



Protecting LED systems in accordance with IEEE & ANSI C62.41.2

Transient Surge Requirements

The above standard gives guidelines for recommended surge protection levels for indoor and outdoor electronic equipment connected to the mains power lines. For outdoor applications, the standard calls for a recommended surge protection level of 6 kV/3 kA for low exposure conditions and, 10 kV/10 kA for high exposure conditions.

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Table 1: Scenario 1 tests for Surge Protection Devices (SPDs) intended for Location Category C¹

| Exposure | Standard tests | | Optional test |
|----------|---|---|---|
| | 1.2/50 μ s Voltage generator | 8/20 μ s Current generator | 100 kHz Ring Wave for front-of-wave response evaluation |
| | Minimum open-circuit voltage to be applied to SPD | Current to be driven through the SPD ² | |
| Low | 6 kV | 3 kA ³ | 6 kV |
| High | 10 kV | 10 kA | 6 kV |

¹ The scope of these tests is limited to SPDs, in contrast with all the other recommended tests that may be applied to equipment other than SPDs.

² Values shown for the current are applicable for each phase of the SPD. In contrast with a test applied to equipment for the purpose of assessing its response to the surge environment, a test applied to characterize the performance of an SPD requires that the specified current be driven through the SPD. For the low exposure, this can be accomplished with a typical Combination Wave generator. For the high exposure, two separate generators, in two successive tests, must be used to apply the specified values.

³ For low exposure tests, if a Combination Wave generator is used instead of two separate generators, the generator charging voltage has to be adjusted to obtain the stated current amplitude. Please refer to Figure 1.

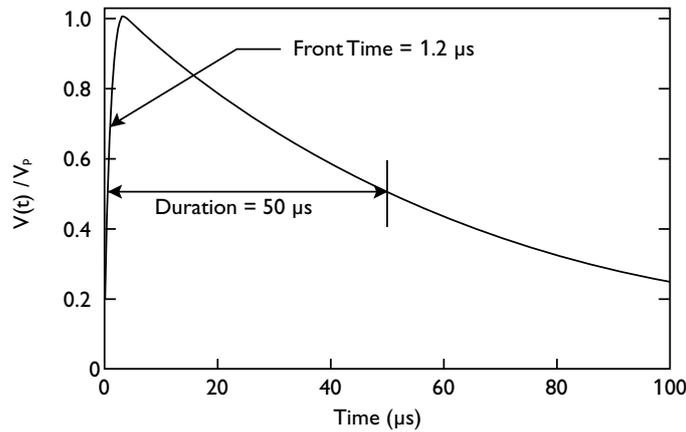


Figure 1: Combination Wave open-circuit voltage

Figure 2 below gives an explanation of the Location Categories used in the standard - note that Category C includes outdoor mounted equipment. Within Category C, there are 2 exposure levels defined: Low and High. Whether the “Low” or “High” level should be used depends on the application and location of the installation. For example, pole-mounted roadway lighting would typically fall into the more severe High Exposure level of Category C.

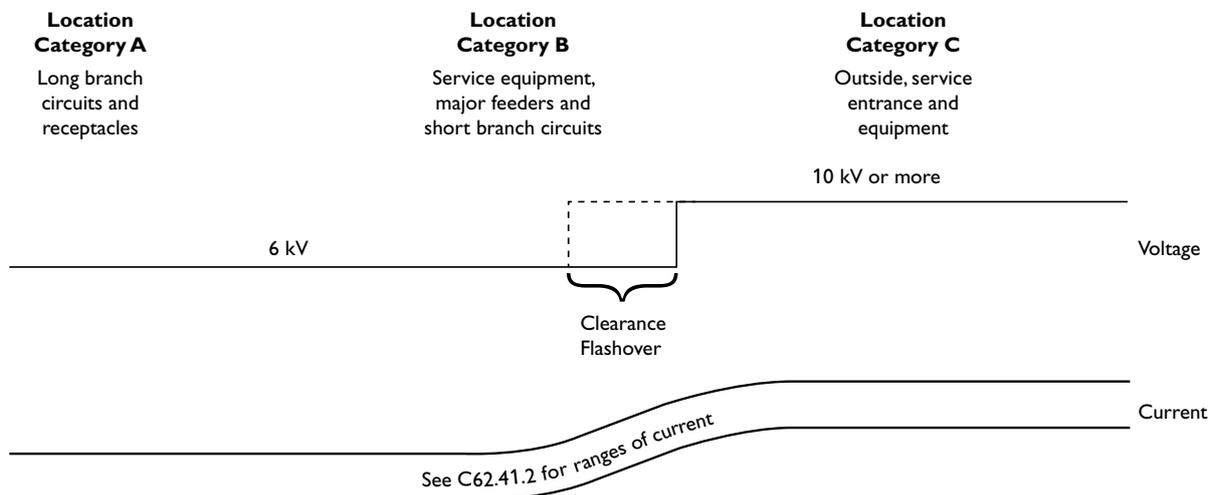


Figure 2: Voltage staircases and current down-slopes according to location category

