Incorporating Control into your LED Product






Russ MacAdam

Director of Engineering Development

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Customer expectations

- Incandescent lamp performance
  - Color temperature
  - <.1% dimming
- Smooth and continuous dimming
  - No flicker or shimmer
  - No pop-on
  - No drop-out
  - No dead travel
- Use standard controls

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Select a Control Type

- Customer wants the aesthetics and functionality of a control
- Select based on performance
  - Dimmed level (ex: 20%, 5%, 1%, <1%)
  - Smooth and continuous performance
- Select based on application
  - Color changing
  - General illumination
  - Accent lighting
  - Energy management
- Select based on target market
  - Residential vs. Commercial

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Select a Control Type

- Low Voltage
  - DMX
  - DALI
  - 0-10V
- Line Voltage
  - Reverse Phase (ELV)
  - Forward Phase (incandescent)

DMX

- Accent Lighting, Theatrical
- ANSI Standard (USITT DMX 512-A)
- Protocol used primarily for mixing colors and varying color intensity

DALI

- General Illumination, Energy Management
- Provides individual fixture control for up to 64 devices per link
- IEC standard 60929
- Test Protocol in IEC 60929 Annex E
    - Follow standard for compatibility

DALI

- Pros
  - Wiring flexibility
    - Polarity free
    - Topology free
    - class 1 or class 2
  - Individual Fixture Addressability
  - Test Protocol part of IEC 60929 Annex E
    - Follow standard for compatibility
- Cons
  - Requires commissioning
  - Control protocol not defined (ex: for sensors)

0-10V

- General Illumination, Energy Management
- IEC standard 60929
  - 2 power wires, 2 control wires
  - <1V: min light (NOT Off)
  - >10V: max light
  - Driver must source control current
    - 1mA to 2mA max
- Meet the standard for compatibility

0-10V

- Pros
  - Control wires are separate from power wires
  - Standardized because of history as fluorescent control
  - Supports good power factor and THD
- Cons
  - Light level differences for long runs
  - Unfamiliar to residential market

Reverse Phase Control

- **General Illumination**

- Designed for Electronic Low Voltage loads
  - Also works well for many LEDi loads

- ELV loads and many LEDi loads are capacitive and have large impedance changes.
  - High impedance until oscillator in transformer or driver starts to run, then switches to lower impedance.

- Dimmer requires a neutral connection which addresses the impedance changes but may be challenging to install (if neutral isn't available in the wallbox)

Reverse Phase Control

- Pros
  - More immune to load impedance changes
  - Better with minimum loads
- Cons
  - Higher cost (FETs vs. Triac)
  - Neutral wire required
  - Limited selection (compared to incandescent) and less of an installed base

Forward Phase Control

- **General Illumination**
- **Energy Management**
- **Accent Lighting**

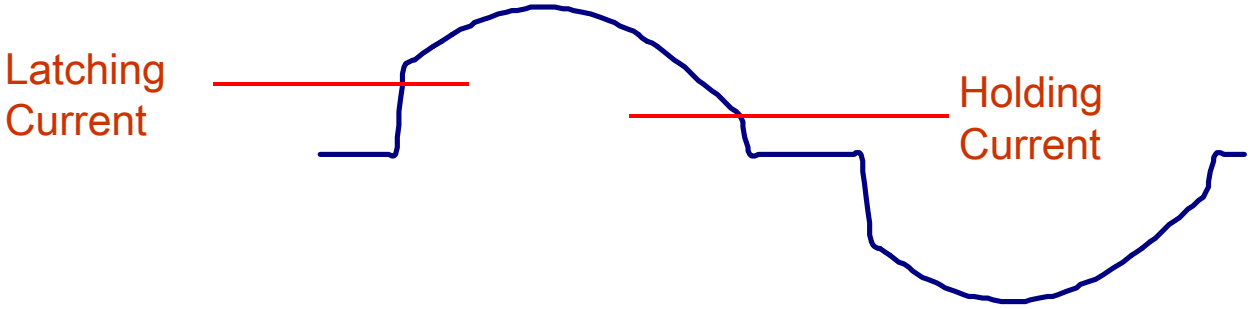
- Used for Incandescent and Magnetic Low Voltage loads
  - Most are two-wire construction
  - Works well on a resistive (incandescent) load
  - Has issues with complex loads like LEDi

