

Designers Light Forum

Everything You Ever Wanted to Know
About Dimming LEDs

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.



Learning Objectives

At the end of the this course, participants will be able to:

1. Learn the common terms and metrics associated with dimming LEDs
2. Identify the different analog and digital methods of dimming
3. Understand the key considerations when specifying a fixture
4. Understand the important trade-offs to consider when choosing the control for a job

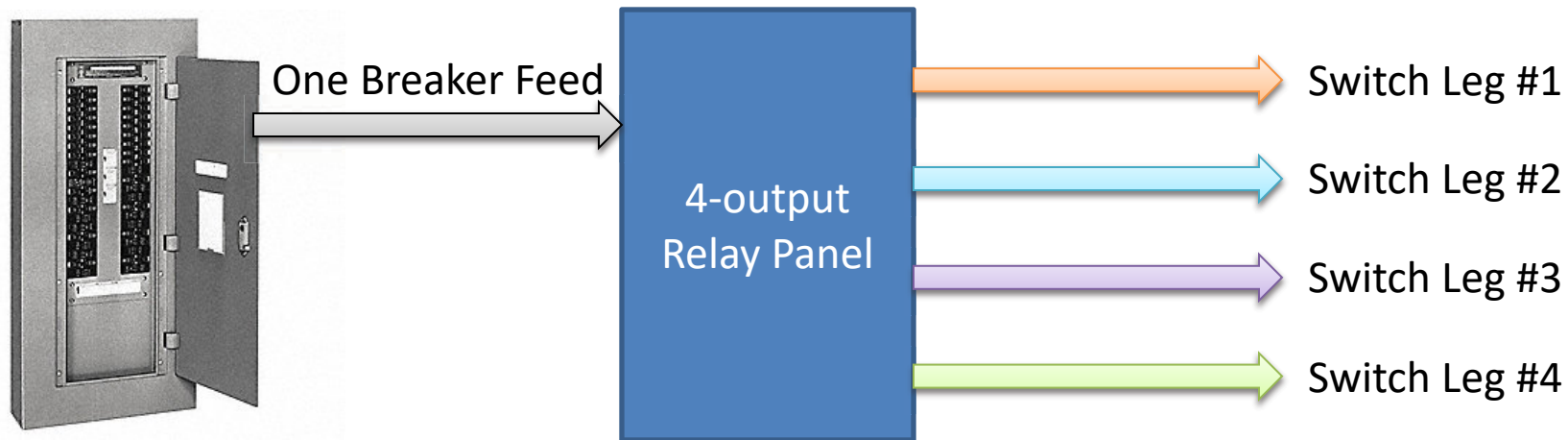
Agenda

- Define Common Terms
- Analog Control Types
- Digital Control Types
- Common Problems and Misaligned Expectations

- *....Ok, so what do I do now?*

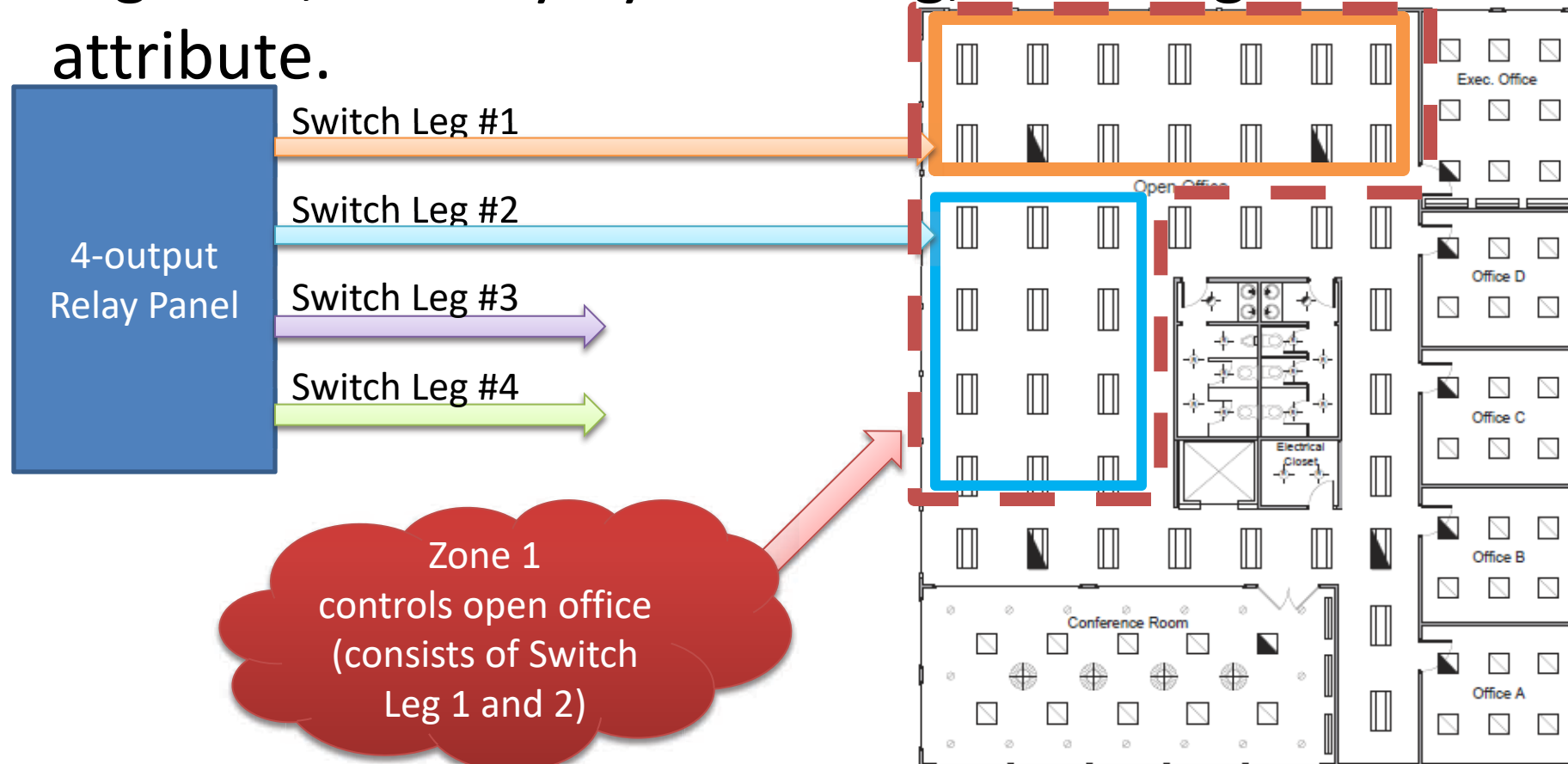
Common Terms

- **Switch Leg:** The smallest number of fixtures that can be controlled (without rewiring)



Common Terms

- **Zone (or Group):** One or more switch legs that are controlled together, be they by switching, dimming or other controlled attribute.



