XICATO

101 Daggett Drive
San Jose, CA 95134
United States
T +1 866 223 8395

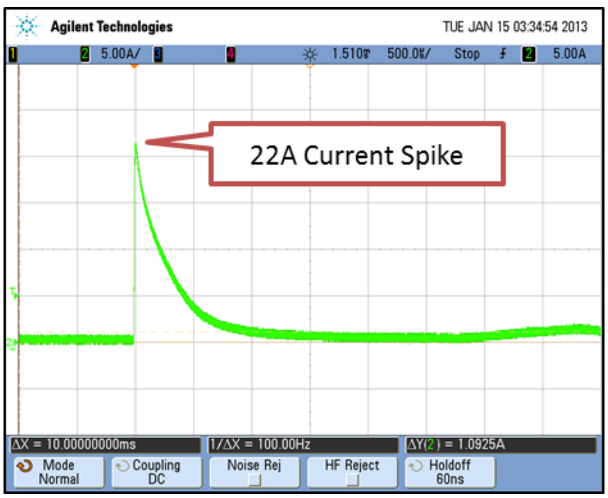
Application Note – Electrical Overstress of LED Modules
Version 20161118

Background

LED modules are susceptible to failure from electrical overstress. The failure results in a module that is either electrically open or shorted. In both cases the result will commonly be complete catastrophic failure (no light). A common source of this stress is "hot plugging" an LED module into a driver or power supply while the power source or driver is "on." This leads to brief, but powerful current spikes. These current spikes that often take place in less than a millisecond can result in a non-operative module in as little as one overstress event.

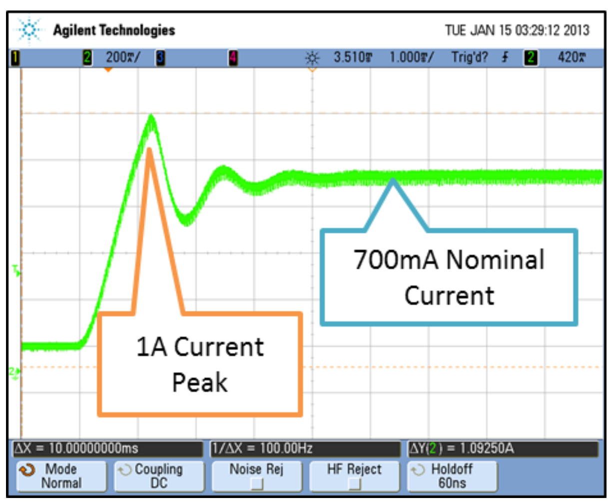
Effects of "Hot Plugging"

To illustrate the effects, a popular driver was selected for this test. The driver has a constant current output of 700mA with a voltage output range of 9-48VDC. The oscilloscope waveforms below show the difference between "hot plugging" a module and correct application of the power source. A Xicato Standard Series module was used for this test.



The waveform on the left illustrates the large current spike generated by "hot plugging" a module into a powered driver. This module normally requires approximately 10VDC to operate at 700mA. With no load, the driver defaulted to its maximum 48VDC output. During the initial contact between the driver and module, a current spike of 22A was generated! This type of stress can lead to premature failure of the module.

The waveform on the right illustrates typical driver behavior. The module was attached to the driver prior to AC power being applied. As the output voltage of the driver increased, the driver attempted to "lock on" to the desired 700mA drive current. It overshot this value to approximately 1000mA. While this is still undesirable, the additional stress created by the overshoot is minimal, compared to the 22A current spike generated by "hot plugging" into the same driver.



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Recommendations for Xicato XSM, XCA, & XTM Modules

Constant current LED drivers and adjustable bench top power supplies are commonly utilized for powering LED modules during factory test and field installation. Constant current sources are typically designed to have the LED module connected prior to applying power to constant current source. In many cases, connecting the LED module to a constant current source after the source has been powered on will result in an over current condition.

