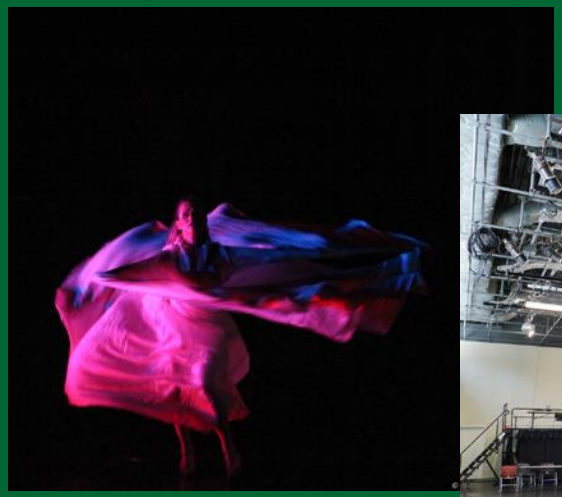
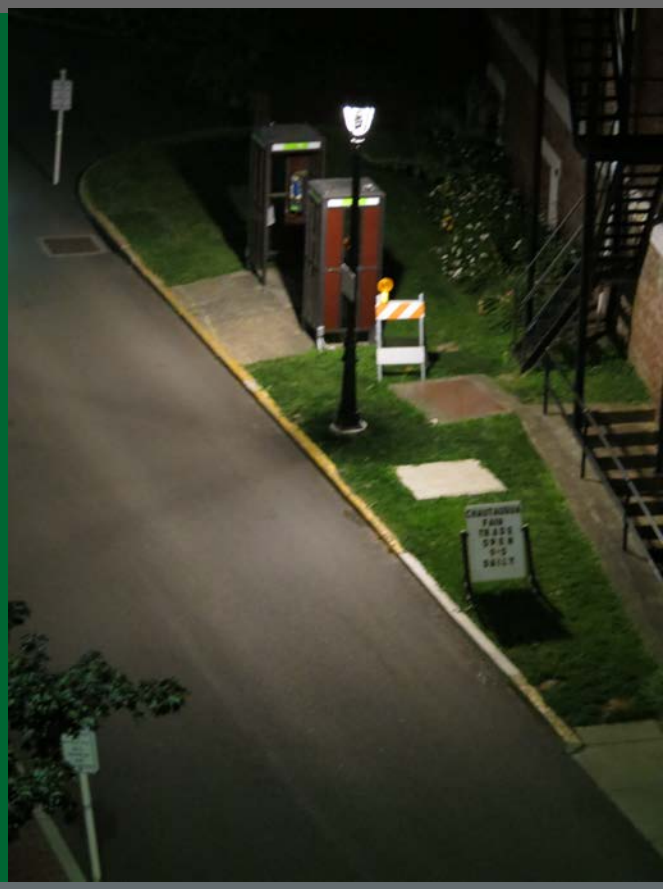
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Specifying LED in a World of Continuous Change





DOE SSL Market Development Workshop

November 12, 2014

Naomi Miller, Pacific NW National Laboratory

Scott Hershman, LF Illumination

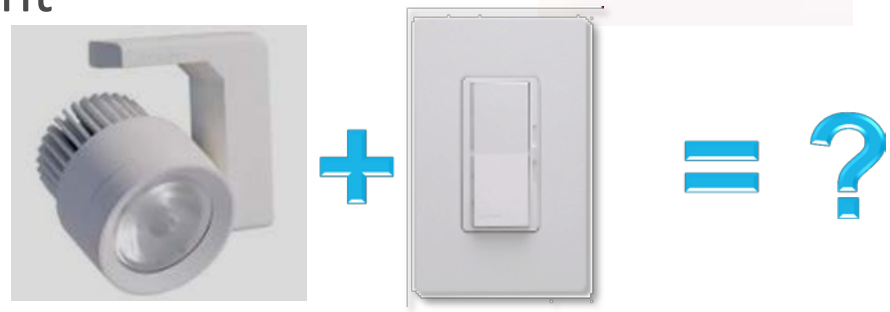
Jim Yorgey, Lutron Electronics

Brienne Willcock, Illuminart

Specifying LED in a World of Continuous Change

LEDs, Drivers, and Controls evolving at a terrifying pace

- LED Product life may be 9 months to 2 years
- New generation chips (likely better performing) may have different electrical needs
- Drivers need to change to suit new chip
- New drivers may have different controls compatibilities and incompatibilities



Specifying LED in a World of Continuous Change

An example: **The Burden Museum, a GATEWAY demonstration**:

- Small project, delayed by 14 months

At bid time:

- Specified LED PAR38 lamps had been discontinued or experiencing reliability issues
- Original PAR38 track head discontinued, necessitating switch to dedicated LED track heads
- LED strip lights no longer available in needed output level. Designer changed to different brand, with different transformer/driver
- Most dimming circuits had to be reevaluated for compatibility and load. Many needed interface module to accommodate higher effective dimmer loading. Some changed from INC to ELV, some ELV to INC.
- Additional design effort, coordination, and cost impact