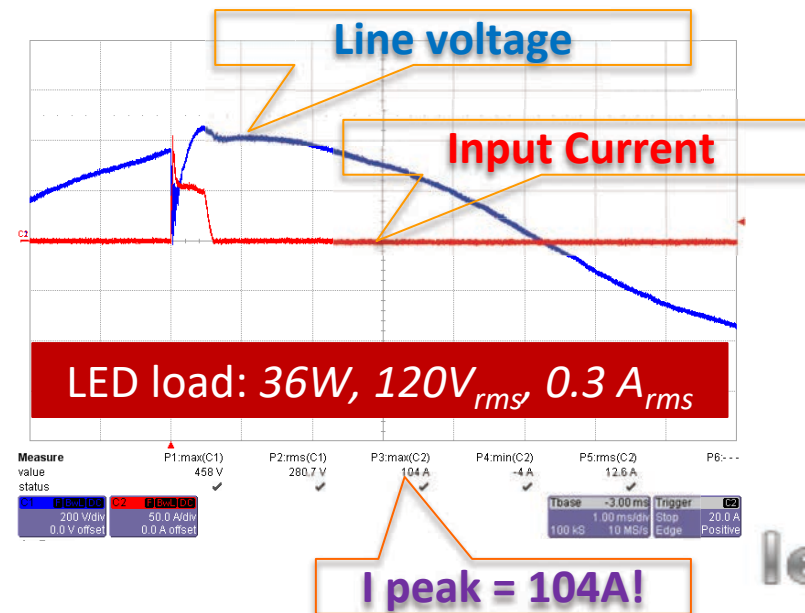
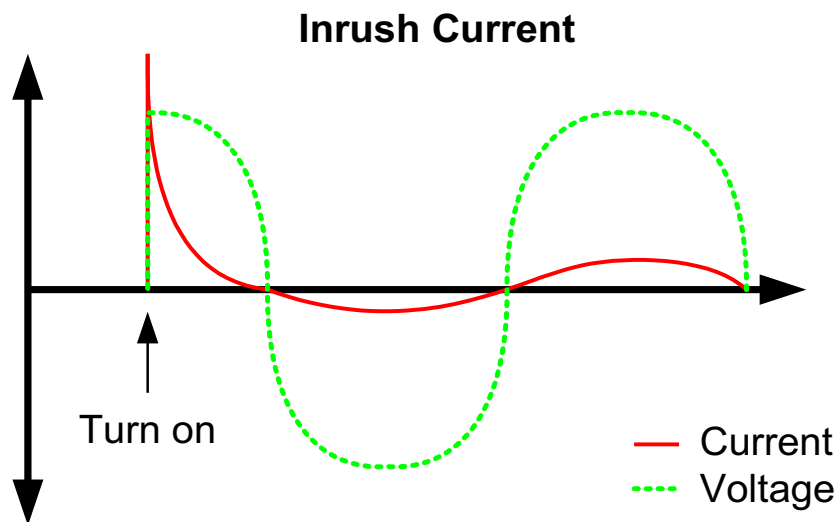
Common Terms

- **Scene:** A particular configuration of zones of lighting, designed to achieve a particular effect



Common Terms

- **Inrush Current:** Surge of current caused by initial connection of power to a load
 - Occurs once per power-up
 - Relevant for forward-phase and reverse-phase dimmers – and switches!
 - Limits established in NEMA 410 specification – look for it!



Inrush Current: Why do we care?

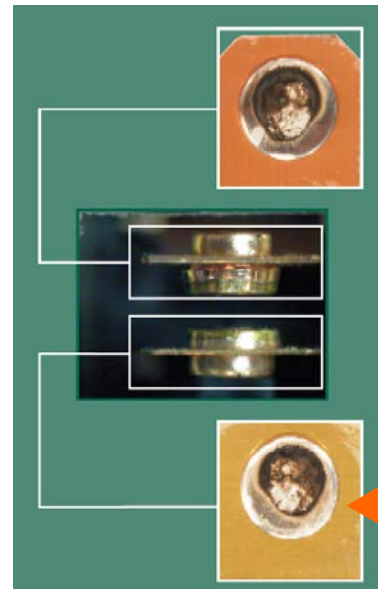
From LED Driver spec sheet:

AC CURRENT	0.6A / 115VAC 0.3A / 230VAC 0.25A/277VAC
INRUSH CURRENT (Typ.)	COLD START 50A (twidth=210µs measured at 50% I _{peak}) at 230VAC; Per NEMA 410
MAX. No. of PSUs on 16A CIRCUIT BREAKER	12 units (circuit breaker of type B) / 20 units (circuit breaker of type C) at 230VAC

0.3A (@230V) * 20 units = only 6 amps maximum per 230V breaker!