Forward Phase Control

- Why work with the “Incandescent” dimmer?
  - 100’s of millions dimmers installed
  - 100’s of aesthetic designs
  - Low cost, easy to install
- But…
  - Uses a Triac
    - Minimum load requirements
    - Does not like capacitive loads

How a Triac Works

- A Triac is a semiconductor switch
- Pulse turns the device on
- Stays on till current goes below holding current



What to avoid

- Reasons for **Flicker:**
  - Triac does not latch initially or unlatches early
  - Unequal power draw by the load between the positive and negative half cycles

Flicker

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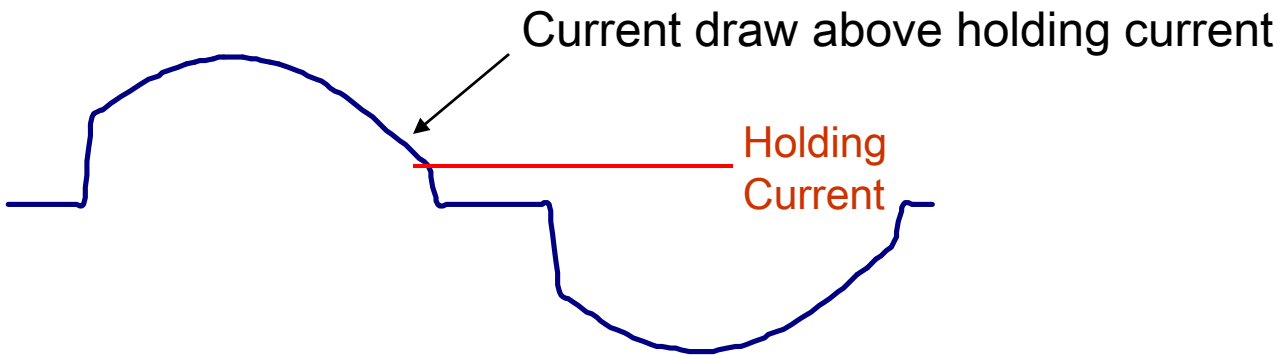
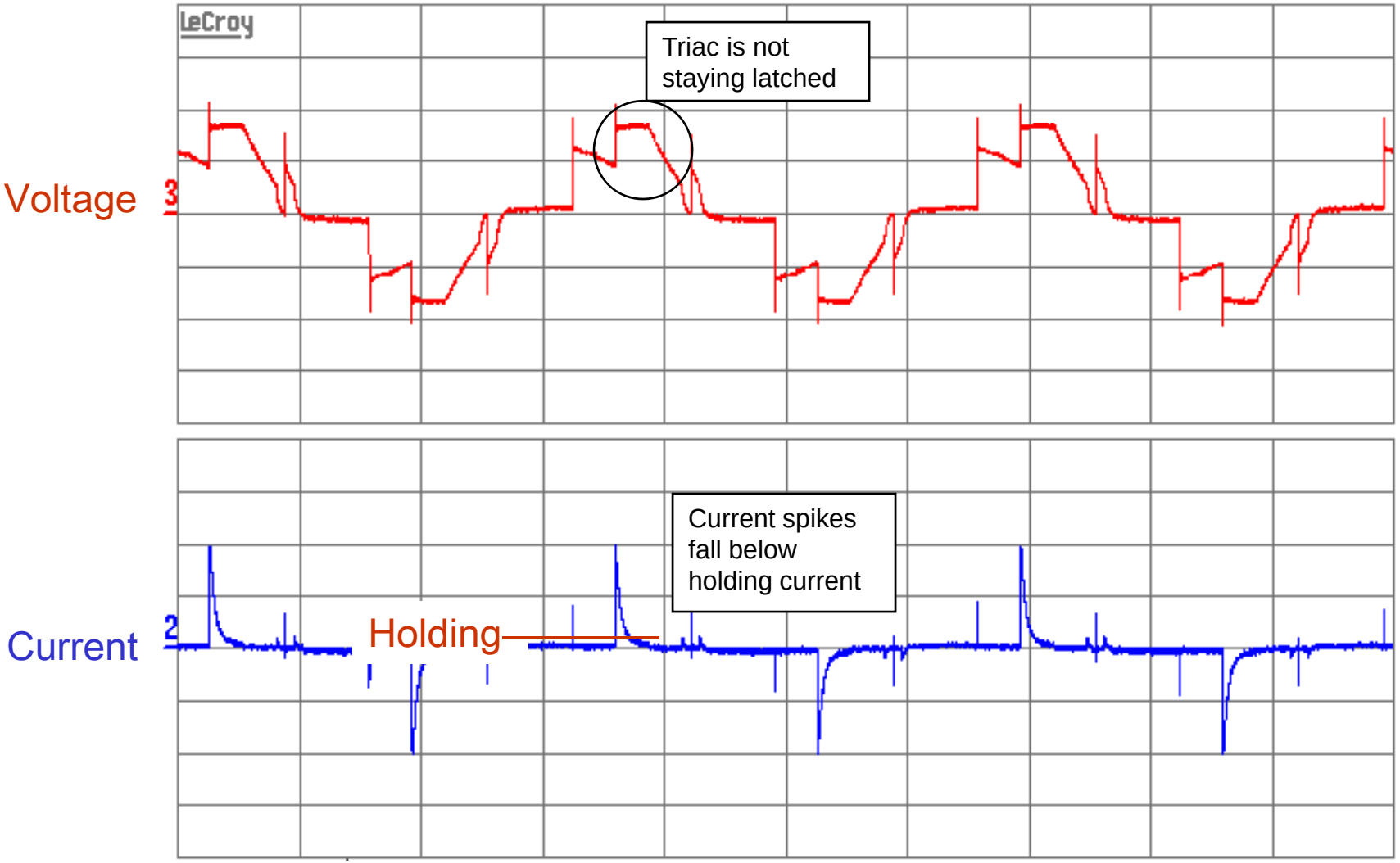
What to avoid

