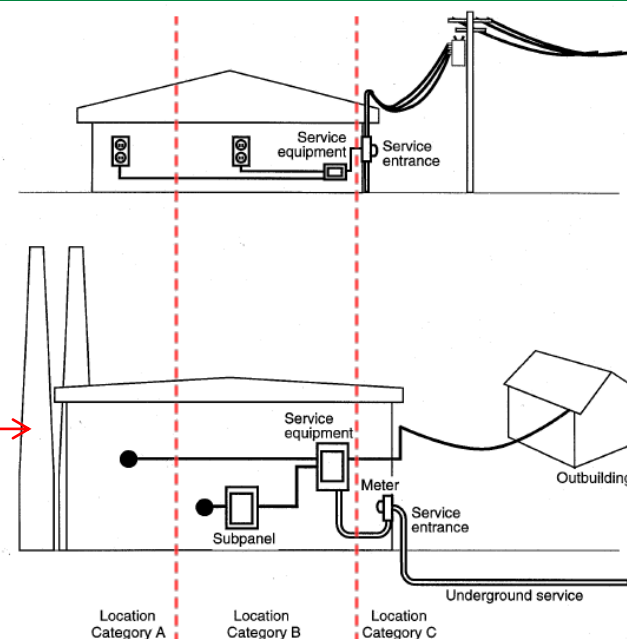
Location Category	Pk Voltage (kV)	Pk Current (kA)	Source
Waveform	0.5 $\mu$ s 100kHz Ring Wave	Impedance (Ohms)	
A (Indoors)	6	0.2	30
B	6	0.5	12
C Low or High	6	0.5	12

\*A combination waveform where specified peak current is calibrated on the tester by a luminaire. Single phase modes: L-N L-G N-G. Polyphase Modes: L-L L-N L's-G

Category A: parts of the installation at some distance from the service entrance

Category B: Between Cat A and Cat C

Category C: External part of structure, extending some distance into the building.





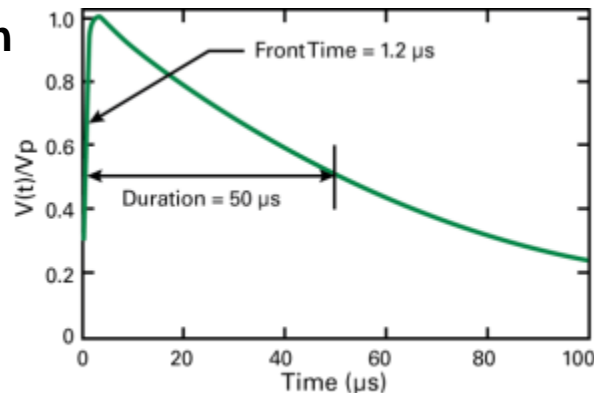
# DOE Spec Surge Testing Requirements for High Exposure Levels

**Table 2: 1.2/50 $\mu$ S – 8/20  $\mu$ S Combination Wave Specification**

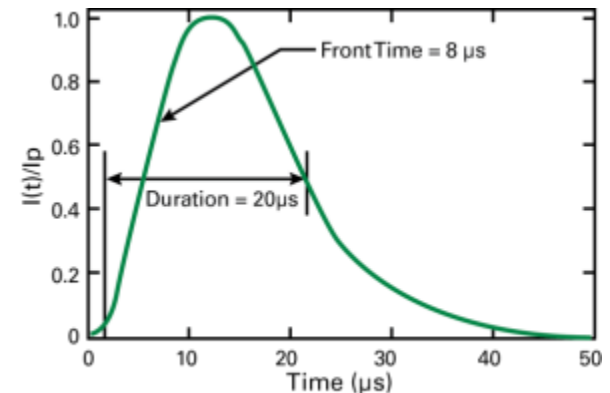
Parameter	Test Level/ Configuration	
1.2/50 $\mu$ S Open Circuit Voltage Peak	Low: 6 kV	High: 10kV †
8/20 $\mu$ S Short Circuit Current Peak	Low: 3 kA	High: 10kA
Coupling Modes	L1 to PE, L2 to PE, L1 to L2	
Polarity and Phase Angle	Positive at 90° and Negative at 270°	
Test Strikes	5 for each Coupling Mode and Polarity/Phase Angle combination	
Time Between Strikes	1 minute	
Total Number of Strikes	= 5 strikes x 3 coupling modes x 2 polarity/phase angles = 30 total strikes	