Problems from excessive inrush:

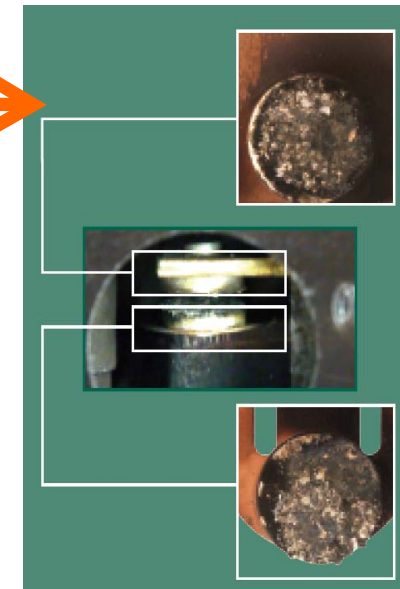
- False breaker tripping
- Premature relay wear and failure



Mechanical and electrical wear (high inrush)

*Relay contacts
120VAC, 16A
50k cycles*

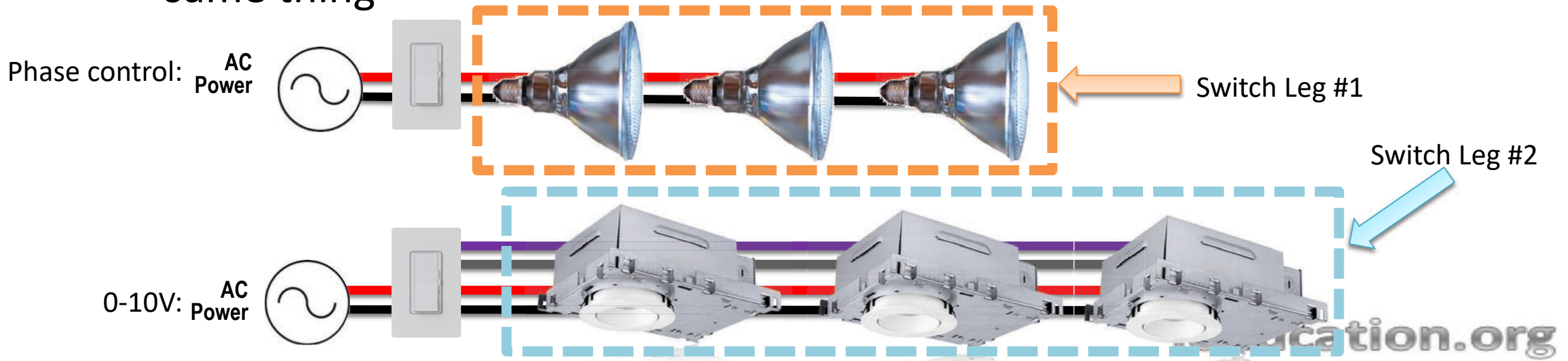
Primarily mechanical wear (no inrush)



Define Common Terms

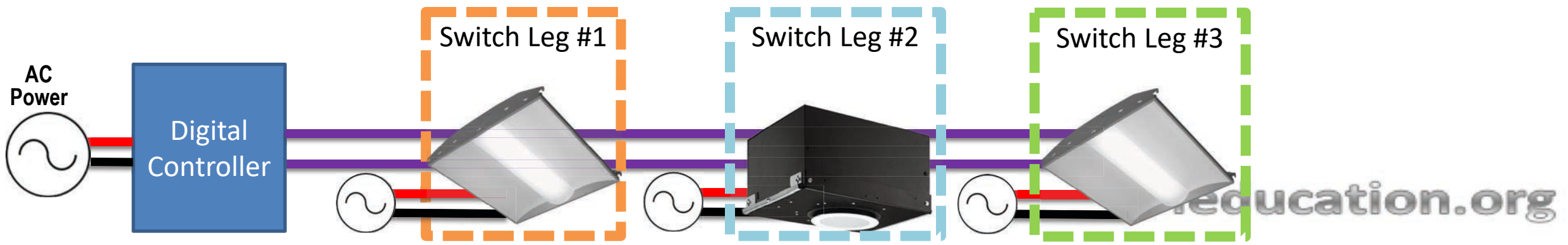
- **Analog Lighting Control:**

- Uses DC or AC voltage set by the control to adjust load's light level
- One-way communication: control → load
- Control signals are broadcast: all loads on the same wires do the same thing



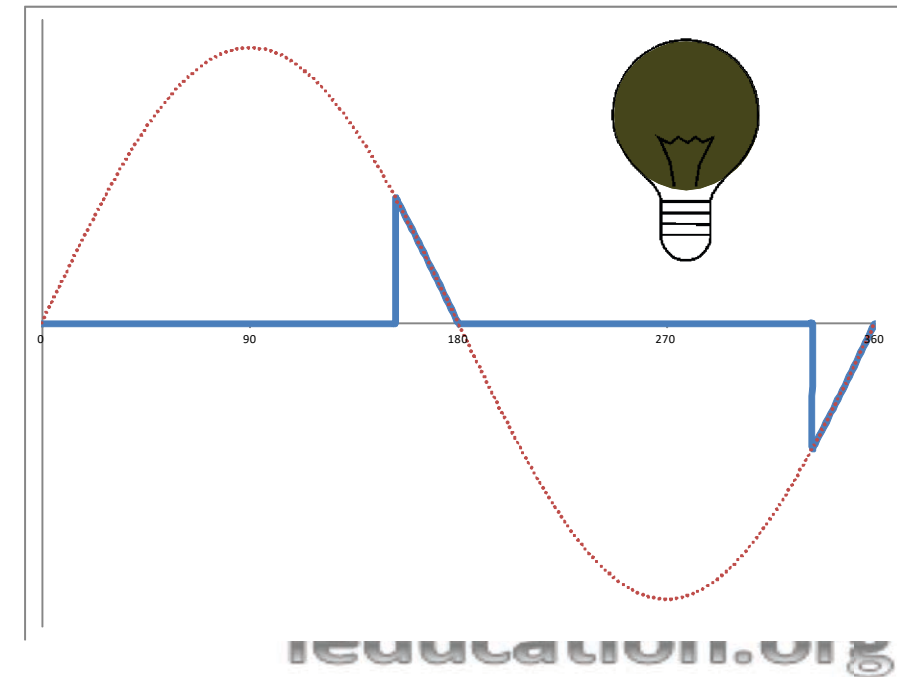
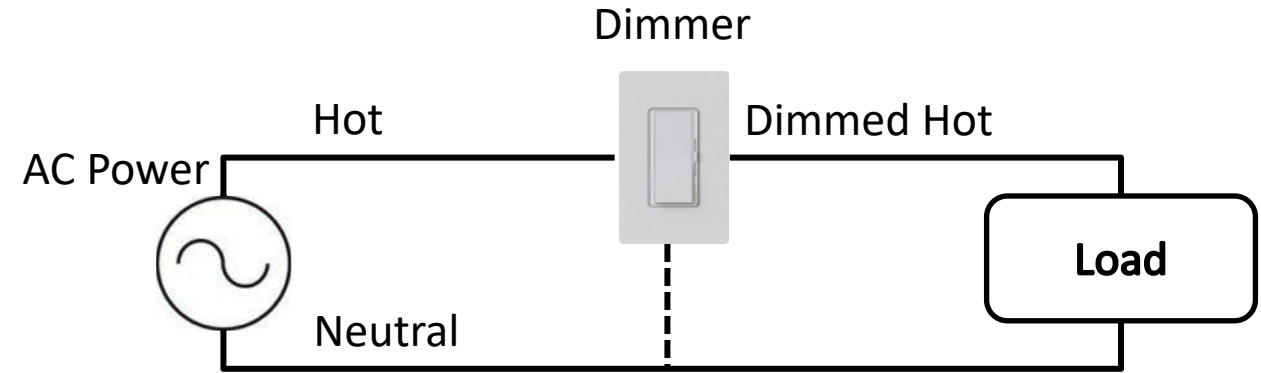
Define Common Terms