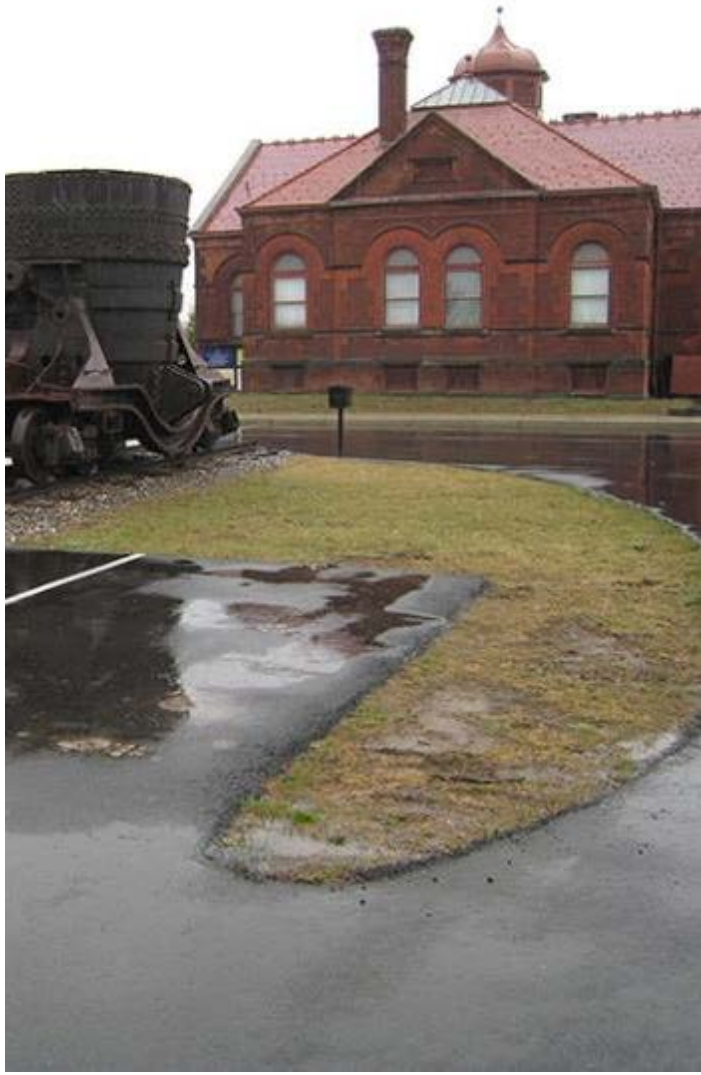


Photo courtesy The Burden Museum

Specifying LED in a World of Continuous Change

Panel members to address this issue from three perspectives:

- Luminaire Manufacturer: Scott Hershman, LF Illumination
- Controls manufacturer: Jim Yorgey, Lutron Electronics
- Lighting Designer: Brienne Willcock, Illuminart

