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Effect of Electrical Disturbances on LED Drivers

Introduction

Electrical disturbances such as voltage variations can significantly impact light-emitting diode (LED) drivers and lighting systems, leading to issues like flickering, premature failure, and reduced lifespan, the effects of which range from minor annoyance to costly operational disruption. One of the most noticeable issues with the existing LED lighting in Building 10 on the NIH campus is caused by power surges affecting LED lighting drivers, resulting in inconsistent lighting performance. Unlike traditional bulbs that respond to any small change in the quality of voltage, LED brightness is primarily determined by the current flowing through the LED driver. A slight variation in voltage can cause a larger change in the current, leading to a noticeable difference in brightness. A thorough evaluation of the electronic driver is critical to understand and address the effects of disturbances and ensure optimal performance and longevity.

LED Driver Stages

A programmable LED driver has multiple components. The first component is a driver input circuit. Alternating current (AC) input voltage is applied to the driver input circuit. The second component is a typical bridge rectifier which converts AC to direct current (DC). The third component uses capacitors to smooth the ripples from the second stage, while the fourth utilizes a power factor correction (PFC) technique. PFC detects the amount of phase shift between the AC input voltage and current and corrects the power factor on the AC input. The PFC circuit shifts the AC input current to match the AC input voltage as closely as possible, which corrects the harmonic distortion of the current. The fifth component is the programmable DC-to-DC converter, which provides voltage and current regulation necessary to operate the LED light array. Feedback from the light array is provided back to the converter. User controls, such as dimming and LED tuning, can be transmitted to the programmable converter.

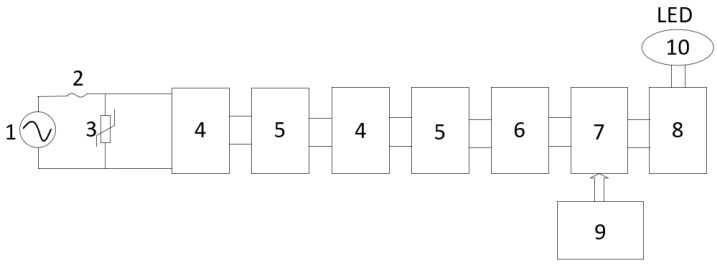

Fig 1: Stages of an LED Driver

1. AC Input
2. AC Line Fuse
3. Metal Oxide Varistor
4. Electromagnetic Interference Filter
5. Rectifier
6. DC Current Filter
7. Power Factor Correction Unit
8. Programmable DC to DC Converter
9. Lighting Control Apparatus
10. Light Array

Causes and Effects of Voltage Variations

Voltage variations are caused by a combination of factors, including changes in electrical load, faulty wiring, disturbances in the power grid, electrical load variations in the system, or switching operations. Poor power quality or other voltage variations lead to voltage swells or sags, harmonic distortion, transient line surge, voltage drop, flickering of LED lights, etc. Long periods of voltage variation can negatively affect the functionality and reliability of the LED drivers and as a result reduce LED lighting performance.

Mitigation Techniques

Voltage variation can be mitigated by installing surge protectors, voltage regulators, a dynamic voltage restorer (DVR), and power conditioning equipment; optimizing driver placement; using appropriate wire sizes; adjusting driver output; and choosing high-quality LED drivers with built-in protection against fluctuations. The best practice to manage voltage variations effectively involves selecting the correct LED driver for the voltage and wattage requirements and keeping a short distance between the driver and the lighting fixture.

Conclusion

Poor power quality can lead to costly equipment damage such as LED driver malfunctions and failures while increasing energy consumption and utility bills. Excessive voltage fluctuations can generate heat and potentially damage a component's insulation or even lead to electrical fires. Frequent also voltage issues accelerate wear and tear on equipment, leading to more frequent repairs and replacements, increasing maintenance costs. Proper mitigation of electrical disturbances like voltage variations is a key aspect of facility management and will save money while extending the lifespan and reliability of LED fixtures.

Further Reading

1. Switching Power Supplies by Sanjaya Maniktala https://www.google.com/books/edition/Switching_Power_Supplies_A_Z/cuyyQ3N_8hIC?hl=en&gbpv=1&pg=PR3&printsec=frontcover
2. Power Supplies for LED Driver by Steve Winder https://www.google.com/books/edition/Power_Supplies_for_LED_Driving/lQPeDAAAQBAJ?hl=en&gbpv=1&printsec=frontcover
3. The Basics of LED by Eric Strandberg, LC & Jeff R. https://www.lightingdesignlab.com/sites/default/files/pdf/Basics%20of%20LEDs.%20pdf