- **Digital Lighting Control:**
 - Uses high-speed (typically low-voltage) signals to send messages from the control to the load via a common protocol (language)
 - Usually two-way communication: control ↔ load
 - Usually power is wired separate from control: “always hot”
 - Control can talk to loads individually: different loads on the same wires can behave separately



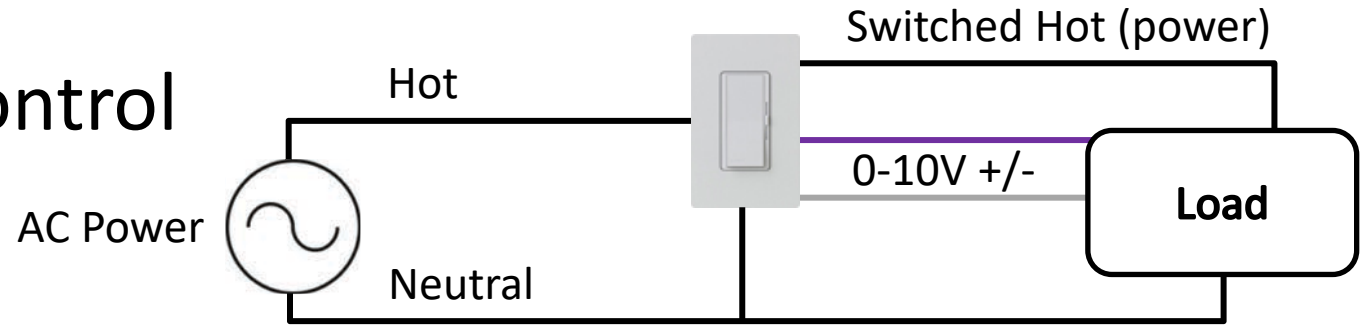
Analog Lighting Control Types: Phase Control

- Simplest retrofit
- Most cost-effective solution
- No/minimal configuration or commissioning
- Widespread availability
- Broad manufacturer and product feature choices
- Some dimmer max/min load restrictions
- Most common dimming method (residentially)
- Largest (by far) installed base

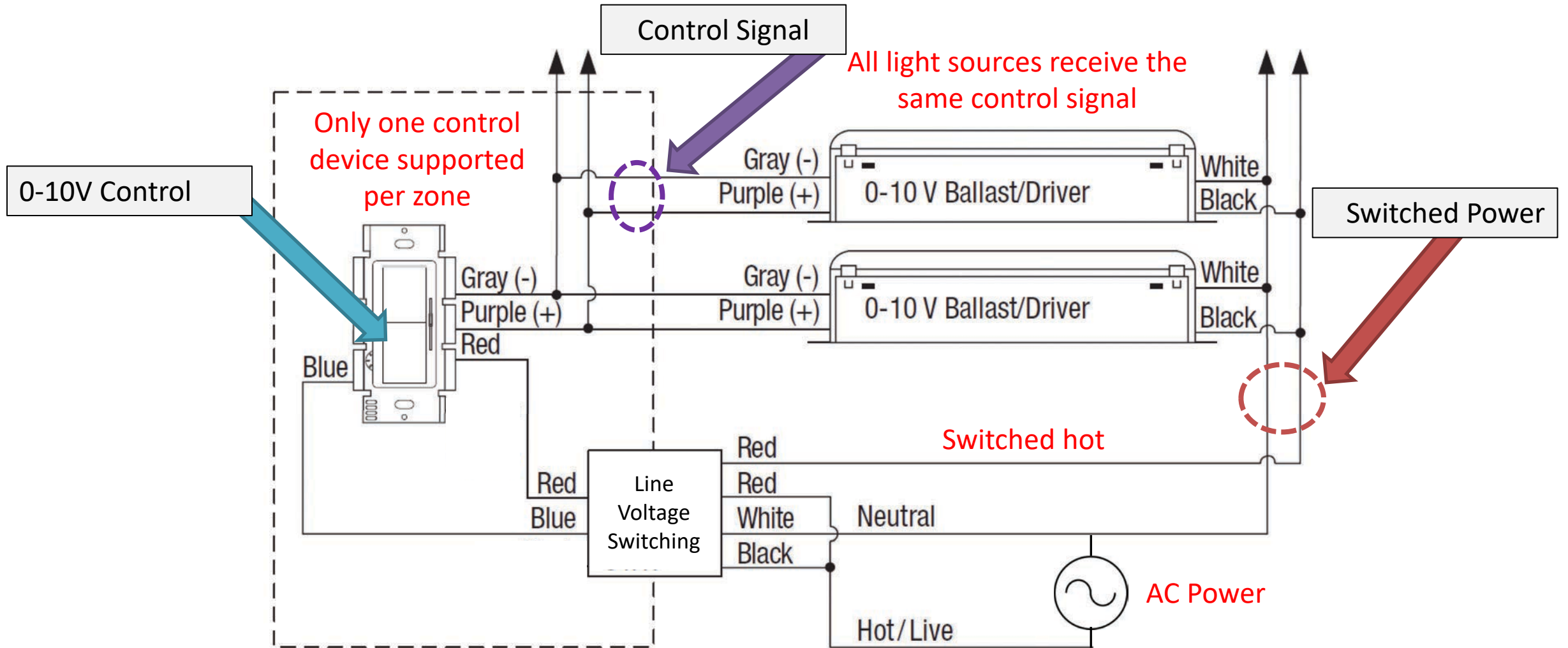


Analog Lighting Control Types: 0-10V

- Separate AC power and control
- One-way communication
- Actually two “standards”
 - ANSI E1.3: originally developed by the Entertainment Services and Technology Association (ESTA) in 1997 for theatrical equipment
 - IEC 60929: originally released in 1992 for linear fluorescent systems
- Requires two low-voltage (analog DC voltage) polarity-sensitive wires per switch leg directly connected between each control and load

