

# EE Harmony: Control Freaks and Compatibility

**ENERGY STAR Products Partner Meeting**

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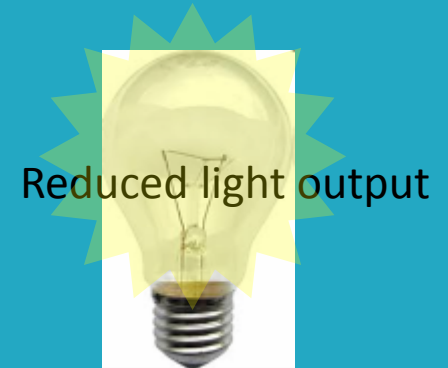
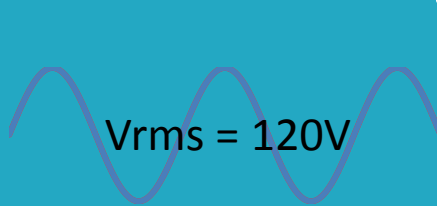
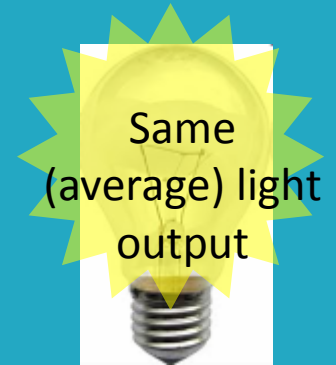
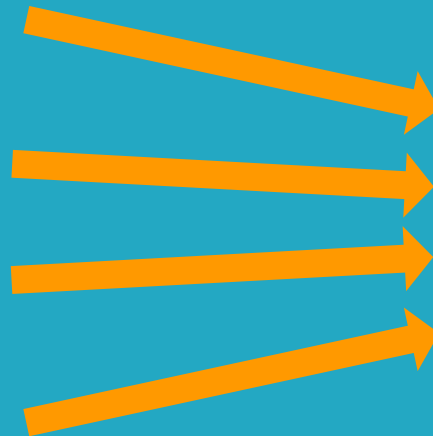
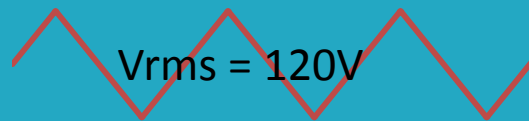
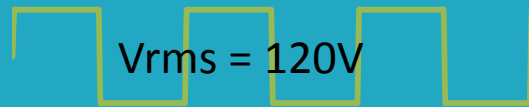
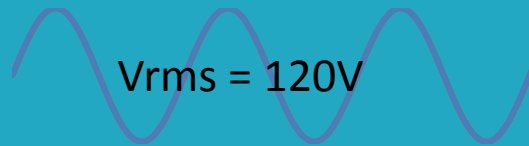
Environmental Protection Agency

## Introduction to LEDs and Dimming for residential applications

- Different types of LED systems
  - LED product with integral driver
  - Dedicated LED product with separate driver
- Dimming performance depends on the LED driver



# Phase-cut dimming was designed for incandescent sources



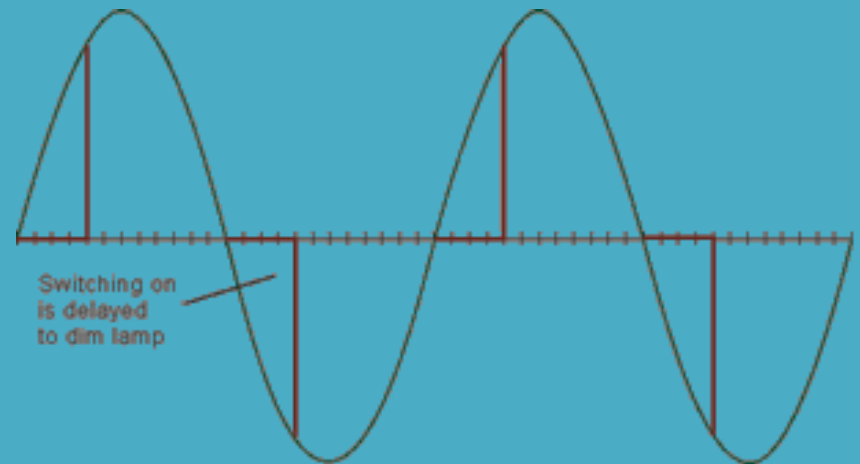
High performance  
Inexpensive  
 $V_{rms}$  adjuster

