

# Lighting Consumer's Conundrum

## Dimming LED's



# Agenda

- LED Lamp Technology
- LED Dimming Methods
- Challenges and Solutions
- Resources and Tools



Successful LED Dimming:

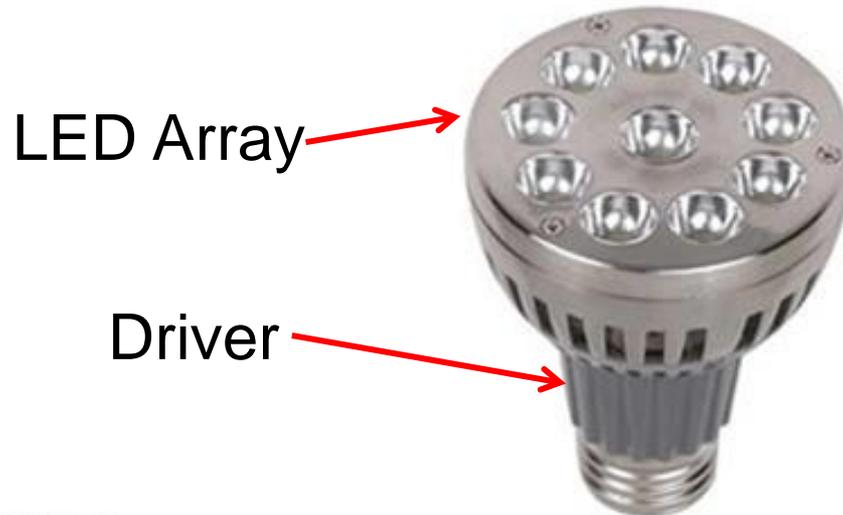
# LED LAMP TECHNOLOGY



# LED Lamp Technology

## LED Lamps consist of an LED Array and Driver

- LED arrays, within a lamp, come in many shapes and sizes
- A driver is required to power the Array,
  - It converts the line voltage power to what the array needs



# LED Lamp Technology

## LED Lamps produce Heat

- Heat is created
  - By the LED Array
  - Components in the driver
- A heat “sink” is required to dissipate the heat
- As LED’s become more efficient, heat sinks can be reduced in size
- Dimming reduces the amount of heat produced

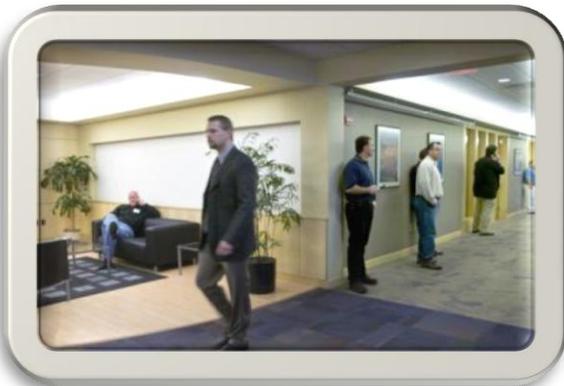


# LED Drivers are Key

- **Compatibility**
  - Between the LED driver and the LED array is critical
  - It determines to what degree the Lamp can deliver upon its desired performance
- **The LED driver design determines the dimming performance**
  - Non-dim vs. Dimmable
  - Dimming range
    - Minimum Level - 20%, 10%, 1%
  - Dimming curve
  - Dimming smoothness

# Understanding Dimming Range

- Dimming range varies greatly
  - Some LED lamps only dim to 50%, others to 1%
- Required dimming range – application dependent
  - 20% minimum level : suitable for a lobby, atrium, office
  - 1% minimum level: needed for restaurant, media room



Lobby or Atrium:



Residences and  
Restaurants:

Successful LED Dimming:

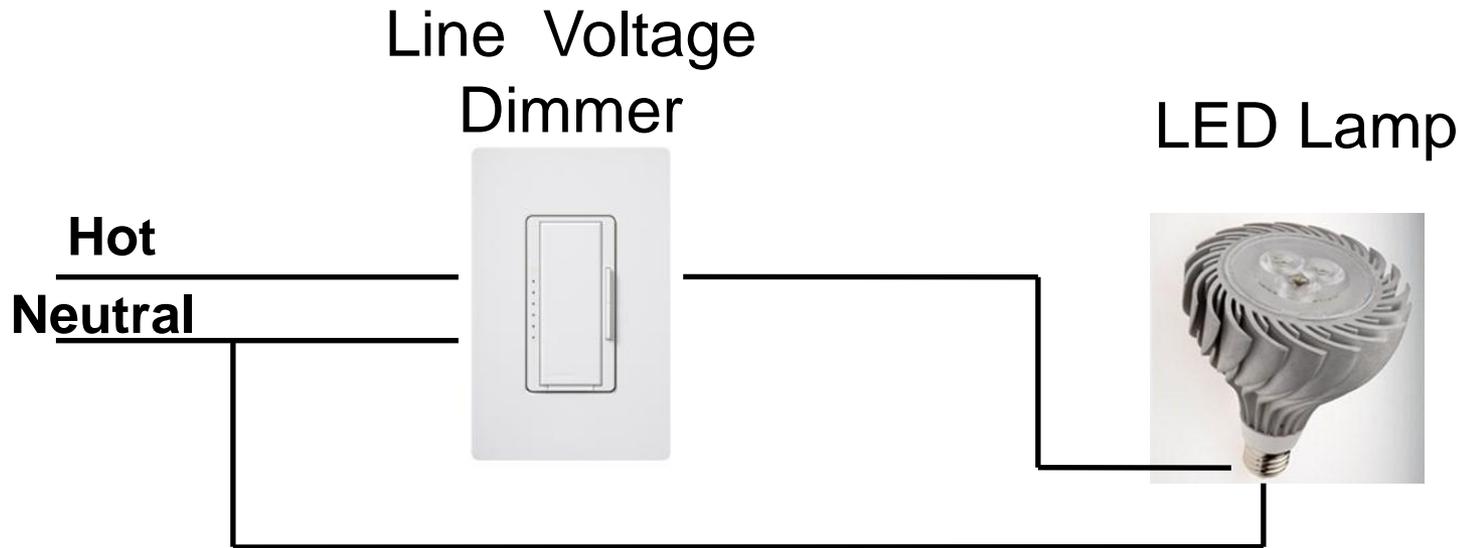
# LED LAMPS – DIMMING METHODS



# LED Lamp Dimming

## Line Voltage Dimmers

- Used to control LED lamps

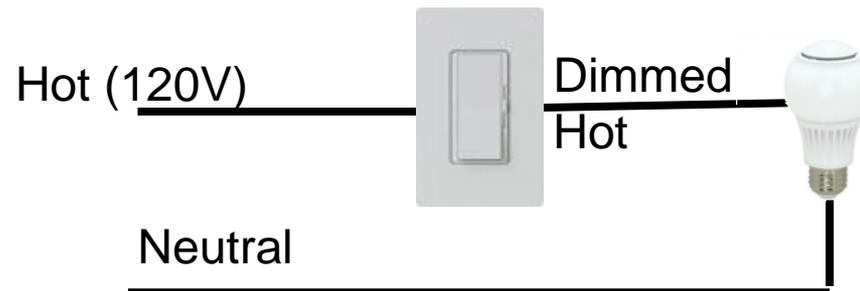
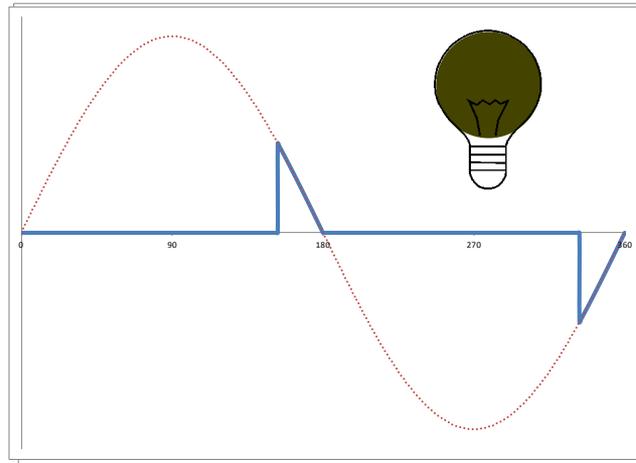