† This is a MINIMUM requirement. Note that for most combination wave generators, which have a source impedance of 2 $\Omega$ , the generator charging voltage will need to be raised above the specified level (to somewhere in the vicinity of 20kV) to obtain the specified current peak.

**Waveform: 1.2x50 $\mu$ s open circuit voltage/8x20 $\mu$ s short circuit current combination wave**



Combination Wave open-circuit voltage



Combination Wave short-circuit current





# Europe/Brazil/Asia Outdoor LED Surge Requirement

## Suggested 10kV/5kA Level Surge Immunity

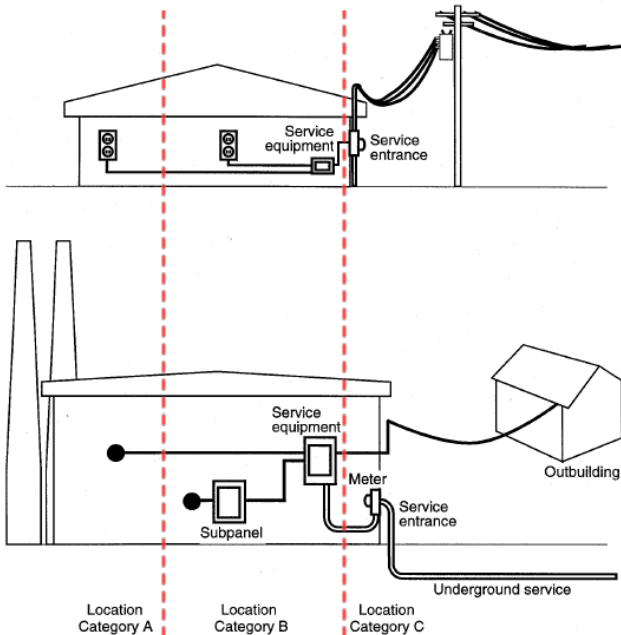
Location Category	Pk Voltage (kV)	Pk Current (kA)	Source	Application
Waveform	1.2/50us	8/20us	Impedance (Ohms)	
A (Indoors)	6	0.5	12	Indoor Commercial Bldg/ Offices/ Retail
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C High (Outdoors)**	20	10	2	Street/ Hwy/ Parking Lot/ Area Flood/ OUTDOOR
Location Category	Pk Voltage (kV)	Pk Current (kA)	Source	
Waveform	0.5us 100kHz Ring Wave		Impedance (Ohms)	
A (Indoors)	6	0.2	30	
B	6	0.5	12	
C Low or High	6	0.5	12	
** It's a combination waveform where specified peak current is calibrated on the tester by shorting the output together prior to connection to the luminaire				
Single phase modes: L-N L-G N-G Polyphase Modes: L-L L-N L's-G				

IEEE C62.41.2 Recommended Practice on Characterization of Surges on Low Voltage (1000V and less) AC Power Circuits

+

IEC 61643 Surge Protective Devices Connected to Low Voltage Power Systems

10kV/5kA





# MOV End-of-Life Failure Mode

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- MOVs tend to degrade gradually after a large surge or multiple small surges. The degradation leads to increasing MOV leakage current, in turn raising its temperature under normal conditions like 120Vac/240Vac operating voltage
- A proper thermal disconnect will sense the increase in MOV temperature as it continues to degrade to its end-of-life condition, at which point it will open, removing the degraded MOV from the circuit and preventing its catastrophic failure