# Introduction to LEDs and Dimming

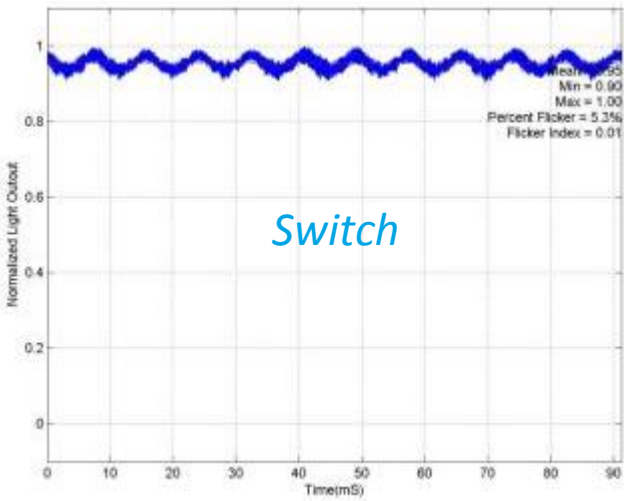
- Interaction of dimmer waveform and driver waveform to LED can do weird things...



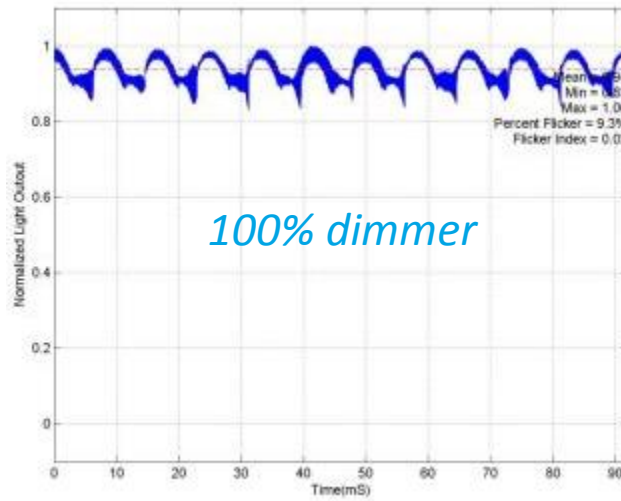
Phase-Cut Dimmer



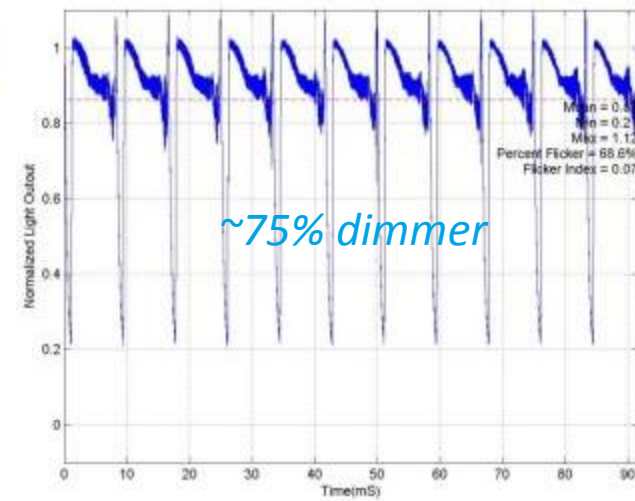
# LED lamp 1 + phase-cut dimmer B



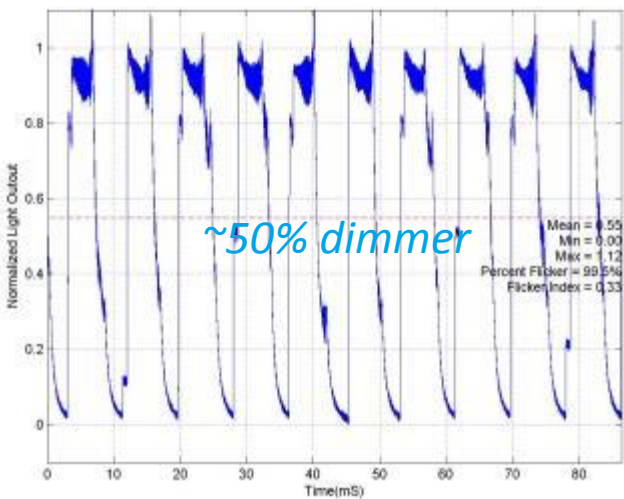
*Switch*



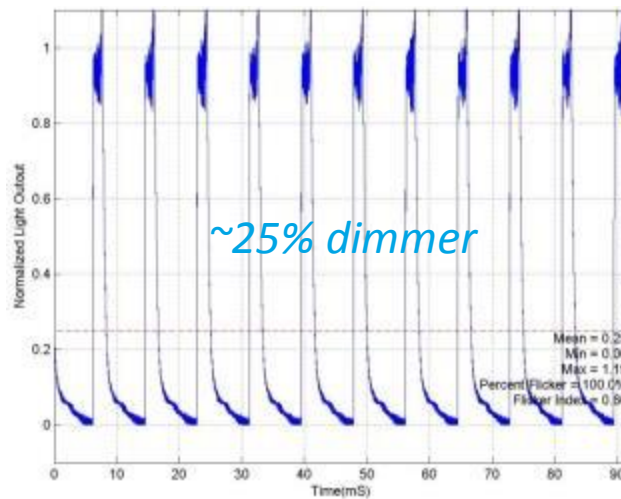
*100% dimmer*



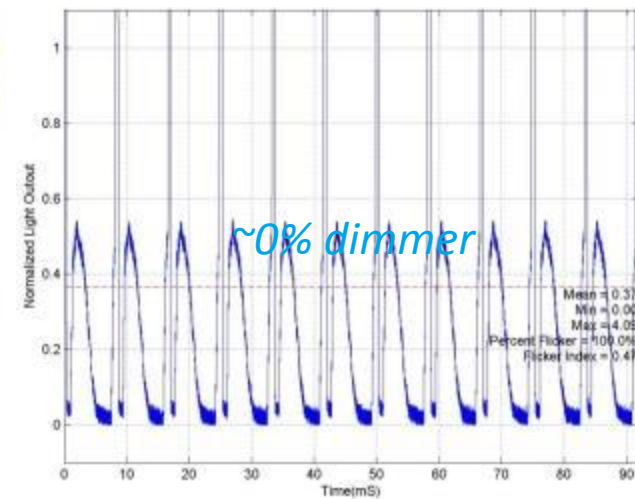
*~75% dimmer*



*~50% dimmer*



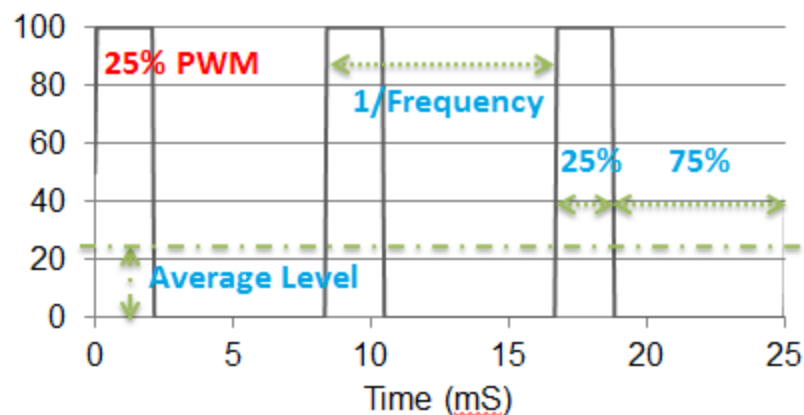
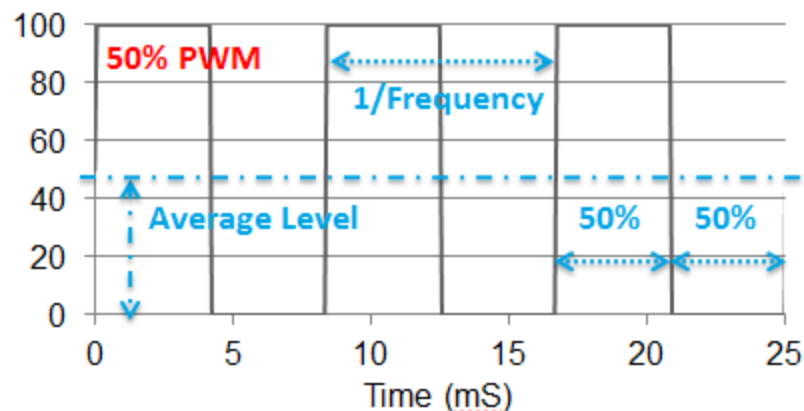
*~25% dimmer*



*~0% dimmer*

# EE Harmony: Control Freaks and Compatibility

- Phase-cut dimmers designed for LEDs are more sophisticated on the inside. They have better ways to work with current flowing in different directions, and low-end trim...
- Different techniques for effecting dimming in driver
  - PWM (pulse-width modulation)
  - CCR (constant current reduction)
  - Hybrid of the two



- No standard definition of “dimmable”
- There are different flavors of phase-cut dimmers. Of the installed dimmer base
  - About 98% are INC (standard incandescent)
  - 2% MLV & ELV (magnetic low-voltage, electronic low-voltage)
  - Well below 5% are LED-capable.