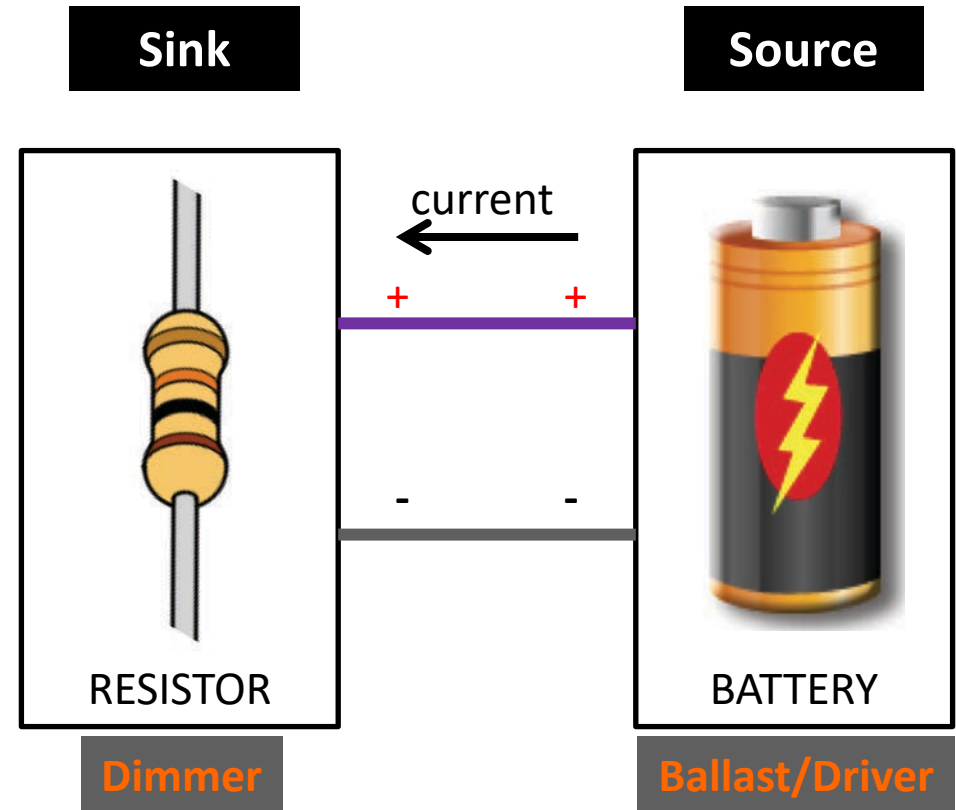


Analog Control Types: 0-10V



0-10V Control (using IEC 60929)

- Most common type in commercial lighting control
- What it defines:
 - The load sources the current
 - The control sinks the current
 - 10V or above = 100% light
 - 1V or below = “minimum light” (not off)
- No definition of dimming performance, dimming curve, flicker, lifetime, etc.



0-10V Control



- Low-cost control and driver choices available
- Few interoperability problems when all components comply with same “standard”, *but...*
 - Using components complying with different standards (IEC vs. ANSI) results in interoperability problems
 - Potential mismatch in performance (light levels, dimming smoothness); not covered by standard
 - Standards do not specify whether controls signals should be run as UL Class 1 or Class 2 (what if control is Class 1 only, and fixture is Class 2 only?)
- Complex and costly wiring requirements
 - Typically (not always) requires line-voltage switching
 - Long wire runs can affect performance (e.g. dimming range, accuracy), because voltage drop means light level drop

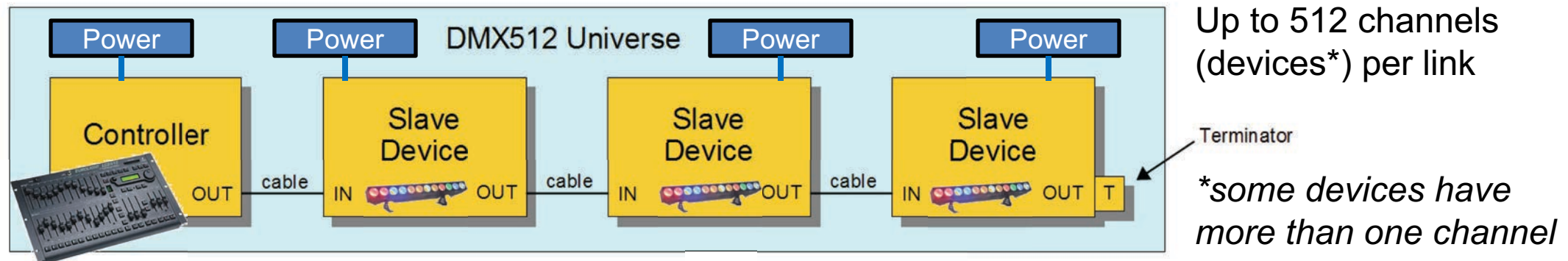
Why are Phase Control and 0-10V so popular?