# LED Lamp Dimming

- Two Types of Dimmers
  - Forward Phase (Leading Edge, Triac)
    - Most Common Dimming Method
    - 150 million dimmers in use
    - Not originally intended for use with LEDs
    - Performance issues is what concerns people
  - Reverse Phase (Trailing Edge, ELV)
    - Traditionally used for Electronic Low Voltage(ELV) Lighting (track lights etc.)
    - Provides improved performance of LED lamps
    - Much smaller installed base

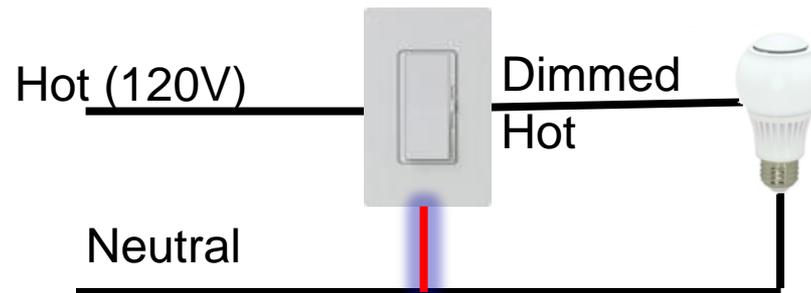
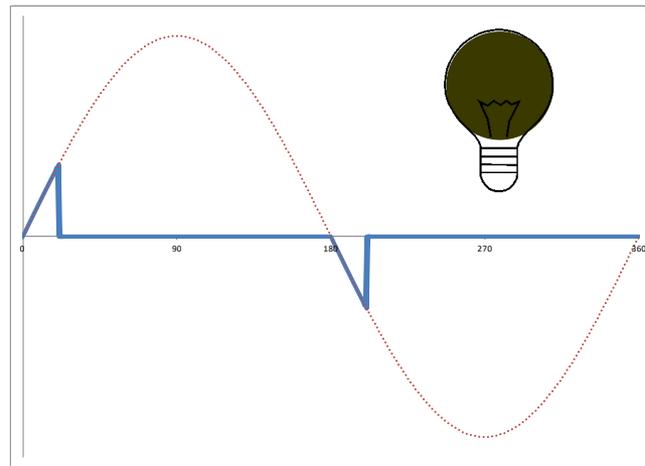
# LED Lamp Dimming

- Forward Phase (Leading Edge/Triac)
  - Designed for incandescent/halogen lamps and magnetic low-voltage (MLV) loads



# LED Lamp Dimming

- Reverse Phase (Trailing Edge, ELV)
  - Designed for Electronic Low Voltage Lighting
  - Requires a neutral wire connection



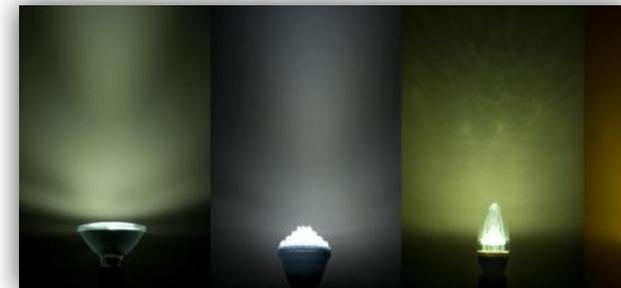
Successful LED Dimming:

# LED DIMMING CHALLENGES



# LED Dimming Challenges

- Controls compatibility
  - Not all LEDs are dimmable
  - “Dimmable” Lamps may have unknown or poor performance
- Color consistency
  - Color shift in LED light output can occur over time
  - LED color doesn’t get “warm” as they are dimmed



# LED Dimming Challenges

- Flicker
  - The unexpected modulation of light level that is visible to the human eye
- Pop-on
  - The lamp flashes on when the dimmer is turned up
- Drop-out
  - The Lamp suddenly goes out as dimmer is turned down
- No Off state
  - The lamp **SHOULD** turn off when the dimmer is off