Photo courtesy USA Illumination

The Manufacturer's Perspective

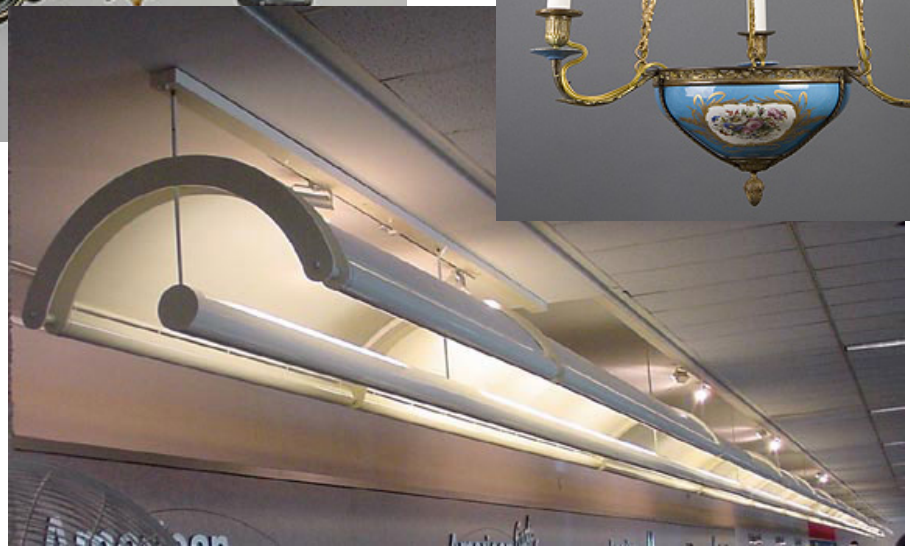
Scott J. Hershman MIES, LC

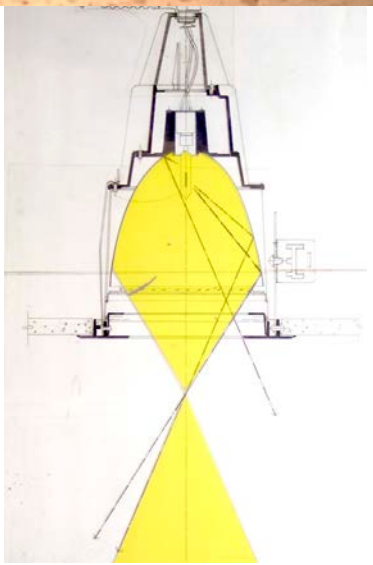
Executive Vice President of Design and Product Development

LF Illumination

Specifying LED in a World of Continuous Change

Every new light source changes luminaire design.





Specifying LED in a World of Continuous Change

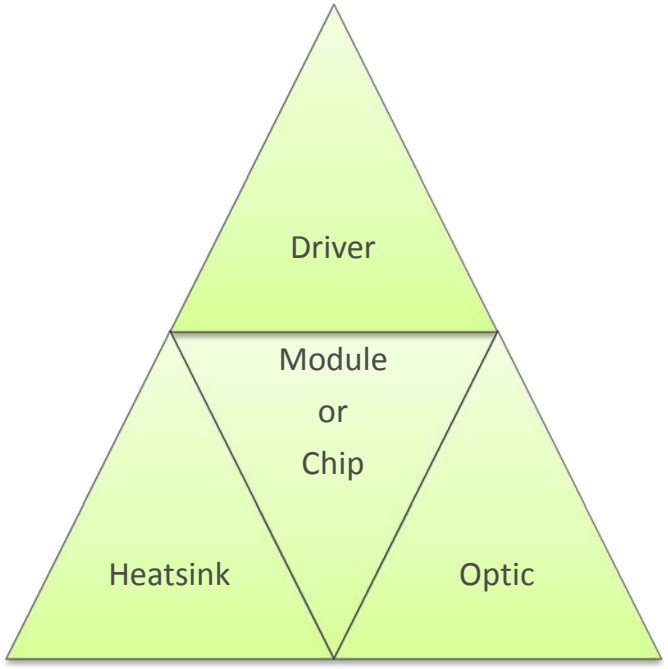
The limited lifespan of conventional sources required them to be a replaceable component.

Luminaires were designed for a source or “lamp” which was standardized and self contained. The source was interchangeable and supplied separately from the luminaire.

Specifying LED in a World of Continuous Change

LED Sources are intrinsically different from all previous light sources.

Earlier sources simply needed a power source to operate. The LED is one part of a complex system that requires additional components to operate.



Specifying LED in a World of Continuous Change

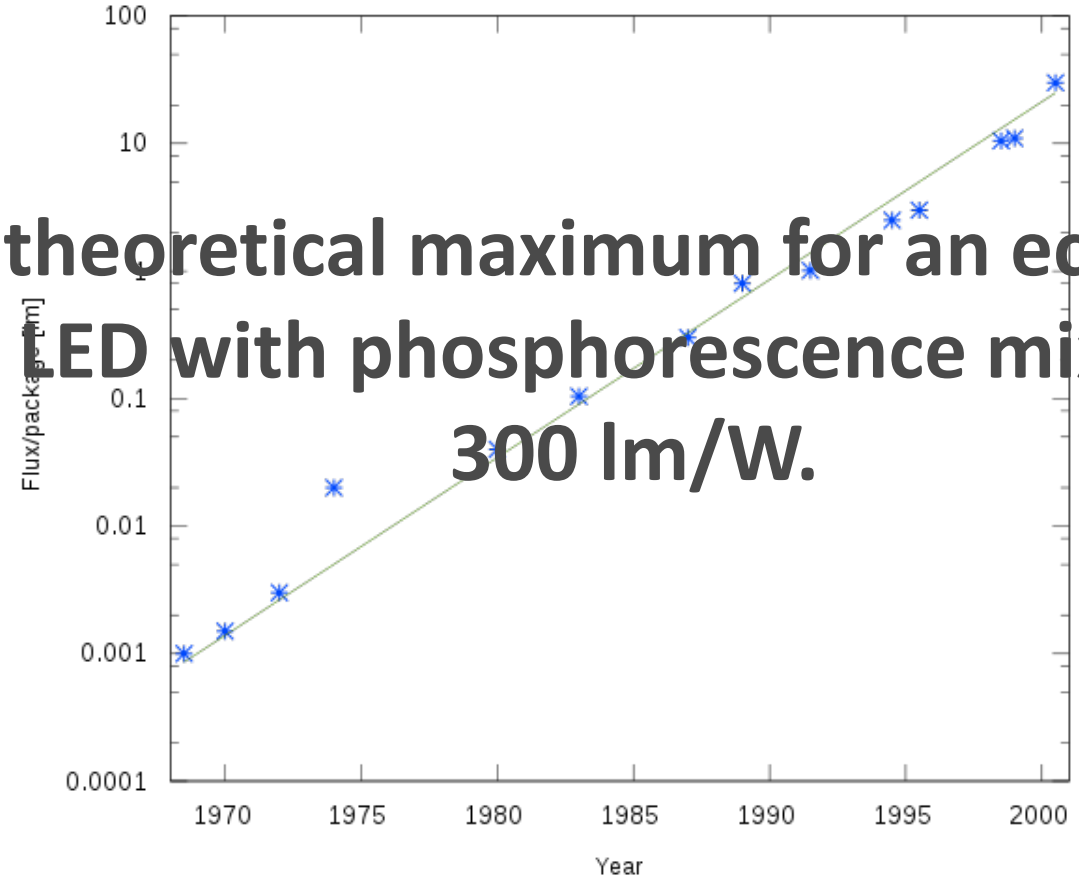
The coordination required to produce an LED light fixture has forced the luminaire manufacturer to assume the role of the source provider.