- How to Eliminate **Flicker**:
  - Prevent triac unlatching by drawing continuous current at least equal to triac holding current

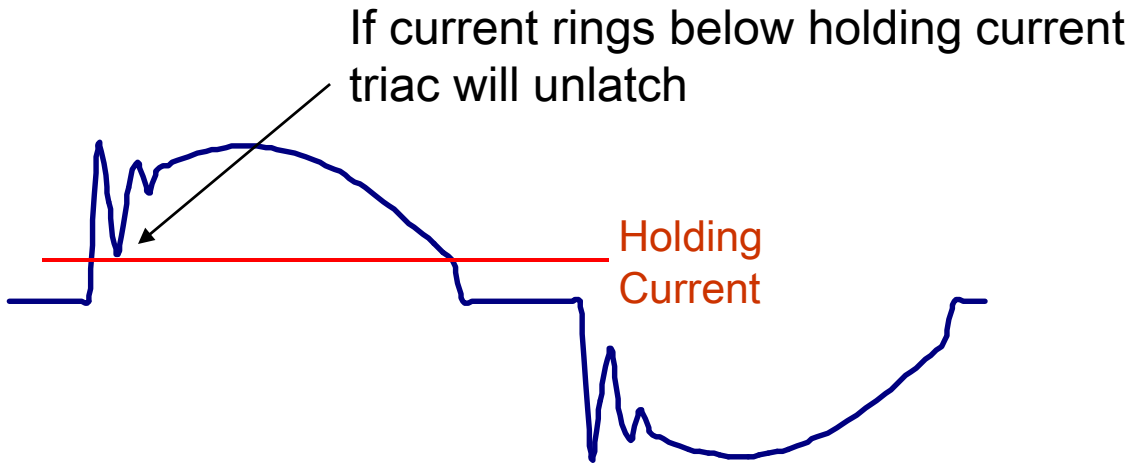


Flicker


LeCroy
Triac is not staying latched
Voltage
3
Current
2
Holding
Current spikes fall below holding current