# Why Thermal Protection in Surge Protection Module – Continuous Overvoltage

- Metal Oxide Varistors (MOVs) are commonly used to suppress transients in Surge Protection Modules
- MOVs can also be subjected **to continuous abnormal overvoltage** conditions rather than short duration transients. Continuous abnormal overvoltage faults are usually caused by **poor power grid quality** or **loss of neutral-to-ground connection in power transformer wiring**. The abnormal conditions may last for minutes, even hours
- If an MOV is subjected to a sustained abnormal overvoltage, the MOV may go into thermal runaway, resulting in **overheating, smoke, and potentially fire**. In many cases, it requires surge protection module makers to include a **thermal disconnect** for an MOV. That thermal disconnect has traditionally been a thermal fuse or Thermal Cut-Off (TCO) device. It disconnects the MOV from the power line when **over-temperature** is detected





# Abnormal Overvoltage (UL1449) Condition

- In AC line applications, the loss of a Neutral-Ground connection can occur .
- Loss can lead to a sustained over-voltage, affecting an MOV that is rated for a much lower continuous voltage
- If tied to the AC line that limits current flow, MOV can overheat, causing the SPD module to overheat, resulting in smoke, out-gassing, and eventually fire
- Ex: U.S. 120V AC Line application, two 120V AC power lines (180° out of phase) are commonly fed from a center-tapped 240V transformer, assuming 150V rated MOV is present in the top 120V circuit, and some load exists on the bottom 120V circuit
- Both the MOV and load share the center tap, which is the Neutral-Ground connection. If a break occurs on the center tap (X—X), then the load in the bottom phase acts as a current limiter and the line fuse may not clear
- **Thermally self-protected MOVs can help protect against TOV conditions and sustained abnormal over-voltage limited current testing as itemized in UL1449. (Typically up to 10A fault current at about double the line voltage)**



Expertise Applied | Answers Delivered

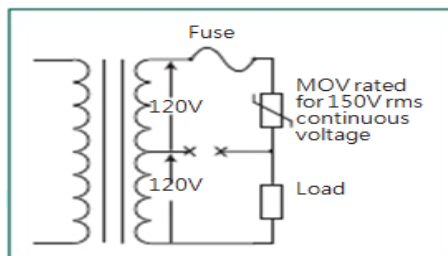


Figure 1. Possible Fault Condition for a limited current abnormal overvoltage event

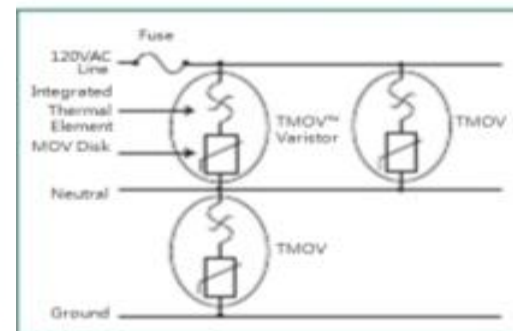
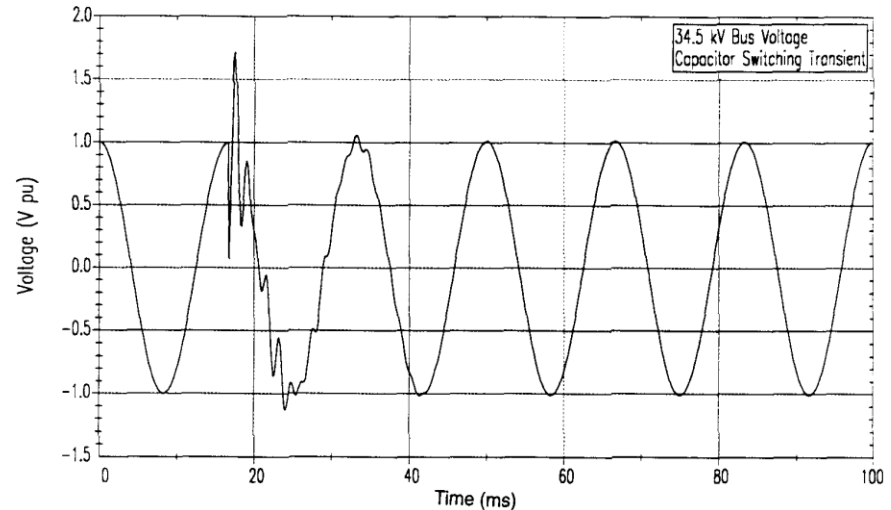