Protecting electronic equipment for Category C, high exposure levels can be challenging for a number of reasons. Typical lighting gear such as LED Drivers requires a hi-pot test according to UL or other regulatory guidelines to ensure proper isolation of the housing of the driver to the input wires. The hi-pot test voltages depend on the overall voltages seen in the system or mains wires (whichever is higher) and are typically 2 kVac to 3 kVac. During the hi-pot testing, the measured leakage current is required to be low (< 10 mArms). The peak voltage of a 3 kVac hi-pot test is $3 \text{ kV} \times \sqrt{2} = 4.5 \text{ kVpk}$. The reason this is an important consideration is that it restricts the use of common metal oxide varistor (MOV) or other surge suppression devices between earth ground (G) and any of the input wires (Line-L, or Neutral-N). However, UL does allow these types of surge suppression devices to be installed after performing the hi-pot testing. This is an important consideration as it is not always practical to add such a suppression device after hi-pot testing at the LED Driver level, while it is quite practical to install these devices in the fixture. What follows are recommendations as to how to implement such suppression devices, how to select them properly and what considerations should be taken.

Choosing the correct suppression device

The LED driver without external protection TVSS (transient voltage surge suppression) is designed to handle surges in the 2-3 kV range for the 1.2/50usec combi-pulse (2 ohm). To achieve a system protection level of 10 kV/10 kA, the external TVSS device must be able to limit the voltage that appears at the driver terminals (L, N, G). To protect for a 10 kV, 1ohm surge (10 kA), the required clamping voltage of the external MOV (or other TVSS) needs to be lower than 1 kV at 8 kA $\{(10 \text{ kV}-2 \text{ kV})/1\text{ohm}=8 \text{ kA}\}$. To select the proper device, MOV (or TVSS) datasheets should be reviewed to find the appropriate clamping level.

Here is what to look for in the MOV ratings:

1. AC voltage rating: This needs to be sufficiently higher than the normal operating voltage range. For an LED driver that is rated 120-277 Vac, a 320 Vac rating is recommended. For LED drivers that are rated to 120V only, 150 Vac ratings is recommended.
2. Maximum surge rating: The 10 kA rating is required for the C62.41.2 high exposure level. 20 mm diameter MOVs can typically be found with this rating.
3. Appropriate agency approvals: UL, CE, etc. as required.

How to connect the MOVs in the fixture:

1. Connect 1 MOV between Line and Gnd
2. Connect 1 MOV between Neutral and Gnd
3. Connect 2 MOVs in parallel between Line and Neutral. Testing has shown that by connecting 2 MOVs in parallel between Line and Neutral improves the differential mode surge capability significantly.

Testing still needs to be completed to confirm that 10 kV/10 kA surges can be tolerated for the system with this configuration.

See Figure 3 below:

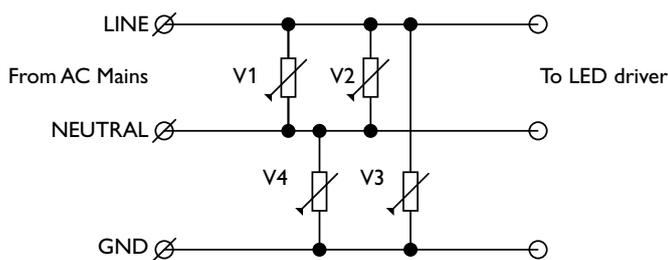


Figure 3

Why not design a LED driver to survive 10 kV directly without clamping to earth ground?

In theory it is possible to design a driver with sufficient spacings internally to survive a 10 kV surge voltage from lines to case (ground) without clamping the voltage so that hi-pot testing is not affected. This concept was implemented on some electronic HID control gear (Xtreme range). However, in a typical LED system, the LEDs are mounted to a heat sink which is connected to earth ground for thermal reasons. A common mode surge voltage of 10 kV would break over the insulation between the LEDs and the heat sink in most installations and, therefore, voltage clamping is required. The typical breakdown of the LEDs to the heat sink is in the order of 2 kV, so clamping below this level is necessary even if the driver is designed to handle the higher voltages. This is why a driver design that can handle 10 kV surges does not help the system pass 10 kV. The voltages must be clamped to a level that the LED-to-heat sink insulation can safely withstand to prevent LED failure. Also, not clamping the common mode surges would put a large burden on the wiring inside the fixture as everything would need to be designed to withstand 10 kV (wires, connectors, wire nuts, etc.). Implementing the above suppression circuit in the fixture eliminates the need to the high withstand voltages on the wires, connectors, and LED-to-heat sink interface.

Technical abbreviations

ANSI :American National Standards Institute

CE : Conformité Européenne

IEEE : Institute of Electrical and Electronics Engineers

MOV : Metal Oxide Varistor

SPDs : Surge Protection Devices

TVSS : Transient Voltage Surge Suppression

UL : Underwriters Laboratories Inc.



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