White Paper

Protecting Electronic Lighting Components From Transient Overvoltages

ASCO®

PROTECTING ELECTRONIC LIGHTING COMPONENTS FROM TRANSIENT OVERVOLTAGES

The newest lighting equipment increasingly relies on electronic components to provide energy efficient service. The electronic components used in this equipment are more vulnerable to damage from transient overvoltages than the devices used in older lighting equipment. The following narrative explains why engineers, project managers, and contractors should provide appropriate surge protective devices (SPDs) when designing, installing, and retrofitting lighting equipment that is controlled by electronic components.

Need For Energy Efficient Lighting

In the United States and Canada, the adoption of energy efficient lighting has been driven by regulations, industry standards, and market forces. In the United States, the *Energy Policy Act of 2005* and the *Energy Independence and Security Act of 2007* set forth requirements and tax incentives for increasing energy efficiency. Legislation requiring improved energy efficiency has also been enacted in Canada, Europe, and other regions of the world. These regulations, together with concern for the environment and market pressures to reduce energy costs, have resulted in the introduction of lighting products that are more energy efficient.

To improve energy efficiency, the newest lighting products rely on electronic components. Two examples include electronic ballasts that are used with fluorescent lamps, and Light Emitting Diode (LED) luminaires that are electronically controlled. Because the electronic components are vulnerable to damage from transient overvoltages, protection of these systems should not be overlooked when deploying new systems or retrofitting existing facilities.

The *IEEE Recommended Practice for Powering and Grounding Electronic Equipment (IEEE 1100)* recognizes that sources outside of buildings such as lightning and utility circuit switching events can produce damaging transient overvoltages. As a result, Section 8.6.4 of IEEE 1100 specifies that *"a listed and properly rated surge protective device should be applied to each individual or set of electrical conductors penetrating any of the six sides forming a structure."* Transient overvoltages also originate inside buildings from electrical switching and equipment operation. To protect equipment from external and internal overvoltage transients, Section 8.6.4 of IEEE 1100 recommends installing SPDs using a cascaded approach (Figure 1), with surge protective devices located at the service entrance and downstream distribution and branch panel boards.

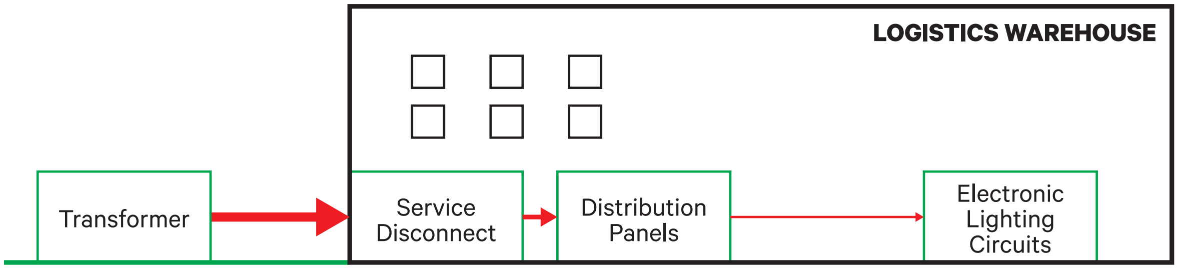
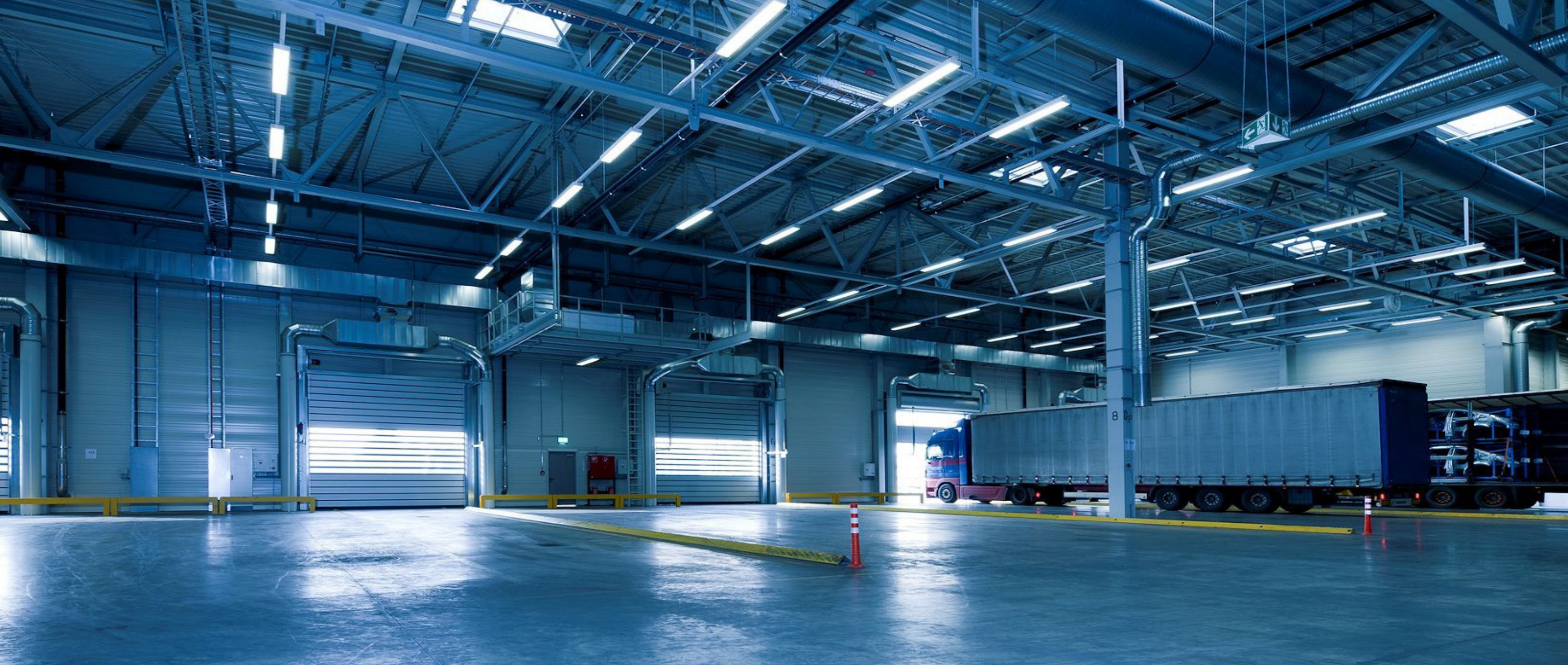