The only safe method of connecting an LED module to a constant current source is to:

- Turn off the constant current output of the power source. With a bench top power supply, this is generally accomplished by pushing a button. With an LED driver, the AC mains will need to be unplugged or disconnected and the operator/installer will need to wait as much as 60 seconds for the driver to discharge its internal capacitors. Please follow your LED driver manufacturer's recommendations for the duration of this waiting period.
- Attach the LED module to the constant current output of the power source.
- Turn on the power source.

Recommendations for Xicato XIM Modules

When using an XIM in a hot plug application (e.g., inserting a fixture into a live track), a large transient inrush current spike is generated to charge the input capacitors of the XIM. The inrush current spike is maximized when connecting to a high-power (greater than 100W) PSU with very rapid contact engagement. When using high-power PSUs, the XIM should only be installed into a non-powered circuit since the inrush current spike sourced by a high-power PSU will likely damage an XIM that is hot-plugged into it. Once XIM fixtures are installed, power can be switched on and off as usual.

There are no issues with steady state operation of an XIM powered by a high-power PSU or with having an XIM connected to a high-power PSU as the PSU is energized (powered up).

XIM Inrush Limiter

If shutting off electricity to a high-power track or circuit when installing fixtures is impractical in an installation, an inrush current limiting device should be installed at the input of the XIM. In order for the inrush limiter to work effectively, it must be included as part of the device that is hot plugged into a DC source. In other words, the inrush limiter has a fixed connection to the XIM and it is effectively the device that is connected to the live DC circuit. The following reference schematic for an inrush limiter design is being provided to OEMs that would like to protect the XIM from damaging current spikes during hot plug events.

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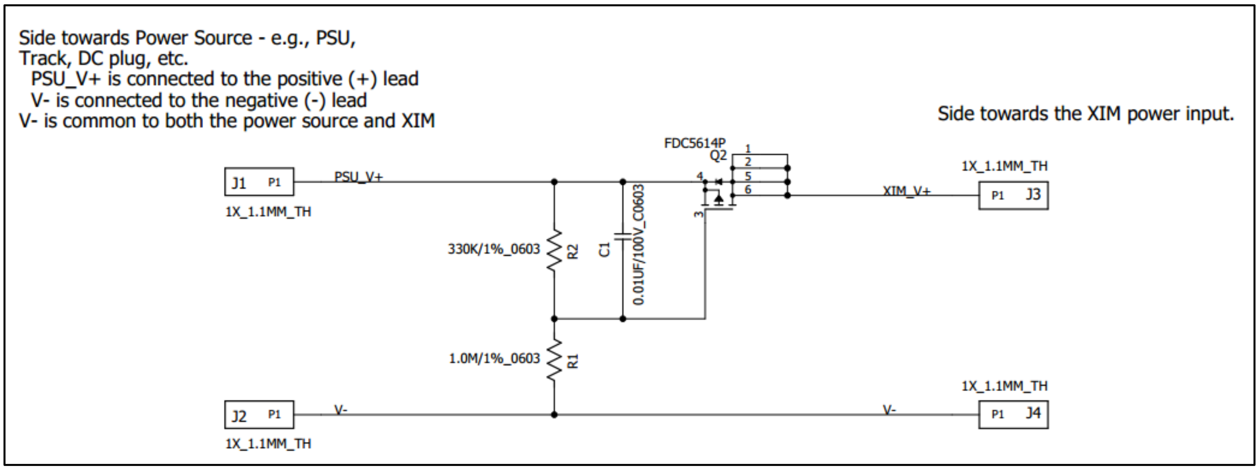

Schematic Notes

1. The P-channel FET (FDC5614P) will only conduct between the Source (pin 4) and Drain (pins 1,2,5,6) when the Gate (pin 3) voltage is below the source voltage by at least 1V (i.e., Vgs(th) min = -1V).
2. When power is first applied, the voltage across the (discharged) capacitor C1 will be 0V causing the gate voltage to match the input voltage. The capacitor will be charged by the resistor divider formed by R1 and R2. As the capacitor charges, it will gradually bring the gate voltage below the source voltage causing the P-channel FET to conduct.
3. The final voltage at the Gate pin is determined by the resistor divider values, and based on the FDC5614P datasheet should be kept within the range of -4.5V to -20V relative to the source voltage

Inrush Limiter Simulation

The following images are simulations that represent an XIM being hot-plugged into a live 48V circuit. The hot plug event was simulated by having an input voltage transition from 0V (unplugged) to 48V (energized) in 4 microseconds. For both sets of simulations, the input stimulus was identical, with the only difference being the insertion of the inrush limiting circuit shown above between the source power supply and the XIM.