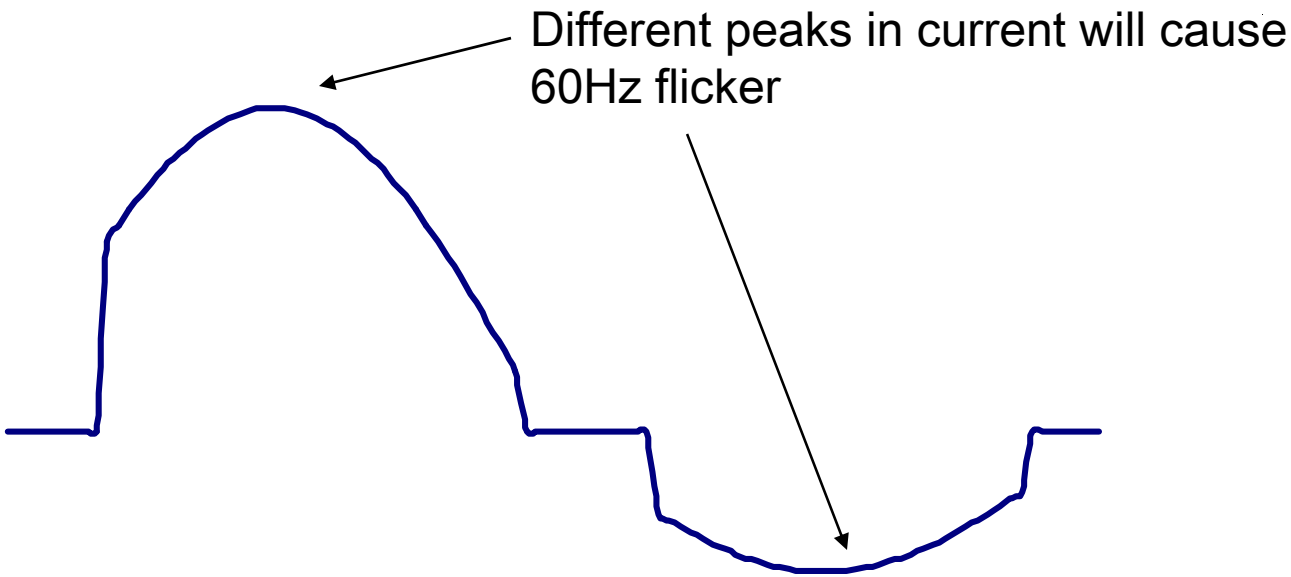
What to avoid

- How to Eliminate **Flicker**:
  - Avoid step changes in current draw
    - may create ringing of the triac current that causes it to unlatch
    - Must damp the ringing in the design



What to avoid

- How to Eliminate **Flicker / Shimmer**:
  - Pull power equally (magnitude and shape) in both positive and negative half cycles



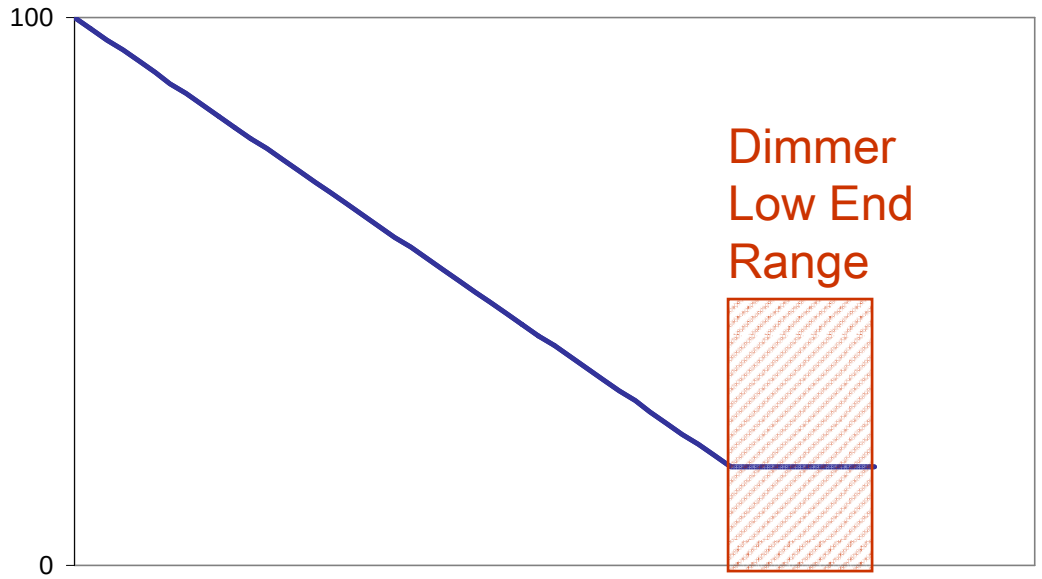
What to avoid

- Eliminate **Pop-on**:
  - Low end on dimmers vary from about 35V (~2ms) down to 12V (1 ms)
  - The ideal light source will start at low-end voltages of 12-35 volts RMS