# LED Dimming Challenges

- Dead-travel
  - As dimmer is adjusted there is no corresponding change in light level
- Audible Noise
  - From control *or* lamp
- Popcorn
  - Multiple lamps on the same dimmer turn on at different times



# LED Dimming Challenges

- Dimming Low Voltage (MR-16) Lamps
  - MR-16 Lamps need a low-voltage transformer
    - Reduces the Line voltage to 12V
  - Compatibility required:
    - Between the dimmer and transformer
    - PLUS the transformer and lamp
  - There are many lamp/transformer combinations
    - But few good solutions for dimming LED MR16 lamps



# LED Dimming Challenges

- Dimming Low Voltage (MR-16) Lamps
  - Dimmers and transformers have minimum load requirements
  - The dimmer type must match the transformer type
    - MLV or ELV

*compatibility requirements  
both here and here*



Successful LED Dimming:

# LED DIMMING SOLUTIONS



# LED Dimming Solutions

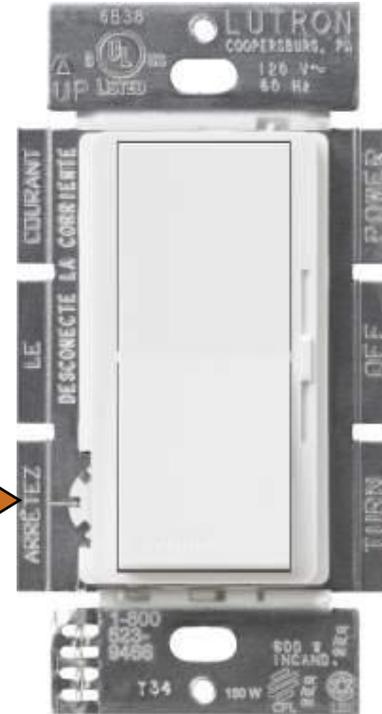
- Dimmers designed for LED Lamps
- New designs specifically for **dimnable** LED Lamps
  - UL listed with LED lamps
  - Also dim incandescent and halogen lamps
- LED Lamps designed for dimming
  - Improved driver electronics



# LED Dimming Solutions

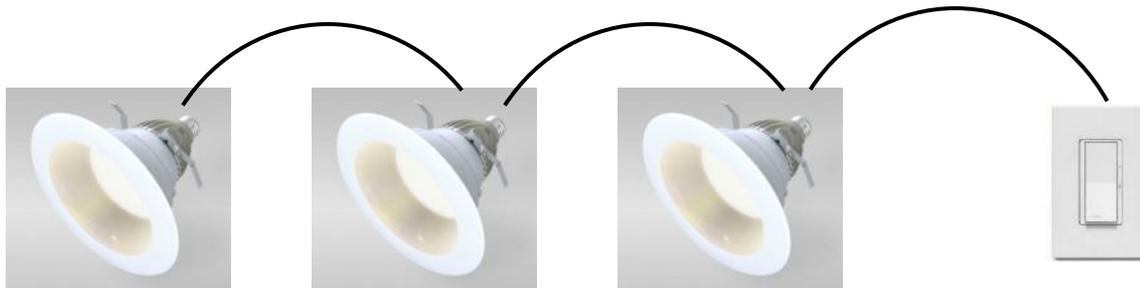
- Dimmers designed for LED Lamps
- Advanced dimming circuitry
- Voltage compensation to reduce flicker issues
- Improved minimum load requirement
- Added low-end adjustment dial
  - Set the bottom (low end) of the dimming range
- Mixed load type rating
  - Allows end-user to gradually replace incandescent lamps with LEDs