- They are the ONLY truly “open” protocols that work across manufacturers
-However, there is no guarantee of performance.
 - Fun fact: Standards almost never guarantee performance! (Few “guarantee” compatibility)



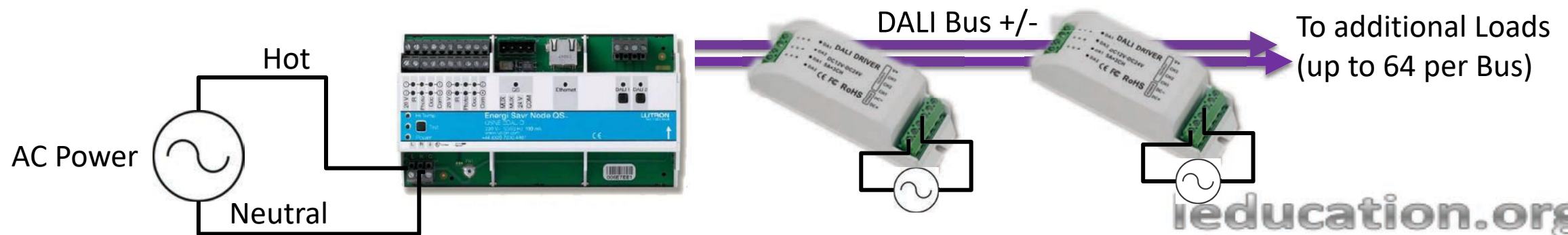
Digital Lighting Control Types: DMX

- Originally developed by the US Institute of Theater Technology and released in 1988 for theatrical applications – specifically RGB light sources
- Standardized as ANSI E1.11-2008 “DMX512-A - Asynchronous Serial Digital Data Transmission Standard for Controlling Lighting Equipment and Accessories”
- Initially, one-way communication (RDM later added feedback)
- Requires specialized wire which carries a high speed signal, daisy-chained across one or more devices (more complex and expensive)
- Easy to assign individual control devices to one or many light sources without added wiring
- Available in wireless implementations as well (WDMX)



Digital Lighting Control Types: DALI

- Two-way communication
- Originally developed in 1990's as part of IEC 60929 for fluorescents
 - Later removed, expanded and turned into IEC 62386 series of standards
 - LOTS of different parts and pieces: most are optional
- Requires two low-voltage wires which carry a low-speed signal, daisy chained across one or more devices (easy and low-cost)
- Assign or reassign individual control devices (dimmers, sensors) to one or many light sources via software, no added wiring

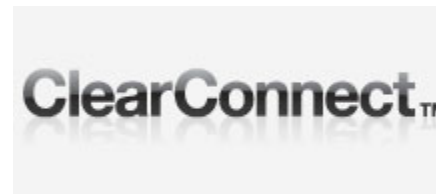
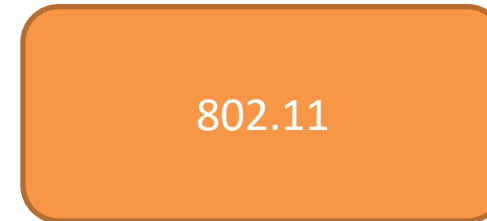
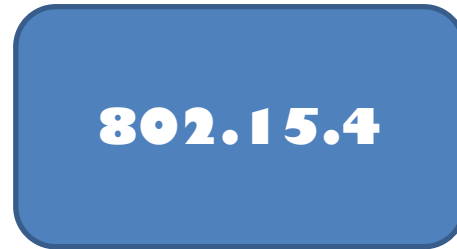


DALI Control

- Addressing of up to 64 individual components per DALI link
- Allows control and status reporting of a wide variety of ballasts, drivers, dimmers, sensors
- Presumes that control signal is run as UL Class 1 (with AC); some manufacturers run control signal as UL Class 2 (low voltage)
- Many manufacturers have “proprietary” extensions, resulting in interoperability problems with components from other manufactures
 - No “guarantee” of compatibility across vendors, even if they both meet the standard
 - Many parts of the standard are optional, and may not be supported by both the load and control system
- Typically time-consuming and complex commissioning

Oh, by the way...there's wireless, too

Interoperability and performance concerns exist here, as well



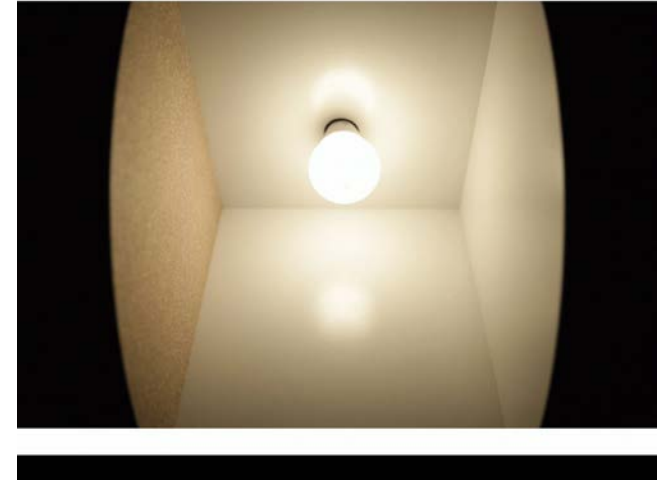
Digital Lighting Control

- Why do proprietary digital controls exist?
 - Protocols are often “based on” standards, but manufacturer-specific extensions are common
 - For example, “802.15.4 compliant” does not mean it “works” with other 802.15.4 devices (merely they can co-exist)
 - Most protocols explicitly leave room for vendor-specific differentiation
 - Regarding “interoperability” between vendors, few offer guarantees. If something’s not working, who’s responsible?

We comply with the standard!
Must be the other guy’s gear...

