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TECHNICAL NOTE

Title: EFFECT OF INRUSH CURRENT ON LED LIGHTING SYSTEMS

A guide for the Electrical Contractor

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Date: 27/04/2015

SUMMARY

Inrush current is the current drawn by a piece of electrically operated equipment when power is first applied. It can occur with AC or DC powered equipment, and can happen even with low supply voltages.

An inrush current event subjects one or more LED units to current that is higher than the maximum rated current on the data sheet, either directly through high current or indirectly through high voltage. These events are transient, meaning that they happen for a short period of time – typically less than one second. They are sometimes referred to as surges or spikes, such as "current spike" or "voltage spike".

Exposing an LED to any current exceeding the maximum current specified in the LEDs data sheet and depending on the duration and amplitude of the exposure, has the potential to damage an LED driver and /or head unit.

This damage might result in an immediate failure or in a gradual failure many hours, days or weeks after the event, particularly if reinforced by ongoing inrush current events.

Many low-end relays systems used in Lighting Control areas within the commercial sector are designed for low inrush current lighting, without consideration of high inrush LED technology. The high inrush on LEDs when installed can also cause components in these systems such as relay contacts, photocells, occupancy sensors etc. to continually trip or fail over time, especially in a retrofit situation.

Building designers are failing to appreciate the technological differences in advanced LED lighting and continue to write building electrical lighting specifications that fail to ensure a robust, cost effective solution.

CAUSE AND EFFECT OF INRUSH CURRENT

"Inrush Current" refers to the input current of short duration that flows into the LED driver during the initial start-up used to charge the capacitors on the input side. Typically, this is a short duration current, whose amplitude is much greater than the operating or steady-state current. The inrush is due to the EMC filter on the input and bulk capacitor on the boost circuit that is inherent to LED technology.

This is not usually a noticeable problem in households, where the number of lamps per switch is small, or in commercial buildings where circuits have a very low on-off cycle. But if a circuit has a number of 10 or more with a high switching frequency, the total inrush can be significant and it is also possible for a high surge current to flow through the LED driver until the current-limiting circuitry reacts.

It is not unusual for a 13W LED downlight rated at 350ma to have a 30A inrush current at start-up, albeit for a very short time (often only a few milliseconds). The problem arises when there is an LED driver included in an LED luminaire, and if there are a number of such LED luminaires on one circuit, the maximum peak inrush current and its duration may be additive. However, it is not an exact mathematical calculation; i.e. for "N" drivers connected in parallel does not equal exact "N" times the inrush current for one driver or "N" times the duration for one driver. There is a multiplier effect, but it is not completely linear.

Detecting damage to an LED subjected to adverse inrush current events can be difficult. The damage is often not immediate and catastrophic and therefore goes undetected because the LED continues to produce light. However, changes to an LEDs electrical parameters can be detected by measuring

forward and reverse bias currents of the suspect LED. In other words, the LED becomes “leaky” and will eventually fail prematurely, either at the driver or within the LED “head” with damaged bond pads (where the wires are soldered to the chipset).

Common causes

- Overloading circuits with LED units
- Using existing lighting circuits in a retrofit situation without calculation
- On-off sensor cycles that restrict LED electrical circuit heat dissipation
- Mixed lighting technology on the same circuit
- Circuit wiring size, length

INRUSH CURRENT PROTECTION

The normal protection levels built into LED lighting units consist of “on-board” resistors and diodes designed under normal operating conditions to restrict the average, low level effects of inrush current.

It is incorrect to say that the manufacturer, supplier or installer has the responsibility to build or supply for a “worst case scenario” The protection level is based on average switching cycles, low level dimming, normal ambient temperatures etc. as well as cost. In the first instance, it is the responsibility of the building stake holders to ensure adequate written specifications are available.

Furthermore, no manufacturer will supply a LED driver /head capable of operating under adverse conditions without a significant cost increase. A specification would have to be written and agreed to clearly stating the parameters involved before any build could be undertaken or, if available, existing fittings supplied. It should be noted that adverse operating conditions could possibly restrict warranties even with enhanced internal circuitry.

Recently, a small number of suppliers have introduced to the lighting market, stand alone , inrush peak current limiters specifically for LED lighting applications. These units, typically about twice the size of an average LED driver integrate either into the wiring circuit or are placed on the respective switch board. They are effective at eliminating damaging inrush currents while still allowing various

control mechanisms to function as designed. They are currently priced at around AU$200 / ea at 2015 prices.

CONCLUSION

Building designers and stakeholders remain unaware of the specific requirements of LED lighting. Of concern is the trend towards retrofit situations using price as the main criteria without due consideration of the technical aspects involved.

Amongst other issues, inrush current factors are causing a high level of unit failures in service. Stakeholders continue to assume installers and suppliers will have all the answers and ask all the right questions even though they have no input and very little, if any, influence in the building design criteria.

Stakeholders maintain that warranty claims be met even though the LED lighting design parameters have been exceeded.

It is not sufficient to expect average build quality within an LED lighting unit to perform in anything other than “average “conditions. The trend towards dedicated, external inrush current limit protection is expected to increase dramatically over time.

END REPORT

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