Adjustment  
Dial



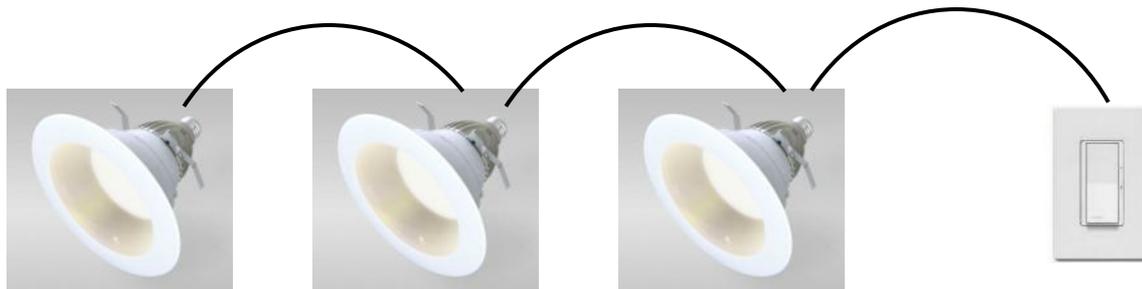
# LED Dimming Solutions

- Minimum number of lamps on a Dimmer
  - Performance may suffer with too little load
  - Incandescent dimmers require a 25 – 40 watt load
  - New dimmers only require 5 to 10 Watt load



# LED Dimming Solutions

- Maximum number of lamps on a dimmer
  - A 10 Watt LED is similar to a 100W incandescent in terms of dimmer stress
  - Start-up inrush and repetitive current create stress on the dimmer



# LED Dimming Solutions

- A new standard, NEMA SSL-7A
- Helps provide compatible solutions
- SSL-7A is an interface standard:
  - it specifies the interaction between LED lamps and dimmers
- Allows different manufacturers to provide compatible products



# SSL-7A Adoption agents

- Manufacturers
- Retailers
- Zhaga
- EPA ENERGYSTAR
  - Lamps Specification
  - Luminaire Specification
- California Energy Commission



Successful LED Dimming :

# RESOURCES AND TOOLS



# Resources and Tools

- Compatible LED Lamp Lists
  - Many manufacturers
  - Specific Lamp Model No's.

Dimmable CFL & LED bulbs approved for use with C-L<sub>w</sub> dimmer

Approved for use with C-L dimmers

List updated May 6, 2011  
For the most up-to-date list, visit [www.lutron.com/dimmed](http://www.lutron.com/dimmed)

**LED bulbs for wall-mounted C-L<sub>w</sub> dimmers**

Dimmable C-L<sub>w</sub>: DMWL-153P, DMCL-153P, DMSCCL-153P  
 Stylish Contour<sup>™</sup> C-L<sub>w</sub>: CFL-153P  
 Lutron C-L<sub>w</sub>: LQCL-153PH  
 Toggle/Analog C-L<sub>w</sub>: TQCL-153P, A/CCL-153P

Brand	Model	Wattage	Bulb description
<b>Cree</b>	CFL6	10.5W	6" Downlight
	CFL6-GL26	10.5W	6" Downlight
	LWS	10.5W	6" Downlight Module
<b>ecosmart</b>	ECS 19 WW 120	8W	A19, Warm White, 3000K
	ECS 20 WW FL 120	8W	PAR20, Warm White, 3000K
	ECS 25 WW 120	8W	G25, Warm White, 3000K
<b>Halo</b>	CFL-67SL	10.5W	6" Downlight
	ML708855	13.5W	6" Module
<b>Lighting Science</b>	DFN 19 CW 120	8W	A19, Cool White, 5000K
	DFN 19 NW 120	8W	A19, Neutral White, 4000K
	DFN 19 W27 120	8W	A19, Warm White, 2700K
	DFN 19 WW 120	8W	A19, Warm White, 3000K
	DFN 20 CW FL 120	8W	PAR20, Cool White, 5000K
	DFN 20 CW NFL 120	8W	PAR20, Cool White, 5000K
	DFN 20 NW FL 120	8W	PAR20, Neutral White, 4000K
	DFN 20 NW NFL 120	8W	PAR20, Neutral White, 4000K
	DFN 20 W27 FL 120	8W	PAR20, Warm White, 2700K
	DFN 20 W27 NFL 120	8W	PAR20, Warm White, 2700K
	DFN 20 WW FL 120	8W	PAR20, Warm White, 3000K
	DFN 20 WW NFL 120	8W	PAR20, Warm White, 3000K
	DFN 25 CW 120	8W	G25, Cool White, 5000K
	DFN 25 NW 120	8W	G25, Neutral White, 4000K
	DFN 25 W27 120	8W	G25, Warm White, 2700K
DFN 25 WW 120	8W	G25, Warm White, 3000K	
<b>Philips</b>	8E12BA11-E	3W	Candle, Blunt Tip
	8E12B11-E	3W	Candle, Blunt Tip
	8E29F10	6W	T10
	7E29A60	7W	A19
	7E29WFD0-E	7W	PAR20
	8E29A60	8W	A19
12E29A60	12W	A19	