About half of dimmers available for sale today are LED capable, but that doesn't mean it will dim a specific LED lamp.)



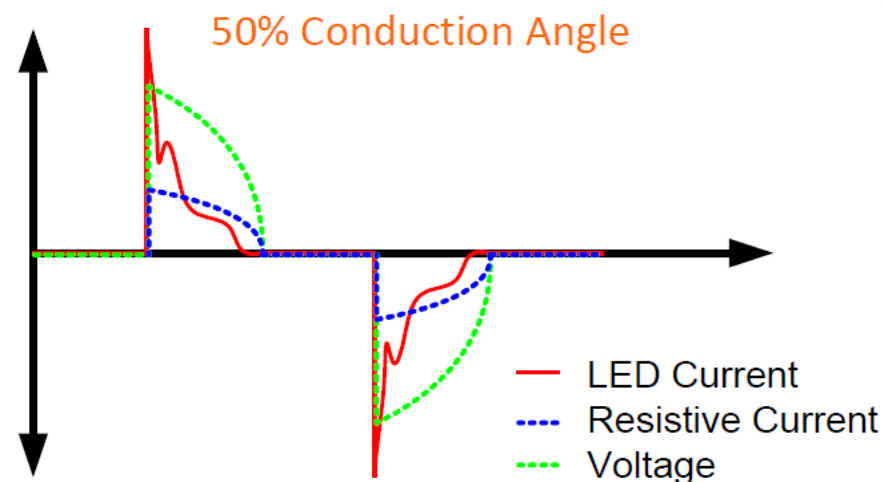
Problems that can occur with incompatible dimmer and driver

- Flicker
- Inconsistent dimming curve/drop-out/flash and other erratic behavior
- Audible noise



Other issues with LEDs and dimmer

- Insufficient load from low-wattage LEDs, especially when dimmed
- Higher effective load on dimmer due to LED's inrush current and repetitive peak currents (can result in tripped breakers)
- Repetitive peak currents from LED/driver system affects apparent load to the driver, so you may overload a 600W dimmer with a mere 150W LED load or less
- LEDs exhibit no luminous persistence, so flicker can be a problem
- Derating of dimmer load for LED



Other issues with LEDs and dimmer

- By putting LED lamp on an existing dimmer, the combination is technically not UL compliant.
  - Is that a safety concern?
  - (Probably not). This means that no one has tested that combination with authority. No problems are expected beyond a rare failed dimmer or lamp, or tripped breaker. No safety-related issue has been reported.

Should the message be: NEW bulb/NEW dimmer?

Checking for compatibility – what's a mother to do??

- The importance of mockups
- Can this be done in a lighting showroom or a retail store? If the dimming looks good in the showroom, give it a try at home. (Save the receipt. 😊)
- Dear homeowner: Find out what dimmer is installed in your house. (Pull off front plate, look for mfr name and dimmer number, and take that number to the lamp store. Choose bulb that is compatible with that dimmer, or buy a new dimmer.)
- Store staff needs to learn to use a dimming compatibility report.



