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February 27, 2009

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Subject: Draft Criteria for ENERGY STAR Integral LED Lamps

I am writing in response to your letter of January 16, 2009 requesting input on key issues related to integral LED lamps. In particular, I am responding to your concerns about dimming.

I agree with you that CFL or LED lamps designed to replace incandescent lamps must be dimmable in order to meet the needs and expectations of consumers. I also agree with you that most dimmable CFLs and LED replacement lamps do not perform as well on phase control dimmers as the incandescent lamps they are intended to replace.

Both CFLs and LEDs are inherently dimmable, with LEDs having the edge on dimming range and color stability with dimming. However, both CFL and LED replacement lamps require the use of electronic drivers, known as ballasts when used for CFLs, and the TRIAC-based phase control dimmer, designed for use with incandescent lamps is basically incompatible with electronic drivers. This leads to the current situation where the dimming experience is a function of which brand and model of TRIAC dimmer is used with which brand and model lamp; and even then, dimming is never fully satisfactory.

TRIAC-based phase control dimmers create two other problems:

- The power factor at the input to a phase control dimmer will always decrease to values significantly less than 1.0 as the dimmer is used to decrease the output of the lamp.
- The National Electrical Code limits the use of phase control dimmers to permanently installed incandescent luminaires, unless they are listed for the control of other loads[1].

Power Factor

The low power factor created by phase control dimmers is of great concern to electric power utilities because the efficiency of power delivery decreases when the power factor is less than 1.0. Through my clients I have learned that some electric utilities have requested that special CFLs be designed to produce high power factor at the input side of phase control dimmers when those dimmers are being used to dim these CFLs. It is not possible to get high power factor at the input to the dimmer by changing the design of the CFL.

The power factor degradation takes place even when the load is an incandescent lamp, a load that has unity power factor itself at all light levels. The power factor degradation is caused by the fact that the input voltage to the dimmer is a sine wave, while the current passed by the dimmer is a chopped sine wave. Whenever the voltage and current do not have exactly the same shape waveform, the power factor will be less than unity. As the divergence between the shapes of the waveforms increases, the power factor decreases.

This power factor problem cannot be solved on the load side of the dimmer. That is, there is no modification of the ballast or driver that will produce high power factor at the input side of a phase control dimmer.

National Electrical Code

National Electrical Code (NEC) presents two problems. One problem is that dimmers cannot be used to control wall outlets. Many homes built during the past 50 years use wall switch controlled wall outlets, instead of permanently installed luminaires on the ceilings of rooms, as the primary light source for that room. It would be useful if consumers could use dimmers for wall outlets used for primary lighting. However, this is not possible with phase control dimmers, due to their incompatibility with other devices that may be plugged into those outlets, such as electronic equipment, or motorized equipment, such as vacuum cleaners.

The second problem raised by the National Electrical Code is that installation of LED-based luminaires on circuits controlled by a phase control dimmer appears to be in violation of Section 404.14(E) of the 2008 NEC, unless those dimmers are listed for use with LED-based luminaires. While I'm not an expert on the National Electrical Code, it seems to me that use of CFLs or LED-based lamps in incandescent luminaires controlled

[1] NFPA 70, National Electrical Code, 2008, Section 404.14(E)

by phase control dimmers would also be a violation of Section 404.14(E) of the 2008 NEC.

A Solution

One solution to both the power factor problem and the issues raised by National Electrical Code would be to replace phase control dimmers with simple power line communication devices which would send dimming signals to intelligent CFL and LED-based replacement lamps and luminaires connected down-stream of the dimming control.

This system has many advantages over the continued use of phase control dimmers:

- The power factor of the system could remain high, even while dimmed, as long as the ballast or driver was properly designed to have a high input power factor.
- The system would discourage "fall-back" to incandescent lamps, since they would not have the intelligence or the power control circuitry to respond to the power line carrier signals.
- The CFLs and LED-based replacement lamps and luminaires would achieve their full dimming potential.
- This system would not violate the National Electrical Code when used with permanently installed CFL or LED-based luminaires, or incandescent luminaires which have been retrofitted with CFLs or LED-based replacement lamps.
- The power line carrier dimming controls could be installed in circuits that control wall outlets, since normal electronic devices and motorized devices would just ignore the power line carrier signal.

I do not currently have a preferred power line carrier protocol, and, at least for now, leave that decision to people who are expert in that area.

The most significant problem to implementing power line carrier dimming is the huge installed base of phase control dimmers. The lighting industry must continue to provide the best products we can for use with these brute force dimmers. However, there will never be a fully acceptable dimming solution for CFL or LED-based lamps using phase control dimmers.

I believe our limited resources should be devoted to the development of a dimming system inherently designed for the next generation of lighting, rather than continue our efforts to try to fix the basic incompatibility between phase control dimmers and electronic ballasts and drivers.

Victor Roberts, President
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