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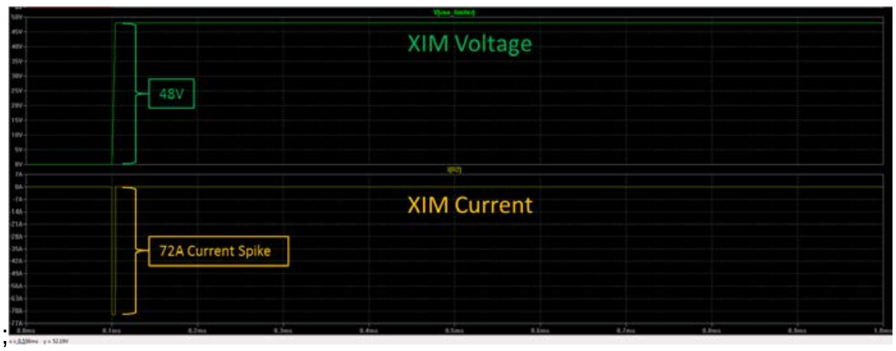
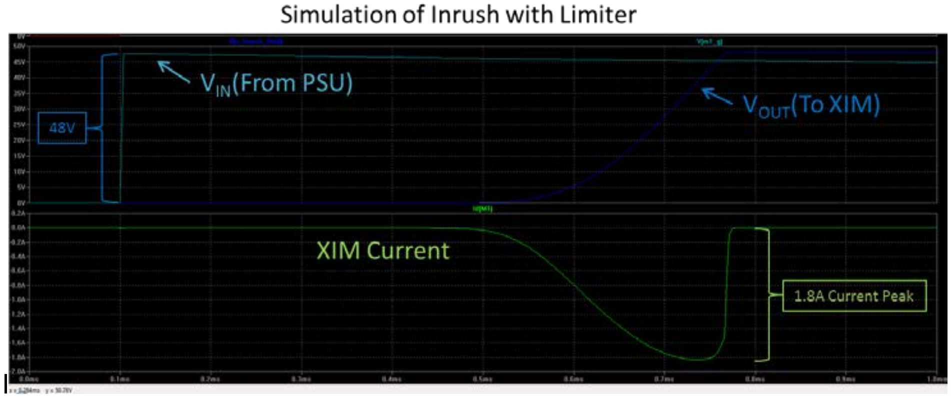
In the first example, no inrush limiter is used and it represents the XIM being plugged directly into the live 48V circuit. When the XIM is hot-plugged into the live circuit, a surge current is created as the PSU sources the current needed to charge the input capacitors of the XIM to 48V. In an actual hot-plugging event like this, the resulting 72A inrush current spike would blow the XIM's internal fuse damaging the XIM module.

Simulation of Inrush without Limiter



In the 2nd Simulation, the inrush limiter has been inserted between the 48V source and the XIM. The input side of the inrush limiter circuit (i.e., "Side Towards Power Source") is what is hot-plugged into the live circuit. As can be seen in the simulation, the P-channel FET is initially turned off, preventing the inrush current surge, and then as the Gate voltage drops as the Gate capacitor is charged the FET begins to conduct. Since the FET is relatively high resistance as it turns on, it limits the current that can be passed through it to instantaneously charge the input capacitors. As the FET Gate voltage continues to drop, the FET transitions to its conductive region and there is a small inrush current of 1.8A which will not damage the XIM.

Simulation of Inrush with Limiter



Conclusion

Improper application of power to a Xicato module can lead to premature failure and is not covered under the module warranty. Xicato highly recommends the above procedure for safe power application to our LED modules. Following this procedure ensures compliance to Xicato guidelines and specifications. For any further inquiries, please contact your Xicato technical representative.