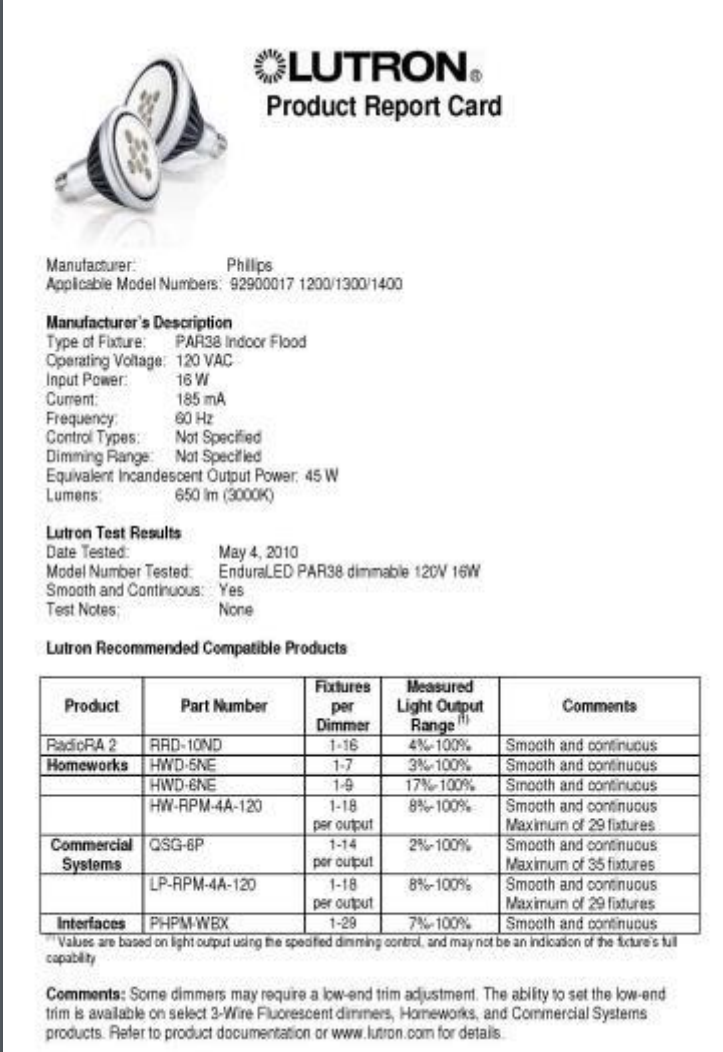
# EE Harmony: Control Freaks and Compatibility

Dimmer compatibility report based on testing by lamp/luminaire company AND/OR dimming company for SPECIFIC make/model of lamp and SPECIFIC make/model of dimmer.

*For a specific LED/driver product:*

- *Tells you which makes/models of dimmers work*
- *Min # of lamps or luminaires on dimming circuit*
- *Max # of lamps on dimming circuit*
- *What low end of dimmed output is (%)*
- *Whether flicker or other instability is noted*

Your best chance of compatibility is if both the lamp and dimmer mfr reports agree the combination works.



**LUTRON®**  
Product Report Card

Manufacturer: Philips  
Applicable Model Numbers: 92900017 1200/1300/1400

**Manufacturer's Description**  
Type of Fixture: PAR38 Indoor Flood  
Operating Voltage: 120 VAC  
Input Power: 16 W  
Current: 185 mA  
Frequency: 60 Hz  
Control Types: Not Specified  
Dimming Range: Not Specified  
Equivalent Incandescent Output Power: 45 W  
Lumens: 650 lm (3000K)

**Lutron Test Results**  
Date Tested: May 4, 2010  
Model Number Tested: EnduraLED PAR38 dimmable 120V 16W  
Smooth and Continuous: Yes  
Test Notes: None

**Lutron Recommended Compatible Products**

Product	Part Number	Fixtures per Dimmer	Measured Light Output Range <sup>(1)</sup>	Comments
RadioRA 2	RRD-10ND	1-16	4%-100%	Smooth and continuous
Homeworks	HWD-6NE	1-7	3%-100%	Smooth and continuous
	HWD-6NE	1-9	17%-100%	Smooth and continuous
Commercial Systems	HW-RPM-4A-120	1-18 per output	8%-100%	Smooth and continuous Maximum of 29 fixtures
	QSG-6P	1-14 per output	2%-100%	Smooth and continuous Maximum of 35 fixtures
Interfaces	LP-RPM-4A-120	1-18 per output	8%-100%	Smooth and continuous Maximum of 29 fixtures
	PHPM-WBX	1-29	7%-100%	Smooth and continuous

<sup>(1)</sup> Values are based on light output using the specified dimming control, and may not be an indication of the fixture's full capability.

**Comments:** Some dimmers may require a low-end trim adjustment. The ability to set the low-end trim is available on select 3-Wire Fluorescent dimmers, Homeworks, and Commercial Systems products. Refer to product documentation or [www.lutron.com](http://www.lutron.com) for details.

# What does “Compatible” mean?

- UL / CSA
  - Safety standard, no requirements for performance
  - A UL Listed load and a UL Listed control will be safe together
    - “Matched Pair”
  - Incandescent controls were never tested with LED loads
    - Who takes responsibility?



