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**Sent:** Friday, February 27, 2009 4:40 PM  
**To:** richard.karney@ee.doe.gov; SSL  
**Cc:** Briggs, Steven J (GE Indust, ConsInd); Dowling, Kevin; Russell Weightman; Chris Salvestrini; Amanda Beebe; Russ MacAdam; Pekka Hakkarainen; Scott Hanna  
**Subject:** ENERGY STAR For LED Replacement Lamps

Richard -

Lutron has specifically addressed the **dimming** section of the criteria, based on your January 16 request for comments. I have copied Steven Briggs @ GE and Kevin Dowling @ Philips/Color Kinetics as we have had separate conversations with them on this topic already.

First, we have attached an initial specification for the LED lamp to perform with forward or reverse phase control dimmers. This would be a baseline that would allow some of the existing installed dimmers to operate properly - but, keep in mind, the definition of properly would only apply to the lamps being relatively stable throughout the dimming range. It would not define the dimming range itself which is ultimately the most important specification nor the stability being smooth and continuous through the dimming range.

Accordingly, if the performance of the lamp is to mimic an incandescent lamp, the minimum low end should be at least 1% measured light output, providing a dimming range of 100% to 1% of full light output. We believe that this range should be complimented by a perceived light range as the human eye adapts to lower light levels, perceiving higher light levels than what a light meter measures. A specification to the consumer should then be:

Dimming range: 100% - 1% (measured), 100 - 10% (perceived).

This is why current 20% low end lamps are often unacceptable to the consumer because of their perceived level of 45%. The effect was first published for the incandescent lamp in the 1966 IES handbook and applies to all light sources.

Ultimately dimming to a "filament glow" level would be the best case scenario for LED lamps as that is what the public has come to expect with the incandescent lamp. You clearly stated this is why CFLs have not been considered acceptable to many users and why the LED replacement lamps need to have this capability - or something very close (i.e. 1%).

The term "dimmable" should NOT be considered an acceptable term on any consumer packaging as it is as clear as "provides light" for a light bulb. Energy Star would NOT allow such a vague statement for the amount of light provided by a light bulb - the same should hold true for dimming.

Ultimately, an LED compatible dimmer will be necessary to provide the optimum control of these lamps, keeping in mind that much of the attached specification could be used to ensure the highest performance.

I know that Lutron, GE, and Philips would all be interested in working together to establish this combination lamp/dimmer specification.

Eric

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## **Specifications for Dimmable LED Loads Requiring Reverse Phase Control**

Operating temperature	0 to 40 degree C
Operating frequency	60 Hz
Nominal input voltage	120 Vrms
Circuit type	Reverse Phase Control (Trailing Edge)
Dimmer High End – No change in light level over this range:	
Voltage	110 to 115 Vrms
Device Turn-off Angle	124.5° to 136.7°
Time from Zero Cross to Dimmer off	5.76 to 6.33 mSec
Dimmer Low End – No change in light level over this range:	
Voltage	10 to 30 Vrms
Device Turn-off Angle	18.5° to 39.4°
Time from Zero Cross to Dimmer off	0.85 to 1.82 mSec
Dimming Curve	To Be Specified
Recommended Minimum load	5 W
Minimum current (hold I)	Not Applicable (FET Based)
Pop-On	None
Safety Regulation	UL1472
Wiring	Neutral Wire Required
Dimmer Off-state Leakage	To Be Determined
Lamp Power Factor	> 0.95

## **Specifications for Dimmable LED Loads Requiring Forward Phase Control**

Operating temperature	0 to 40 degree C
Operating frequency	60 Hz
Nominal input voltage	120 Vrms
Circuit type	Forward Phase Control (Leading Edge)
Dimmer High End – No change in light level over this range:	
Voltage	110 to 115 Vrms
Firing angle	55.5° to 43.3°
Time from Zero Cross to Dimmer on	2.57 to 2.00 mSec
Dimmer Low End – No change in light level over this range:	
Voltage	10 to 30 Vrms
Firing angle	161.5° to 140.6°
Time from Zero Cross to Dimmer on	7.48 to 6.51 mSec
Dimming Curve	To Be Specified
Recommended Minimum load	5 W with Neutral wire Dimmer 30 W without Neutral wire Dimmer
Minimum current (hold I)	Not Applicable (FET Based)
Pop-On	None
Safety Regulation	UL1472
Dimmer Off-state Leakage	To Be Determined
Lamp Power Factor	> 0.95
Maximum One-time Inrush Current	< 10x steady state