Figure 1: Cascaded SPDs reduce surge propagation through facility systems.



Changes In Ballast Technology

In fluorescent light tubes, an arc current passes through a gas that contains mercury vapors. Electrons collide with the mercury atoms to produce UV radiation. The UV photons excite phosphor crystals on the interior surface of the tube, which then glow to emit light.

In order limit current flow through fluorescent tubes, a ballast is wired in series with the lamp. Older magnetic ballasts use a coil that generates a magnetic field, which in turn generates an opposing voltage. As the AC current changes direction with each cycle, the process is continually reversed and repeated, effectively limiting current flow. This process occurs at the frequency of the AC power source, nominally 50 or 60 times per second. Heat dissipation from this process limits the efficiency of this type of lighting. Flickering effects and acoustic hum can also be produced by magnetic ballasts. Overvoltage transients typically have not caused problems with magnetic ballast operation and reliability.

Newer energy-efficient ballasts use electronic components to control current flow to fluorescent lights. These ballasts typically incorporate a switched mode power supply to reverse current flow and control power. Operating at frequencies up to 20,000 cycles per second, flicker and hum are virtually eliminated. Because the arc inside the lamp has less time to dissipate, less energy is required to sustain luminescence and energy efficiency is increased.

Susceptibility Of Electronic Ballasts To Surges

Like other electronic equipment, electronic ballasts are sensitive to transient overvoltages. The *IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits* (IEEE C62.41.2) characterizes the surge environment by location in electrical systems, as shown in Figure 2 below.

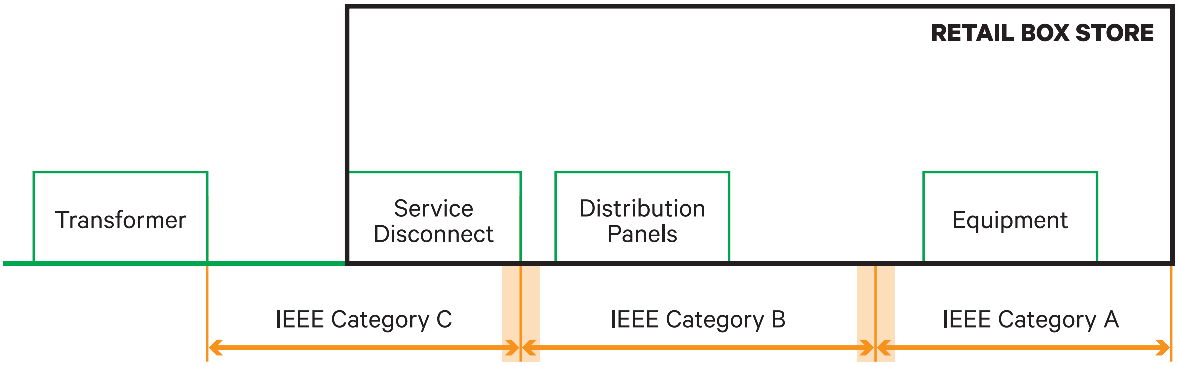


Figure 2: IEEE Location Categories

Electronic ballasts are typically designed to withstand IEEE C62.41.1-1991 Category A overvoltage transients, which identified three levels of transient overvoltages for Category A locations. However, the more recent standards, ANSI/IEEE C62.41.1-2002 and C62.42.1-2002, no longer differentiate severity levels for Category A and Category B, and refer testing to the least severe of the Category A waveforms specified the 1991 standard. In addition, the relative boundaries of the IEEE location categories within buildings are somewhat indistinct. For these reasons, it is possible for electronic lighting products to be deployed in locations that are subject to transients exceeding present Category A levels, thus exposing components to momentary overvoltages exceeding those for which they were designed.