Common Problems and Misaligned Expectations

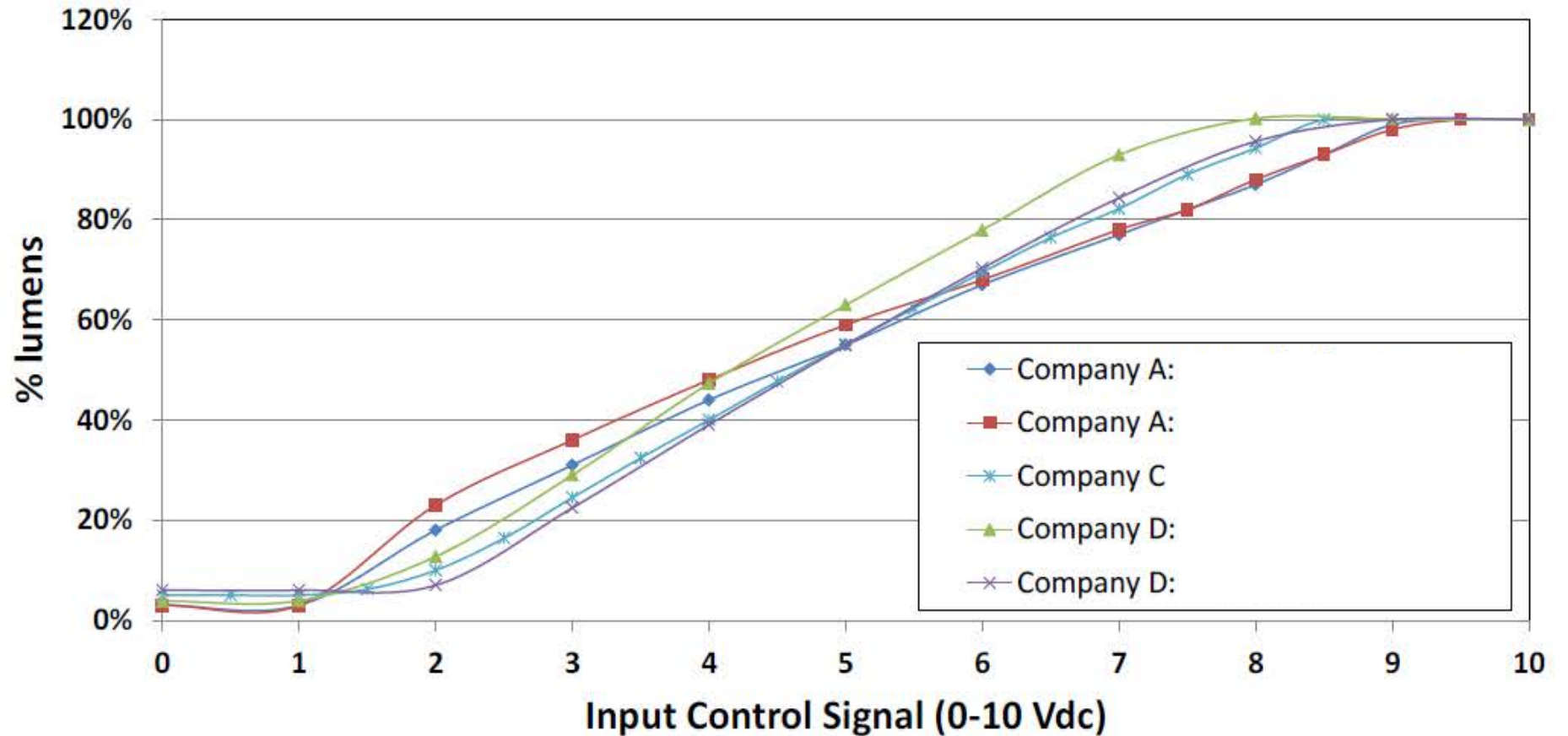
- Poor Dimming
 - Flicker
 - Turn on/off



Common Problems and Misaligned Expectations

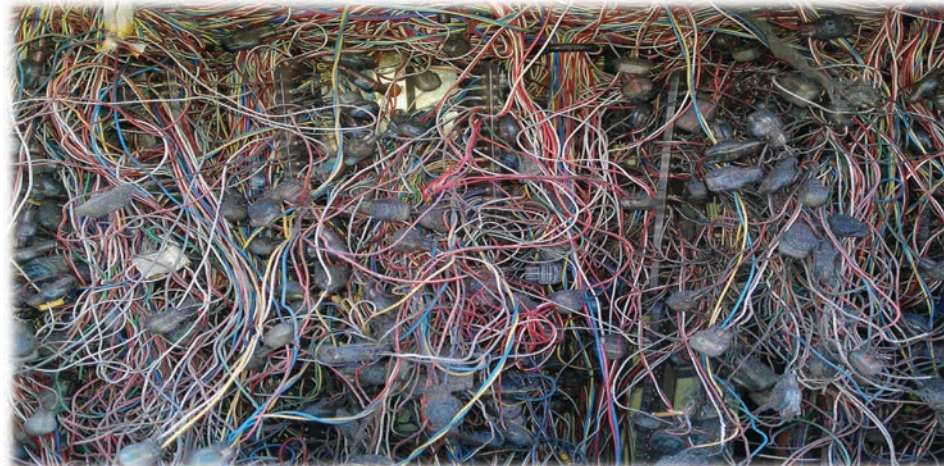
- Mismatched dimming curves
- Low end dimming

Light Output Summary



Common Problems and Misaligned Expectations

- **Design Complexity:** Addressing the increasingly complex code requirements with customized application needs is burdensome to Lighting Designer and Engineer, and is risky for EC to install without error.
 - Digital Controls solve these issues