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# Resources and Tools

- LED Product Selection Tool
- Lamp type/ Manufacturer / Control type Compatibility

## LED Product Selection Tool

Share   

While LEDs have shown great potential within the lighting industry, they – like all lights – benefit from the proper control. Use the dropdown choices to search for tested LED solutions that will ensure compatibility between controls and drivers with other LED products.

Fixture/Lamp Type	Manufacturer	Control Technology
<input type="text" value="Select All"/>	<input type="text" value="Cree"/>	<input type="text" value="Select All"/>

Lutron Control *	Input Voltage
<input type="text" value="Select All"/>	<input checked="" type="checkbox"/> 120 V
<input type="checkbox"/> Ariadni Dimmer	<input checked="" type="checkbox"/> 120/277 V
<input type="checkbox"/> C.L Dimmers	<input checked="" type="checkbox"/> 240 V CE
<input type="checkbox"/> Cree Dimmer	<input checked="" type="checkbox"/> Low Voltage (12-24 volt)

\* Hold Ctrl key for selecting multiple items

Show only Lutron drivers (removes any non-Lutron driver options)

[www.lutron.com/ledtool](http://www.lutron.com/ledtool)

# Resources and Tools

- LED Report Cards
  - Detailed compatibility report





**LUTRON®**  
Product Report Card

**Manufacturer:** [Cree](#)  
**Model Number Tested:** [CR6](#)  
**Other Model Numbers:** [CR6-GU24](#)

**Manufacturer's Description**  
 Type of device: [LED](#)  
 Operating voltage: [120 V](#)  
 Input Power: [11 W](#)  
 Input Current: [Not Specified](#)  
 Input Frequency: [60Hz](#)

Control Type: [Unspecified Phase Control](#)  
 Dimming Range: [100% - 5%](#)  
 Output Power: [Not Specified](#)  
 Lumen Output: [575 lm](#)

**Lutron Test Results**  
 Date Tested: [28-Jul-10](#)  
 Figure of Merit: [0.59](#)  
 Test Voltage: [120 V](#)  
 Test Notes: [None](#)

**Lutron Recommended Compatible Products**

Product	Model Number	Fixtures per Dimmer		Measured Dimming Range <sup>(1)</sup>		Perceived Low End <sup>(2)</sup>	Comments
		Minimum	Maximum	Low End	High End		
<b>Wallbox Dimmers</b>							
Diva C-L Skylark Lumea C-L Toggle/Ariadni C-L	DV_CL-153P CTCL-153P LGCL-153PH TGCL-153P / AYCL-153P	1	14	1%	99%	10%	Low end trim required
<b>Commercial Systems</b>							
Commercial Panel Module	HW/LP-RPM-4A-120	1	17	1%	99%	10%	Low end trim required
Grafik QS	Grafik Eye QS Main Unit	1	7	1%	99%	10%	16 fixtures maximum per unit
<b>Residential Systems</b>							
Commercial Panel Module	HW/LP-RPM-4A-120	1	17	1%	99%	10%	Low end trim required
Grafik QS	Grafik Eye QS Main Unit	1	7	1%	99%	10%	16 fixtures maximum per unit
RadioRA 2	RRD-10ND	1	5	1%	93%	10%	Low end trim required
RadioRA 2	RRD-6NA	1	6	1%	99%	10%	Low-end trim required Startup at low-end slightly unstable "Blip" turned off through APM
<b>Interfaces</b>							
	PHPM-WBX with DVF-103P	1	18	1%	98%	10%	Slight buzzing throughout range
	PHPM-PA with Grafik Eye QS	1	18	1%	99%	10%	Low end trim required

Notes: (1) Values are based on light output using the specified dimming control, and may not be an indication of the fixture's full rated capability





# COMMENTS AND QUESTIONS