Standards & Specifications Update: Dimming & Flicker

Lightfair
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• NEMA SSL-7A contains design criteria and compliance test and measurement procedures for LED light engines and forward phase-cut dimmers
  – Published 4/22/2013
• EPA ENERGYSTAR is working on dimming criteria for Lamps
  – Draft 4 Version 1.0, published 4/19/2013
• California Code of Regulations, Title 20, Public Utilities and Energy does not contain any dimming criteria
  – CEC-140-2012-002, published November 2012
• Voluntary California Quality Light-Emitting Diode (LED) Lamp Specification contains some dimming criteria
Flicker update

- IES Testing Procedures Committee Working Group S408-10 is poised to form a committee in May to work on a test method for optical waveforms
- EPA ENERGYSTAR is working on flicker criteria for Lamps
  - Draft 4 Version 1.0, published 4/19/2013
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  - CEC-140-2012-002, published November 2012
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  - CEC-400-2012-016-SF, published in December 2012
Inception of NEMA SSL-7

- Market demand by lamp and control manufacturers and sales channels
- Demand from industry forces
- Work by other standards bodies
- Frustrating user experiences
Inception of NEMA SSL-7

- Release of NEMA SSL-6 in 2010
  - Described installed base of phase-cut dimmers
  - Latent realization that variation in installed base was difficult to design for
- Formation of NEMA SSL-7 committee in late 2011
  - NEMA Lighting Section members
  - European manufacturers, IC manufactures (invited through Zhaga)
  - UL, DOE
- Adoption of a forward-looking strategy to bound the problem
  - Don’t address *existing* products
  - Do provide design criteria for *new* products
  - Do target global scope (100, 120, 230, 277V operation)
NEMA SSL-7 Goals

• An interface standard that addresses the interaction between dimmers and LED light engines

• Design criteria for both dimmers and LED light engines
• Test & measurement procedures for verifying that both dimmers and LED light engines meet the specified design criteria
• Acceptance wholly or in part by standards bodies (Zhaga, UL, IEC, etc.) and adoption agents (EPA ENERGYSTAR, California Energy Commission, etc.)
• The problem is very complicated! A decision was made to focus on a single type of phase control, and separate issues and technical challenges into two areas.

• NEMA SSL-7A will address Compatibility for forward phase-cut dimmers and LED light engines; a potential future extension or new document may address Performance

• Compatibility (or Interoperability)
  – Dimming behavior meets or exceeds specified functionality
  – Reliability of the dimmer and light source are not affected by combining them
Phase-cut dimming issues

Poor User Experiences

- Dimming range
- Dead travel
- Pop-on
- Drop-out
- Popcorn
- Ghosting
- Flashing/Strobing
- Induced Flicker
- Audible noise

- Dimming smoothness
- Dimming monotonicity
- Dimming up/down symmetry
- Dimmer loading
- Dimmer - LED light engine inoperability
- Premature failure of dimmer and/or LED light engine
Dimming range, dead travel, pop-on

Switched output

High End Level

Light output level

Pop-on light level

Low End Level

Dead travel at Low End Level

Off state

Pop-on setting

Dead travel at High End Level

Dimmer setting
dimmer conduction time, phase angle, mechanical position of knob or $V_{\text{AMD}}$

Dimming range

Source: Modified from NEMA SSL-6
Dimming smoothness, monotonicity, up/down symmetry

Source: Modified from NEMA SSL-6
Phase-cut dimming issues

Technical challenges

- LED load RMS current
- LED load inrush current
- LED load repetitive peak current
- Repetitive ring-up voltage
- Dimmer switching element current requirements
- Dimmer timing element series impedance requirements
- Dimmer on-state and/or off-state operating current requirements
What does NEMA SSL-7A achieve?

Poor User Experiences

✓ Dimming range
✓ Dead travel
✓ Pop-on
✓ Drop-out
■ Popcorn
✓ Ghosting
■ Flashing/Strobing
× Induced Flicker
× Audible noise

× Dimming smoothness
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✓ Dimmer loading
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What does NEMA SSL-7A achieve?

Technical Challenges

✓ LED load RMS current
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■ Dimmer switching element current requirements
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✓ Dimmer on-state and/or off-state operating current requirements
What comes next?

• Publication
• Commercial adoption
  – SSL-7A compliant products
  – Product labeling guidelines
  – End-user education
• Adoption by standards bodies
• Influence of specification agents
  – Zhaga
  – EPA ENERGYSTAR
  – California Energy Commission
Flicker issues

- 60W A19
- T12
- A19 CFL
- A-lamp/G-lamp
- R30/PAR30
- R38/PAR38
All traditional light sources flicker, but unprecedented flicker characteristics can be found in commercially available LED sources. Significant potential human health impacts, including various neurological problems (including epileptic seizure), headaches, fatigue, blurred vision, eyestrain, reduced visual task performance, stroboscopic and phantom array effects, and distraction. Not all flicker claims are equal — Metrics exist, but are not widely used, and do not account for frequency. No standard measurement procedure. Potential impacts of flicker have population and lighting application dependencies — requiring risk analysis.
Closing comments

• NEMA SSL-7A
  – Poised to significantly improve user experiences, but only for combinations of compliant LED light engines and forward phase-cut dimmers
  – Manufacture adoption should be high, and compliant products available soon. Achievement of goals, impact of limitations, required refinements to achieve robustness TBD

• EPA ENERGYSTAR
  – Not currently considering requiring SSL-7A compliance
  – Flicker requirements could significantly improve commercial lamp evaluation for flicker, but (currently) only apply to dimmable lamps

• California Energy Commission
  – Title 20 likely to have flicker requirements in the future

• CIE TC 1-83 may begin working on Visual Aspects of Time-Modulated Lighting Systems
DOE SSL Program efforts

• Dimming evaluation of SSL-7A compliant LED light engines and dimming controls
  – Focused on verifying compatibility/interoperability goals
  – TBD, depending on when compliant products become available

• Flicker fact sheet
  – Published March 2013

• Recommendations for Flicker Criteria
  – Multiple options, presented in context of existing research and commercial product performance
  – Focused on capabilities, limitations, and trade-offs
  – Coming soon
Flicker criteria proposal(s)

Potential criteria presented and discussed at CIE Centenary Conference, Paris, April 2013

- Moderate to bad
- Low to moderate
- Acceptable
- Criteria
- Imperceptible

Flicker index vs. Periodic Frequency graph:

- Not Allowed
- Allowed

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