Testing has shown that electronic ballasts can be damaged by Category B transient overvoltages, and that SPDs can protect electronic ballasts from these transients, preventing failures. In a 2007 study, nine ballasts from four manufacturers were tested using transients representative of Category B environments. These samples were subject to 500 surges of a 100 kHz, 6 kV, 500 Amp ringwave transients, similar to those that could be generated within a facility's electrical system. These impulses caused six of the unprotected electronic ballasts to fail. The surviving units were subject to five 8x20 us, 6 kV, 3 kA transients, similar to induced transients from lightning. All of the remaining units failed after being subjected to the higher level transients. The testing was repeated with new samples after installing a 100kA, 800V, UL 1449 SPD on the lighting circuit, then subjecting these samples to a single 1.2us x 20kv open circuit voltage, 8x20us, 10kA combination transient. All of the samples survived this testing.

Costs Of Replacing Surge-Impacted Lighting Ballasts

The results above show that unprotected electronic lighting components can be damaged by transient overvoltages that could be present within buildings. In order to fully understand the potential impacts, it is important to consider the actions that must be undertaken to repair damaged lighting components.

When ballasts must be replaced, there is the direct cost of the replacement ballast. In addition, there is a labor cost, which may be incurred with an overtime surcharge if repairs are required outside of normal business hours. In addition, there is the cost of any special tools or equipment, such as a lift where lighting is located along high ceilings. Furthermore, there could be business losses stemming from reduced lighting levels. In a retail setting, dim lighting could reduce customer interest in products. In a manufacturing setting, poor visibility could limit productivity. In any setting, unsafe conditions could result from poor lighting until a ballast is repaired. The true recurring costs become apparent with each failed electronic ballast, and are summarized below.

Replacement Ballast + Labor + Equipment + Lost Revenue = ***True Cost per Failed Ballast***

Installing SPDs on lighting circuits can prevent electronic damages and improve reliability and longevity. To comply with IEEE recommendations, SPDs should be installed at the service entrance, distribution panels, and remote branch panels serving circuits that power lighting with electronic ballasts. The associated one-time expenses include the direct cost of SPDs plus labor and equipment to install the devices.

LED Lighting Requires Similar Protection

The newest LED luminaires also contain sensitive electronic components that need protection from transient overvoltages. These components include LED drivers that rectify AC current to DC and control the amount of power available to the LED. To protect LED lighting equipment, SPDs should also be installed at the service panels serving LED lighting circuits.

Protection Should Extend To Outdoor Lighting

As with the lighting products that preceded them, the newest LED lighting equipment mount on buildings and poles to illumine pathways for ingress and egress, and to illumine building grounds. Because they could be subject to overvoltage transients from both building systems and environmental sources, LED lighting equipment also requires protection. SPDs are needed at these locations to protect equipment within buildings from transients that could be induced along the outdoor conductors that serve building-mounted and pole-mounted equipment, such as equipment used for lighting rooftops, parking areas, and athletic fields and stadiums. For these applications, suitable SPDs should be installed at the fixture or pole, as well as at the panel serving these loads.

Summary

The newest electronic lighting components are susceptible to transient overvoltages and require appropriate surge protective devices to ensure that they will function for their designed service life. Without surge protection, the recurring cost of damages from overvoltage transients could exceed the one-time cost of installing suitable SPDs.

To provide comprehensive protection, IEEE 1100 recommends installing SPDs using a cascaded approach, with surge protective devices located at the service entrance and downstream distribution and branch circuit panels. Consequently, SPDs should be installed at all panels serving circuits that power electronic lighting equipment. SPDs should also be installed at the panels and load ends of circuits serving outdoor lighting equipment.

References

1. Institute of Electrical and Electronic Engineers, *IEEE 1100 - IEEE Recommended Practice for Powering and Grounding Electronic Equipment*. Piscataway, New Jersey, 2005.
2. Institute of Electrical and Electronic Engineers, *IEEE C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits*. Piscataway, New Jersey, USA, 2002.
3. Fox, G, Whitehead, J, *Ballast Survival When Exposed to Commonly Found Transient Voltages.* Institute of Electrical and Electronic Engineers, Industry Applications Conference, 2007. Conference Record of the 2007 IEEE. New Orleans, Louisiana, USA, 2007.

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WP-50015 (R- 07/17)

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