In most cases the luminaire manufacturer must rely on third party vendors to supply the solid state components of the system.

Specifying LED in a World of Continuous Change

Haitz's Law

Every decade, the cost per lumen falls by a factor of 10, and the amount of light generated per LED package increases by a factor of 20, for a given wavelength (color) of light.



The theoretical maximum for an economical white LED with phosphorescence mixing is 260-300 lm/W.

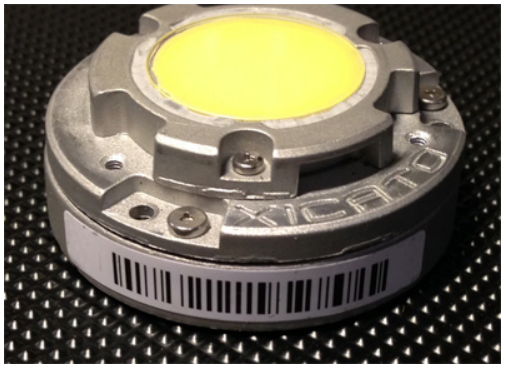
Specifying LED in a World of Continuous Change

What can the manufacturer do *now* to address future proofing?

- Make components replaceable
- Make parts traceable
- Ensure an upgrade path

Specifying LED in a World of Continuous Change

- Identify the manufacturer
- Bar or QC codes
- Quick disconnects for drivers and LED's
- Modular design of key components



Specifying LED in a World of Continuous Change

Standards and Regulations

Specifications

Specifying LED in a World of Continuous Change

Regulations

Government enforced rules generally pertaining to energy usage, safety and consumer protection.

- UL8750
- State and Local Energy Codes

Specifying LED in a World of Continuous Change

Standards

Conventions which are voluntary undertaken by an industry.

Widely Adopted

- IES/ANSI RP1610 – Defined terms
- LM-80 – LED package measurement procedure
- TM-21 – Method for calculating lifetime based on LM-80 testing
- LM-79 – Luminaire test procedure
- ANSI C78.377 – Color characteristics

Selectively adopted

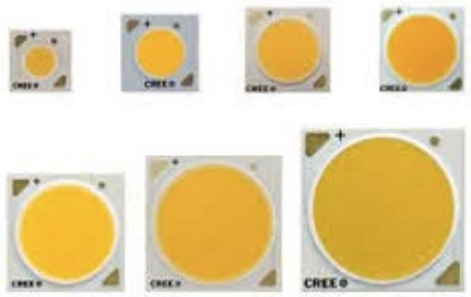
- Zhaga – Primarily deals with physical characteristics
- Alternate color system metrics

Specifying LED in a World of Continuous Change

To date standards and regulations have done little to influence interoperability of components.

Standards are needed for:

- Electrical operating characteristics of LED's - voltage bins
- Thermal characteristics and thermal transfer
- Electrical connections – socketed solutions
- Light Emitting Surface sizes
- Dimming interfaces for drivers



Specifying LED in a World of Continuous Change

- Minimum luminaire performance.
- Make the constants clear. (Lumens vs. Candela vs. Wattage)
- Warranty
- Consider the entire lighting system
- Don’t neglect installation

Specifying LED in a World of Continuous Change

Even with all this there are still many parts of the lighting system which the fixture manufacturer has no control over:

Incoming Power

Dimming

Environment conditions

Installation

Specifying LED in a World of Continuous Change

The Control Manufacturer's Perspective

Jim Yorgey PE, LC

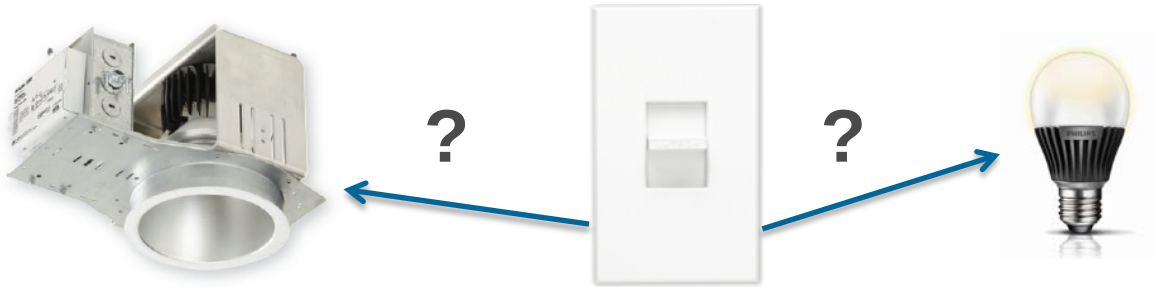
Technical Applications Manager

Lutron Electronics

Specifying LED in a World of Continuous Change

Overcoming LED Control Challenges

- Performance challenges inherent to controlling LEDs
- LED module and Driver technology
- Functional differences between control types
- Standards progress
- Specifying successful projects
  - Knowing the benefits and limitations of controlling LEDs.



Steps to Successful Specs

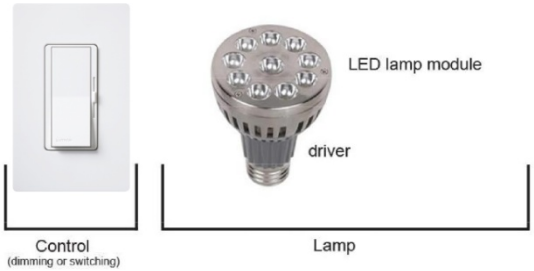
Match performance with expectations :

1. What type of LED product am I using:
   LED Bulb or complete fixture with driver/ light module?
2. What is the dimming range of the LED bulb or fixture?
3. What is the dimming performance of the product?
4. What is the minimum and maximum number of LED bulbs or fixtures that can be connected to the control?
5. What type of control does the LED product operate on?

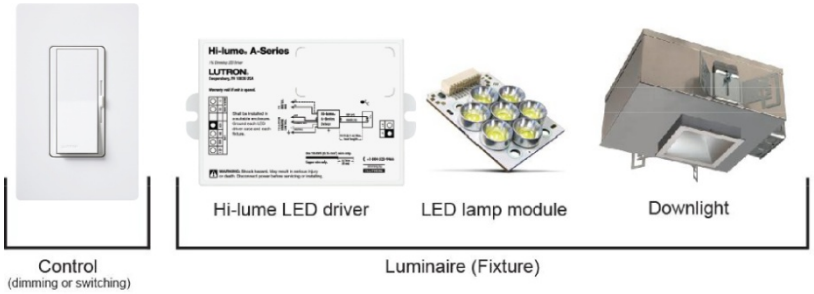
21

General types of dimmable LED products

- LED Bulbs
- Designed to replace standard incandescent or screw-in CFL bulbs
  - Edison base sockets
  - Integral drivers which determine dimming performance



- LED Fixtures
  - Multiple types
    - Cove lights, down lights, 2x2, etc.
  - Usually have a separate driver from light engine
  - Typically fixtures have multiple driver options to support different control technologies



22

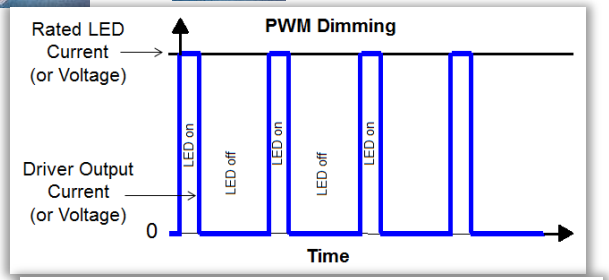
Driver Types and Technology

- Constant current vs. Constant Voltage
  - Constant Current – Typically for downlights – Predetermined LED module with known characteristics
  - Constant Voltage – Typically for linear lighting – Coves, undercabinet

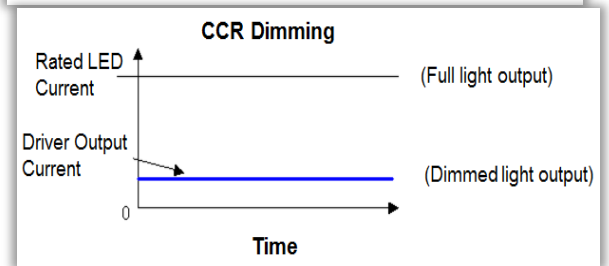
Constant Current Output

- PWM vs. Constant Current Reduction(CCR)
  - PWM - Most common – both Constant Current and Constant Voltage drivers
  - CCR- Eliminates flicker /video interference issues – Only Constant Current drivers