Figure 4. TMOV varistor offline protection scheme



# Line Swells & Oscillatory Transients

- Besides impulsive transient, oscillatory transients are a concern for lighting manufacturers
- Caused by power quality problem on the feeder lines caused by transformers energizing or capacitor banks switching.
- Are of long duration, 3 cycles or more, temporary overvoltage that can last a few seconds.
- Up to 2 times normal operating voltage
- Can lead to equipment damage or **failure surge protection**



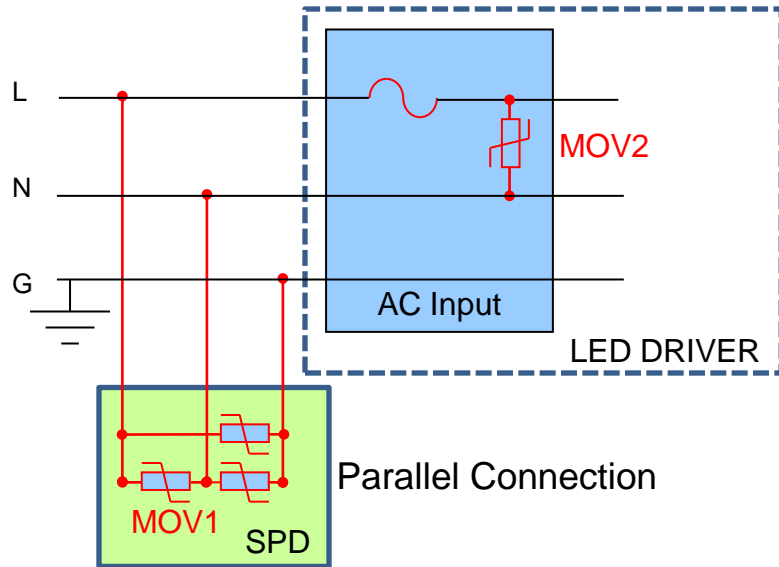
## IEEE 1159 (Recommended Practice for Monitoring Electric Power Quality)

- Spec defines such a temporary overvoltage as an oscillatory transient is a sudden, non-power frequency change in the steady state condition of voltage, current or both, that includes both positive and negative polarity values.

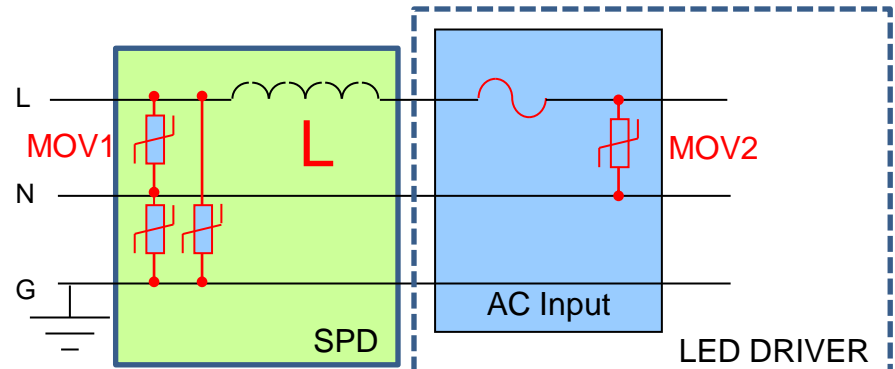
- For frequencies below 5 kHz in power line sub-transmission and distribution, capacitor banks being energized can create an oscillatory voltage transient with voltages reaching 2 times the normal operating voltage and last 0.5-3 cycles