Note: The “basic” (rotary) dimmer will have pop-on even on an incandescent

What to avoid

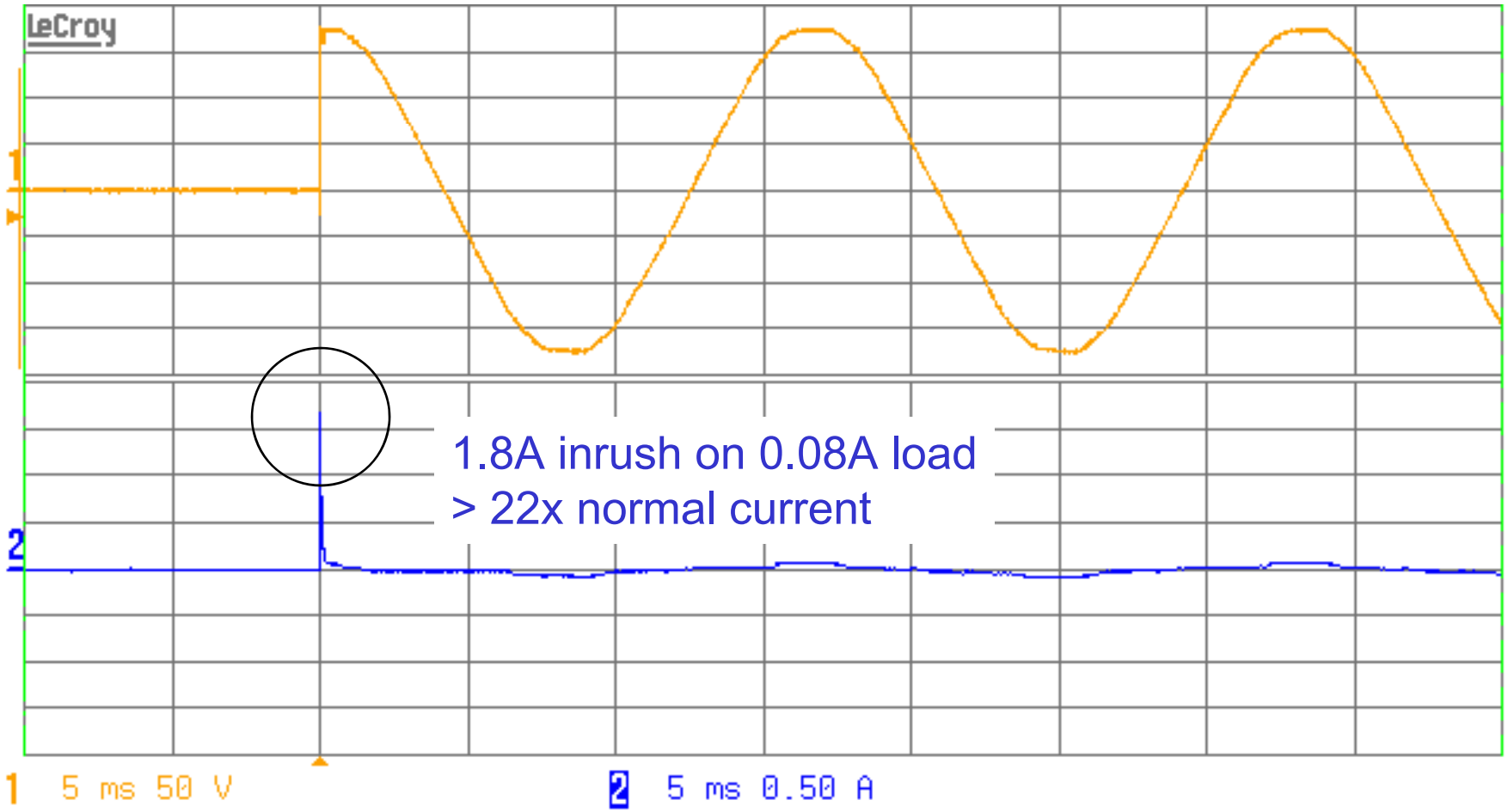
- Eliminate **Drop-out**
  - Meet minimum light level and hold constant from 35V down to 12V (1-2 ms)
  - Dead band at low end helps with tolerance variations and allows for a more “user friendly” product