Constant Voltage Output



- Remote power supply(PS) vs. Integral power supply(PS)
  - Remote PS – high wattage power - multiple small dimming drivers
  - Integral PS – limited wattage – size of enclosure limitation
- Enclosure size and shape
  - Linear stick – linear fixtures
  - Rectangular pack – downlights



Specifying Dimming Range

- Dimming range varies greatly
  - Some LEDs dim only to 50%, others to 1%
- Select a dimming range suitable for the application
  - 20% dimming: suitable for a lobby, atrium, office, etc.
  - 1% dimming: necessary for a restaurant, media room

Lobby or Atrium:

A 20% light level is acceptable for this application

Residences and Restaurants:

A 1% light level is necessary for these applications

24

LED Dimming Performance Issues

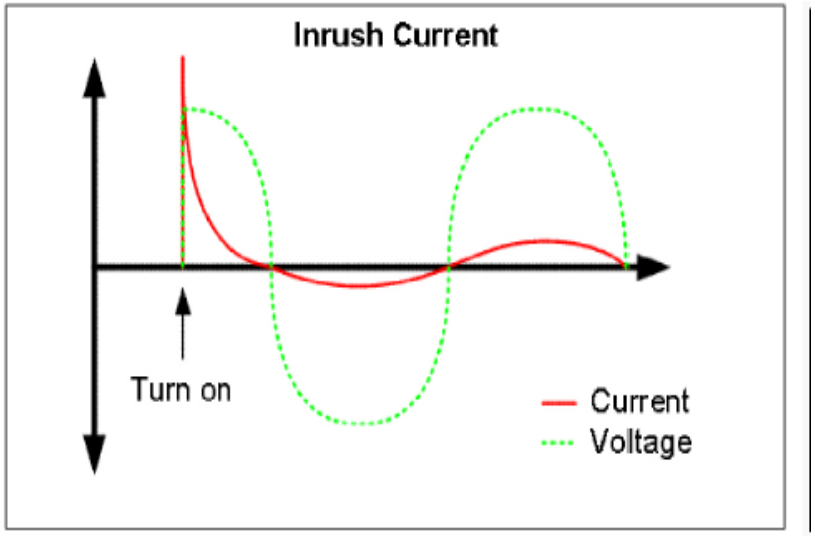
- LED aesthetic issues:

  - Flicker
    - The unexpected modulation of light level that is visible to the human eye (not always visually seen!)
  - Pop-on
    - The level the light is at when it is turned off is the level it should return to when it is turned back on
  - Drop-out
    - The light should only turn off when the dimmer is turned off.
    - The light SHOULD turn off with the dimmer off
  - Dead-travel
    - Adjusting the control without a corresponding change in light level
  - Audible Noise
    - From control *or* lamp
  - Popcorn
    - Multiple lamps on the same control turn on at different times

25

LED Driver Characteristics

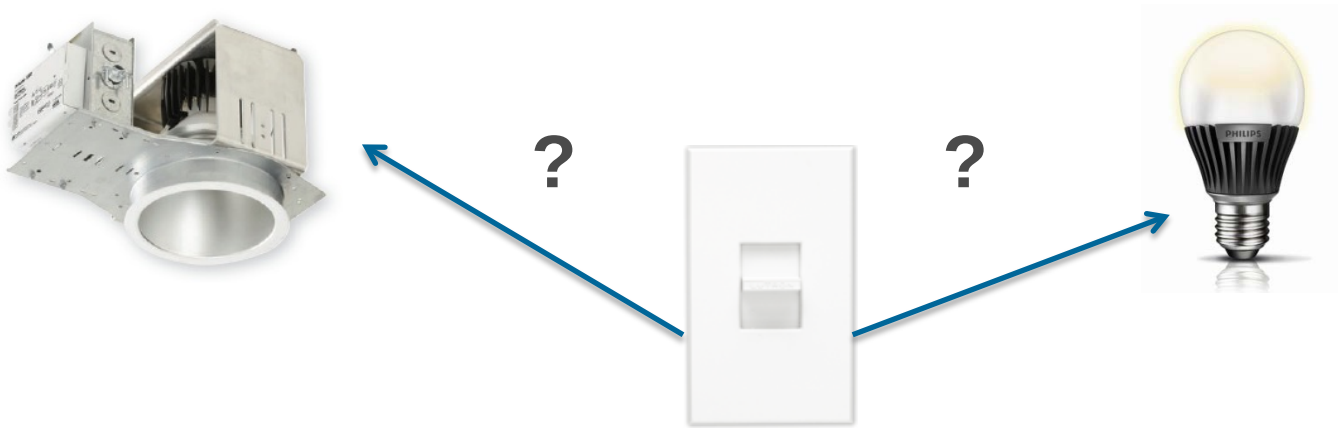
- Start-up inrush
- Drivers have an initial inrush current
  - Primarily affects the switching component or relay
  - Driver specs need to list inrush
  - Dimmer/ Control spec needs to list inrush capacity
  - Standard to use: NEMA 410