# Coordination Recommendations Between MOVs in SPD and in LED Driver



Parallel Connection



Series Connection

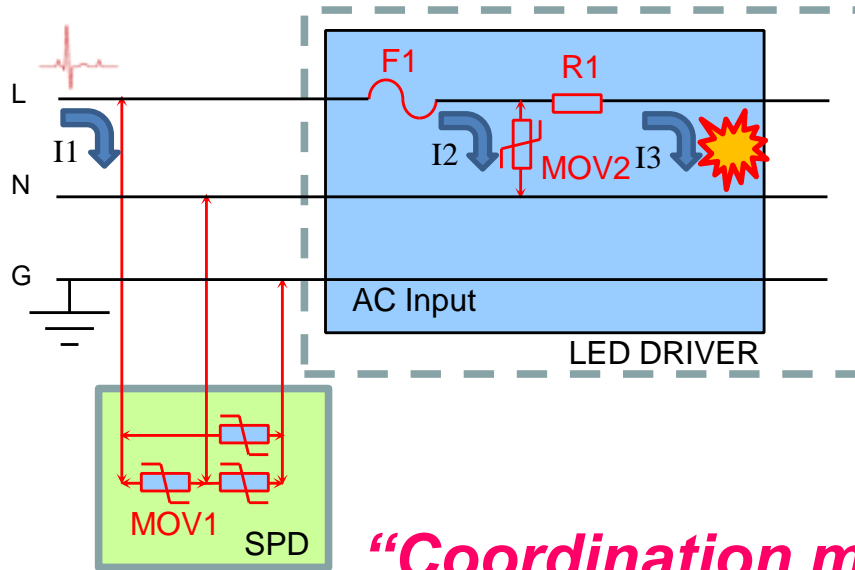
The coordination between the MOVs used in the surge protection module and in the LED driver is also of important consideration. These MOVs must be coordinated such that the larger disc MOVs residing in the surge protection module should clamp before the smaller MOV used in the LED driver power supply. If the driver MOV voltage rating is lower, it will take the brunt of the transient since it will likely turn on first. That could result in a catastrophic event. Impedance between the primary SPD and the driver, perhaps a few uHs will help in ensuring proper coordination.

Engineers must account for enough line impedance to direct a majority of the surge current through the primary MOV (MOV1 in the diagram above) and limit the surge current through the secondary MOV (MOV2 in the figure above) to a level within its surge rating.

1. MOV1 and MOV2 need to be coordinated so that most of surge current/energy flows through MOV1.
2.  $V_M$  (Maximum Continuous Operating Voltage)  
Select MOVs with  $V_{M(MOV1)} \leq V_{M(MOV2)}$
3.  $V_C$  (Maximum Clamping Voltage)  
Select MOVs with  $V_{C(MOV1)} \leq V_{C(MOV2)}$
4. Inductance  $L$  may be added in series connection SPD. Increasing inductance  $L$  will result in better coordination as MOV1 absorbing higher surge energy.  $V_{MOV1} = V_{MOV2} + L \cdot di/dt$



# Residual Surge Energy Passing Through Surge Protection Module



- Surge protection module absorbs most of surge energy; however, there is still residual energy going into LED driver and causing damage to components inside.
- To minimize the damage, the LED driver should coordinate with the surge protection module so that less energy enters the LED driver

***“Coordination makes better protection and less damage”***

- **Residual Voltage**
  - Determined by MOV1; thus, fast-response-time and low-clamping-voltage varistor is preferred
- **Residual Current**
  - MOV2 is suggested as higher clamping voltage than MOV1 to maximize  $I_1$  and minimize  $I_2$  so that fuse  $F_1$  is not damaged by residual current
  - $R_1$ , the equivalent resistance of primary circuitry including NTC, EMI filter, rectifier, PFC, transformer, transistor, etc., could be adjusted higher if necessary to minimize  $I_3$  and component damage in primary circuitry



# Use TVS Diode as Second-Level Transient Suppression

*For components sensitive to and easily damaged by surge voltage or current, place TVS Diodes next to them to absorb “let-through” energy from surge protection module.*