- Energy Star
  - Lamp works on SSL7A dimmer or
  - 5 dimmers from 2 manufacturers
  - 20% low end light level
  - No limits on flicker, pop-on, etc.
  - Taking the first step



# What does “Compatible” mean?

- Manufacturer “Compatibility” Listing

- Varies by manufacturer

- Performance Criteria

- Dimming range – 20%, 10%, 5%, 1%, less
- Lack of flicker
- Minimum load
- Acoustic noise
- “UL said it was ok”



- Does the manufacturer’s requirements meet and exceed your customer’s expectations?

# What is a Specifier to do?

What do you specify today for “Compatibility”?

1. Require system to be UL / CSA listed for safety
2. Require SSL-7A for electrical compatibility
3. Require Energy Star for efficiency and minimum performance levels.
4. Follow manufacturer’s compatibility list and require manufacturer to publish their “Compatibility Definition”
  - No Flicker, less than 20% low end, tested at full load, smooth dimming, etc.

# LED Report Cards

**LUTRON®**  
Product Report Card

Manufacturer: Cree  
Model Number Tested: CR6  
Other Model Numbers: CR6-QU24

**Manufacturer's Description**  
Type of device: LED  
Operating voltage: 120 V  
Input Power: 11W  
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**  
*Lutron products not in this list can be considered to be not compatible, based on our testing.*

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		
<i>Wallbox Dimmers</i>							
Diva C-L	DV_CL-153P	1	14	1%	99%	10%	Low end trim required
Skylark Contour C-L	CTCL-153P						
Lumea C-L	LGCL-153PH						
Toggle/Ariadni C-L	TGCL-153P / AYCL-153P						
<i>Commercial Systems</i>							
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
	4A-120						
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
<i>Interfaces</i>							
	PHPM-WBX with DVF-103P	1	18	1%	98%	10%	Slight buz zing 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  
(2) Perceived light level percentage is the square root of the measured light level percentage, per IESNA Lighting Handbook

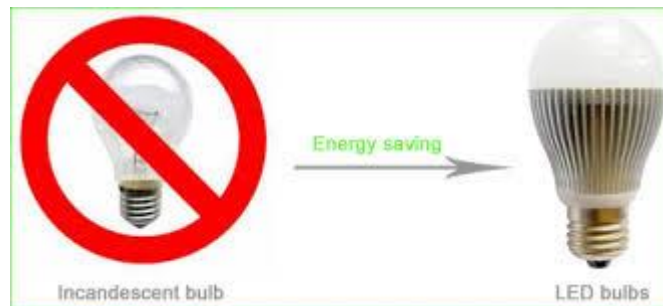


# What is a Consumer to do?

- Follow recommendations from a fixture and/or control manufacturer (Beware: they may be different!)
  - Do you trust them?
    - Are they familiar with the lighting industry?
    - Who will support you if things don't go as expected?
- Understand product dimming performance
  - “Dims from 100%-0%” (what's just before 0%?) – lamp packaging
  - “If it flickers, just move the slider a bit.” – manufacturer phone line
- Do mock-ups
  - Use real amounts of load in real applications
  - System “tuning” may be needed
    - Load type setting
    - Low end / high end trim adjustment

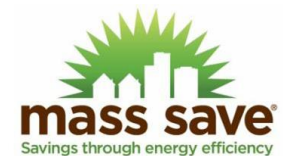
# What is a Consumer to do?

- Energy Star Consumer Guide to Dimming
  - Address Consumer's common concerns with LEDs
  - Answers frequently asked questions on controlling LEDs
  - Gives Consumers confidence that they are doing the right thing.
  - Reduces Fear, Uncertainty, and Doubt



# What is a Utility to do?

- Work with lamp and control manufacturers together
  - Both sides should have input for a good system performance
  - Offer a “Matched Pair” to your customers
- Push for improved dimming standards
  - Join the process
  - Pressure manufacturers to meet consumer requirements
  - Push for more stringent Energy Star performance requirements
- Several Utilities have successfully offered “Matched Pair” rebates



Northeast Utilities Companies

# What is a Retailer to do?

- Offer proven compatibility to your customers
- Allow customers to “try it” in store
- Work with lamp and control manufacturers together
  - Both sides should have input for a good system performance
  - Use trusted manufacturers that show a desire to take care of the customer
  - Market a “Matched Pair” to your customers