26

Controls for LED Lighting

- Control type refers to the method used to accomplish dimming
- Control signal protocol and the wiring type between the controller and fixture / lamp define the type
  - LED bulbs generally use line voltage methods
  - LED fixtures use one or more of any of the methods
  - To be compatible - the LED product and control MUST use the same control type



27

Control Types for LED Lighting

- Line Voltage - 2 wire (dimmed hot + neutral)
  - Forward Phase (leading edge) – Incandescent/ MLV
  - Reverse Phase (trailing edge) - ELV
- Line Voltage - 3 wire (switched hot + dimmed hot+neutral)
  - Legacy fluorescent dimmer
- Low voltage Analog
  - 0-10V
  - PWM
- Low voltage Digital
  - DALI
  - DMX 512
- Proprietary

28

Wireless Controls

- LED bulbs with WIFI or other Embedded RF protocols
- Controls and mobile devices talk directly to bulbs
- Mobile devices geo-sync with lighting controls
- Multiple technologies
  - No clear dominant
  - No lighting control standards

Control Standards

- **SSL-7A**
  - Compatibility of phase cut dimmers and LED bulbs
- **IEC 60929**
  - Defines 0-10V (Sink) analog protocol
  - Defines PWM analog protocol
- **ESTA E1.3**
  - Defines 0-10V (source) protocol
  - Legacy theatrical standard
- **IEC63386**
  - Defines DALI (Digital Addressable Lighting interface) protocol
- **USITT Standard DMX-512-A**
  - Defines digital protocol common to theatrical controls

Improving Driver and Control Standards

- **Manufacturers need to utilize current standards**
- **Standards bodies NEMA, IEC, IES**
  - Develop performance and compatibility based standards
  - Do this quickly
  - How can the effort be funded
- **Industry must create a third party testing process**
  - Qualifies Performance
  - Certifies conformance

Ensuring compatibility today and in the future

- **LED module providers**
  - Need standard ranges of electrical characteristics
- **Driver manufacturers**
  - Need to follow existing standards
  - Create field tunable drivers that can change over time
  - Provide complete specs
- **Control Manufacturers**
  - Develop plug-and-play interchangeable modules
  - Follow one standard for line voltage control
  - Need one standard for low voltage control
- **Designers**
  - Need to do due diligence to ensure projects work
- **Contractors /Installers**
  - Provide coordination among design team, manufacturers and building owners

The Lighting Designer's Perspective

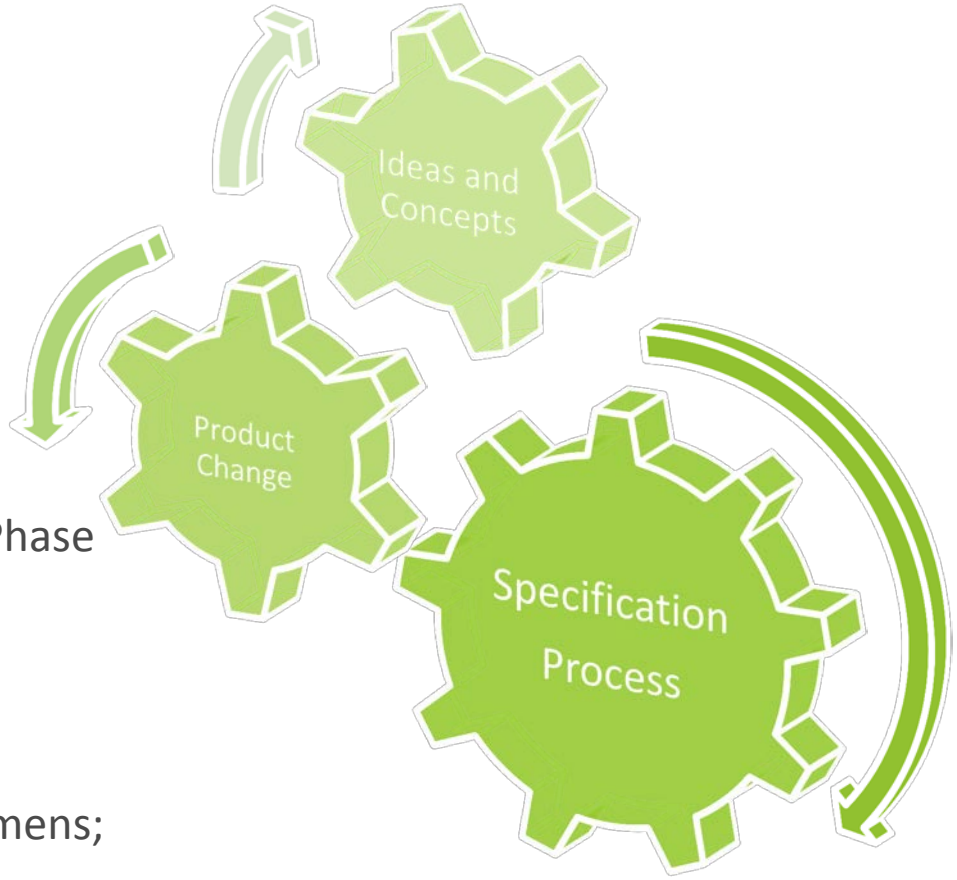
Brienne Willcock, Hon. AIA
IES Detroit President
Illuminart