What to avoid

- Eliminate **Inrush current**:
  - Reduce capacitance on the input of driver
  - Adding inductance can result in voltage ring-up, hurting the systems performance
  - Follow NEMA 410 Standard for fluorescents
  - Good practice to limit peak current at:
    - Turn on < 10x continuous = tungsten load
    - Repetitive < 2x over peak RMS
    - For both 1x is ideal

In-rush Current



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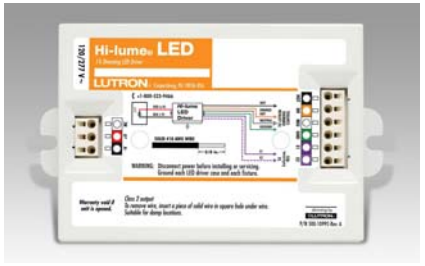
Ensure Compatibility

- Test the system
  - Test the controls and the driver
  - Test the driver and the LED array
- Compatibility confusion is the biggest customer complaint…
- …Followed quickly by products that they perceive do not work



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You will succeed if you:

- Select the appropriate control
- Ensure smooth and continuous dimming
- Publish control compatibility information
  - Support with testing information
- Publish dimming performance

6" Square LED Downlight – High Performance

FEATURES

- 1.5" (38mm) LED spacing and heavy duty heat sink maintain junction temperature below 75°C at 25°C ambient (well below Cree's limit of 150°C) to maximize efficacy and prolong life.
- Drivers and printed circuit board are accessible from below the fixture. A quick disconnect plug simplifies board replacement.
- Optional dimming drivers provide full range (0-100%) flicker-free dimming with standard incandescent dimmers.

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LED Product Report Card

Manufacturer: Cree
Applicable Model Numbers: LR6, LR6-GU24, LR6C, LR6C-GU24

Manufacturer's Description
Type of Fixture: Recessed Downlight
Operating Voltage: 120 Vac
Input Power: 12 W
Current: Not Specified
Frequency: 60 Hz
Control Types: Standard Incandescent Dimming
Dimming Range: 20% - 100% (one fixture)
Output Power: N/A
Lumens: 650 lumens

Lutron Test Results
Date Tested: Feb 25, 2009
Model Number Tested: LR6C
Smooth and Continuous: Yes
Test Notes:

Lutron Recommended Compatible Products

Product	Part Number	Fixtures per Dimmer	Measured Light Output Range [1]	Comments
Nova	NLV-600	1 – 8	20% - 90%	Low end trim required
Nova T*	NTLV-400VA-CPN0199	1 – 8	20% - 90%	Low end trim required
Skylark	SF-10	1 – 12	20% - 90%	Low end trim required
Homeworks	HRD-6ND	1 – 8	21% - 84%	Low end trim required
	HWD-6ND	1 – 8	21% - 84%	Low end trim required
	HW-RPM-4A-120	1 – 16 per output	23% - 100%	Max. 25 per module Low end trim required Must use forward phase
	HW-RPM-4U-120	1 – 25 per output	23% - 100%	Max. 25 per module Low end trim required
Commercial Systems	LP-RPM-4A-120	1 – 16 per output	23% - 100%	Max. 25 fixtures per module Low end trim required
	LP-RPM-4U-120	1 – 25 per output	23% - 100%	Max. 25 fixtures per module Low end trim required
Interfaces	FDI-FTU [2]	1 – 16	23% - 96%	Low end trim required

[1] Values are based on light output using the specified dimming control, and may not be an indication of the fixture's full capability
[2] Controlled with Ariadni, Diva, Lyneo Lx, Nova, Nova T*, Skylark, Vareo, or Vierti Fluorescent dimmers.

For Questions:

- Come to Booth #53 (Lutron Electronics)
- Call 1-877-DIM-LED8 for the Lutron LED Control Center of Excellence to talk directly with an LED control engineer

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