# What is a Retailer to do?

- Home Depot Display- Lutron Controls, Philips LEDs



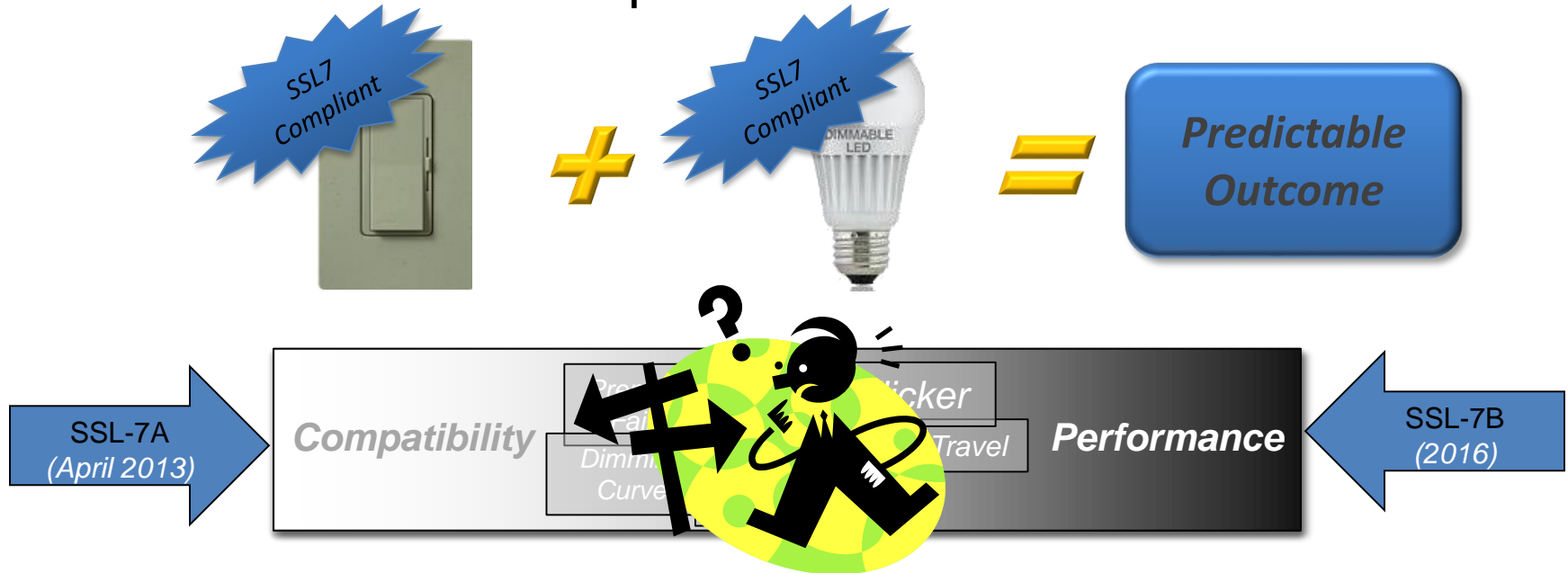
1. 3 Lutron dimmers controlling 3 LEDs
2. Dimmer messaging on the panels
3. Customer gets to see the performance before they buy

- How will we get “Compatibility” in the future?
  - NEMA SSL-7A
  - NEMA SSL-7B
  - IEC Joint Ad Hoc Group 17
  - NEMA Premium
  - Energy Star



# SSL-7A Overview

- SSL-7A was written by NEMA to standardize phase-control dimming of LED loads
- SSL-7A is a voluntary interface standard: it specifies the interaction between lamps and dimmers



- Being adopted by Title 24, Energy Star, and others
- 7A Already available in Lutron 250W C•L products!

# IEC JAHG 17 (Joint ad-hoc group)

- Coordination between IEC “dimmer” and “lamp” groups; primarily for European countries
- Compatibility AND performance
- Just beginning conversations
- Expected 2017



- NEMA Premium

- Proposed market logo for good performance
- Requires compliance to NEMA SSL-7A and 7B
- Expected late 2015



- Energy Star

- Has established a point we can build off of
  - Need to increase the requirements to ensure customer needs are met
- Need an easy way for customers to combine lamps and controls
  - Example: place an Energy Star logo on controls that work with Energy Star lamps

- In person meeting with NEMA
- Round Table Meeting Saint Paul, MN October 21 2012
  - Continue the conversation of dimmable lamp performance
  - Identify existing national, international, and industry efforts and research
- Need for national requirements for dimming
- Smaller group of stakeholders to discuss limited requirements and test method development