Specifying LED in a World of Continuous Change

- Product Changes – The timing
- Performance Specifications – The ins and outs
- Testing Data and Marketing
- Education
- Sustainability

Specifying LED in a World of Continuous Change

- Impact of significant product changes
  - Initial idea generation
  - Obtaining a sample
  - Mockup
  - SD Phase > CD Phase
  - Bid Documents “alternates” reviewed
    - Catalog numbers have changed
    - Lumen packages not available
  - Compatibility
    - Control System – Driver/Dimming
    - ROI – based on wattage from SD Phase
  - Lead times increased



(p.s. no, sometimes I don’t want more lumens;
no, I may not be able to sign an NDA;
and no, I don’t have fee to reevaluate every product)

Specifying LED in a World of Continuous Change

Performance Specifications (with named products)

- No true equals
- Writing out the “fly by nights” in a qualitative *and* quantitative way
- Not enough standards to lean on
  - ANSI, NEMA, IES, DLC, EnergyStar, etc.
- Fixture design differences
- Component replacement verification with each manufacturer

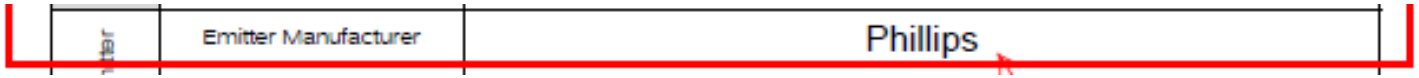
Specifying LED in a World of Continuous Change

Performance Specifications (without named products)

- Allow for flexibility in timing – product changes
- More time in bid documents to review alternates
  - "Alternate" ≠ "VE option"
- Key criteria may also be out of date
- Control system compatibility verified later in design process
- Component replacement as general criteria – may write-out economically viable product

Specifying LED in a World of Continuous Change

- Actual product example – Data Inconsistencies
  - Four different emitter manufacturers (web not shown);
    - Conflict of brochure, web, requested form, cut sheet
    - Conflict in LM79, LM80, TM21
    - Rate of change effects everyone



Specifying LED in a World of Continuous Change

- Testing Standards (LM79, LM80, TM21, LM84, LM82, TM26, LM85, TM28…) are not specification standards. They are testing prescriptive methods for tests and extrapolations; they are not a "quality product" metric
- TM28 Introduction: "The intent is to help product manufacturers and users, standard developing bodes, and other organizations to *avoid any unnecessary burdens related to excessive product testing*"

Specifying LED in a World of Continuous Change

Education

- Sales teams becoming more informed:
  - testing data – what's available, what's useful
  - dimming
  - marketing transparency
  - flicker
- Educating installers about the components they're handling
- Specifications written without buzz words
  - No, the product isn't LM79 and LM80 'compliant'. Stop.
- Lighting designers and specifiers - help drive standards development

Specifying LED in a World of Continuous Change

Lastly, about sustainability:

- Is this pace of change sustainable?
- Beyond energy savings
- Liability
- Recyclable components / replaceable parts
- Long term financial implications of disposing of fixtures and starting over
- Reputations are sustainable, too

Specifying LED in a World of Continuous Change

No one wants to stifle innovation and improvement…. BUT

What would help us get through this awkward time?

- Component standards?
- Dimming standards?
- True interchangeability of components?
- Communication among chip, driver, controls?
- Adaptable or tunable drivers?
- Massive performance specifications?
- Change to design and construction process and fee structure?
- Adding controls integrator to construction process?
- Education for design/construction team and clients?

Photo courtesy Finelite Lighting

Specifying LED in a World of Continuous Change

Discussion time!

- Questions?
- Comments?
- Grousing?
- Great ideas?

Specifying LED in a World of Continuous Change

Thank you!

- Scott Hershman, LF Illumination, scott.hershman@lfillumination.com
- Jim Yorgey, Lutron, jyorgey@lutron.com
- Brienne Willcock, Illuminart, bwillcock@illuminart.net
- Naomi Miller, Pacific NW National Laboratory, naomi.miller@PNNL.gov

KenRicePhoto.com