# ENERGY STAR Lamps V1.0 Final Dimming Requirements & Recommended Practices



## Recommended Practices

- Found in the document “[ENERGY STAR Lamps V1.0 Final Test Methods and Recommended Practices](#)”
- All dimming test methods are considered Recommended Practices
  - Testing is not required to occur at an accredited laboratory
  - Testing is reported to EPA via a Dimming Data Collection Sheet
  - Results are being gathered for further refinement and simplification of testing



# Final Requirements

## Testing Requires:

- 5 Dimmers from at least 2 manufacturers
  - Intent is a wide variety of types
  - Reduced from Draft 4 requirements based on stakeholder feedback
- Test 1 and 4 lamp configurations on a dimmer
  - Models challenge of differing behavior based on configuration



## Final Requirements

- Option for SSL7A as a path for compatibility...
  - ...when NEMA releases marketing guidelines for lamps and dimmers to help consumers match up compatible lamps and dimmers
- Non-phase cut devices have limited testing
  - Only tested on what they are compatible with
  - E.g. a lamp with integrated dimming knob



## Final Requirements

- 80% of the lamp/dimmer combinations must pass
  - EPA recognizes that some incompatibilities may still exist
- 3 measurement points
  - Without a dimmer
  - On a dimmer at maximum control position
  - On a dimmer at minimum claimed dimming level



## Final Requirements

- Maximum Light Output:
  - When on a dimmer, lamp must provide 80% of the lamp's light output when not on a dimmer
- Minimum Light Output:
  - Lamp must dim to 20% or lower of the maximum light output on the dimmer



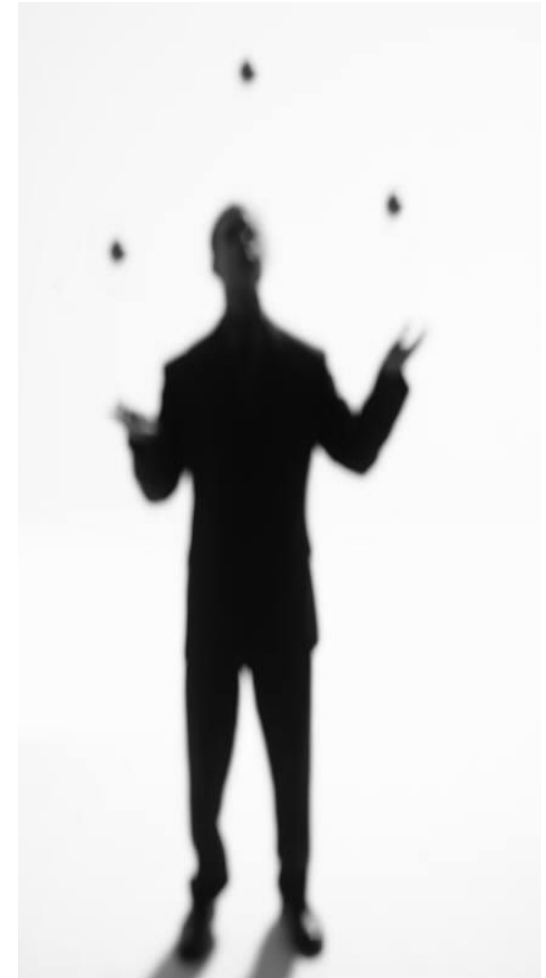


## Final Requirements

- Flicker:
  - Must be tested and the highest Flicker Index (FI) and Percent Flicker (PF)
- Audible Noise:
  - Lamp shall not emit noise above 24dBA at 1 meter or less
    - Reports highest measurement
  - Does not require an anechoic chamber

## Final Requirements

- Multiple tests can be performed concurrently
- One dimming report can represent ALL allowable variations
  - CCT, Beam Angle, Finish, etc. should have no material impact on dimming



## What is Next?

- Monitoring, spot checking and taking suggestions
- Improvements Needed to RPs
  - Refine and simplify testing
    - Noise in particular.
    - Feedback please!
- Data Evaluation
  - Analyze for performance trends
    - Intent is to **reduce testing** based on data and feedback



## Next Steps

- *Please provide suggestions!*
  - *Questions...*
  - *Comments...*
- Contact [lighting@energystar.gov](mailto:lighting@energystar.gov)
- Please fill out evaluation forms!