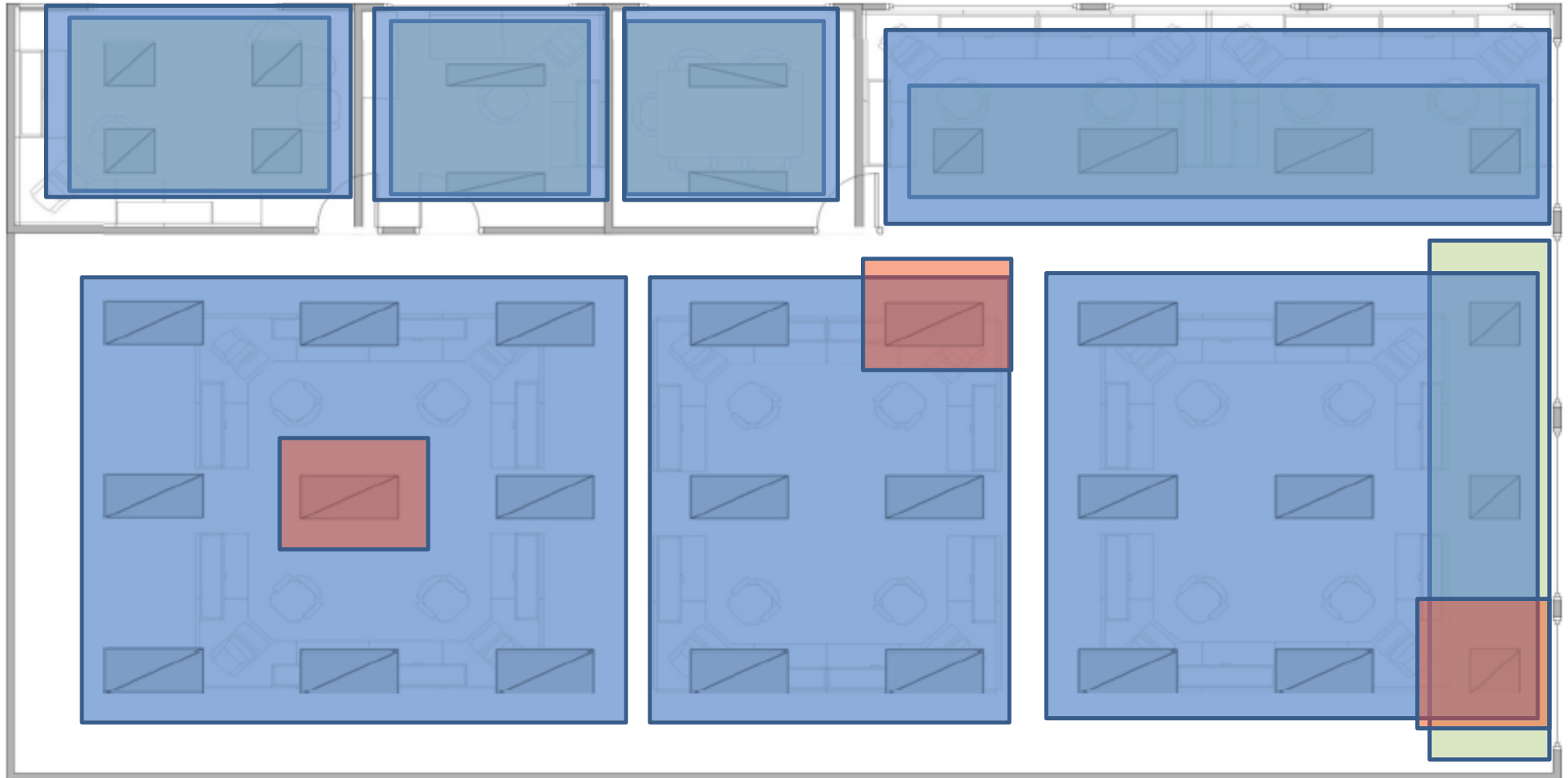
Section of an Open Office

Wiring Legend

Daylighting

Occ/Vac Sense

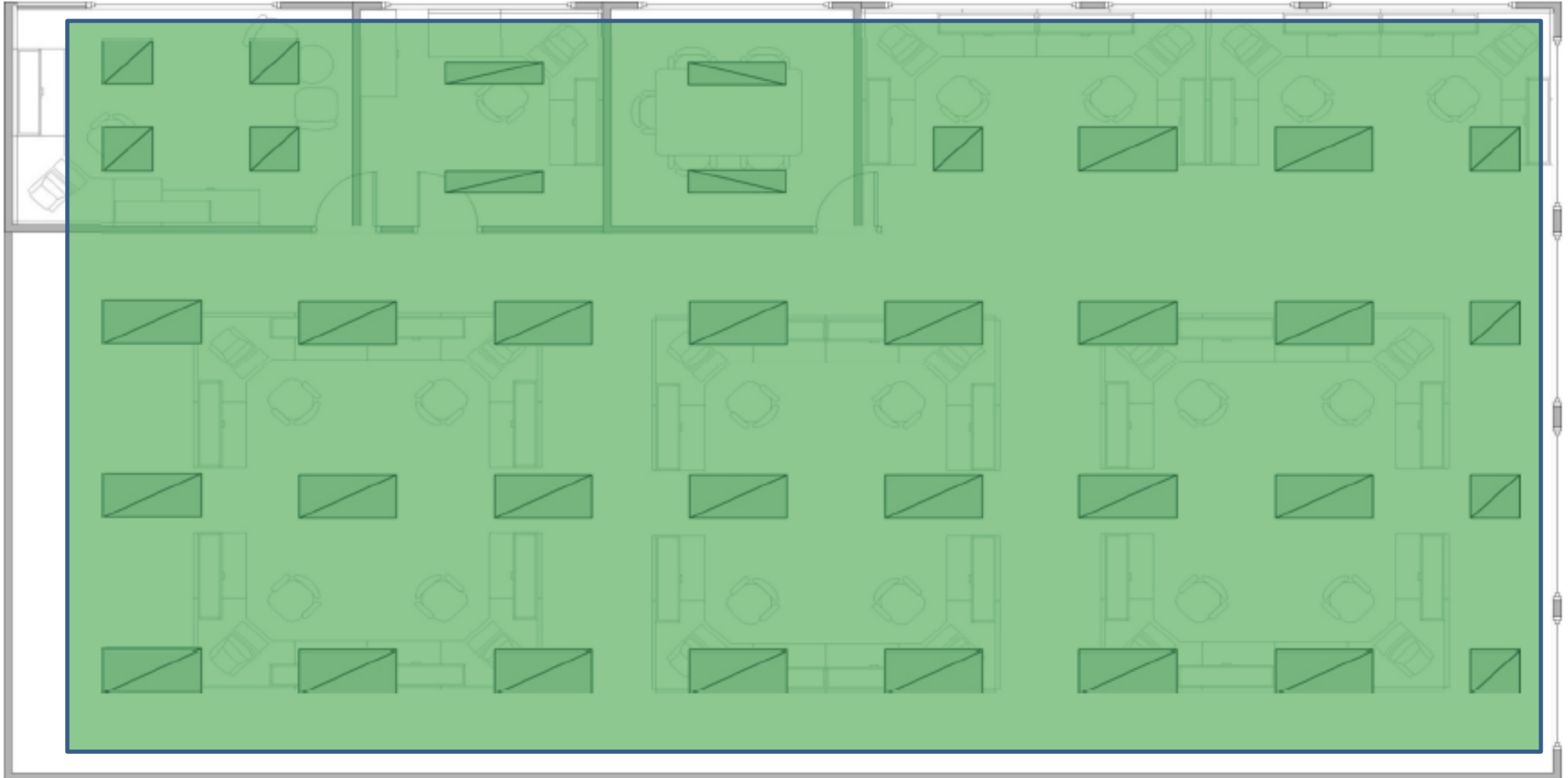
Emergency



...Now With Digital

Wiring Legend

Digital Link



Common Problems and Misaligned Expectations

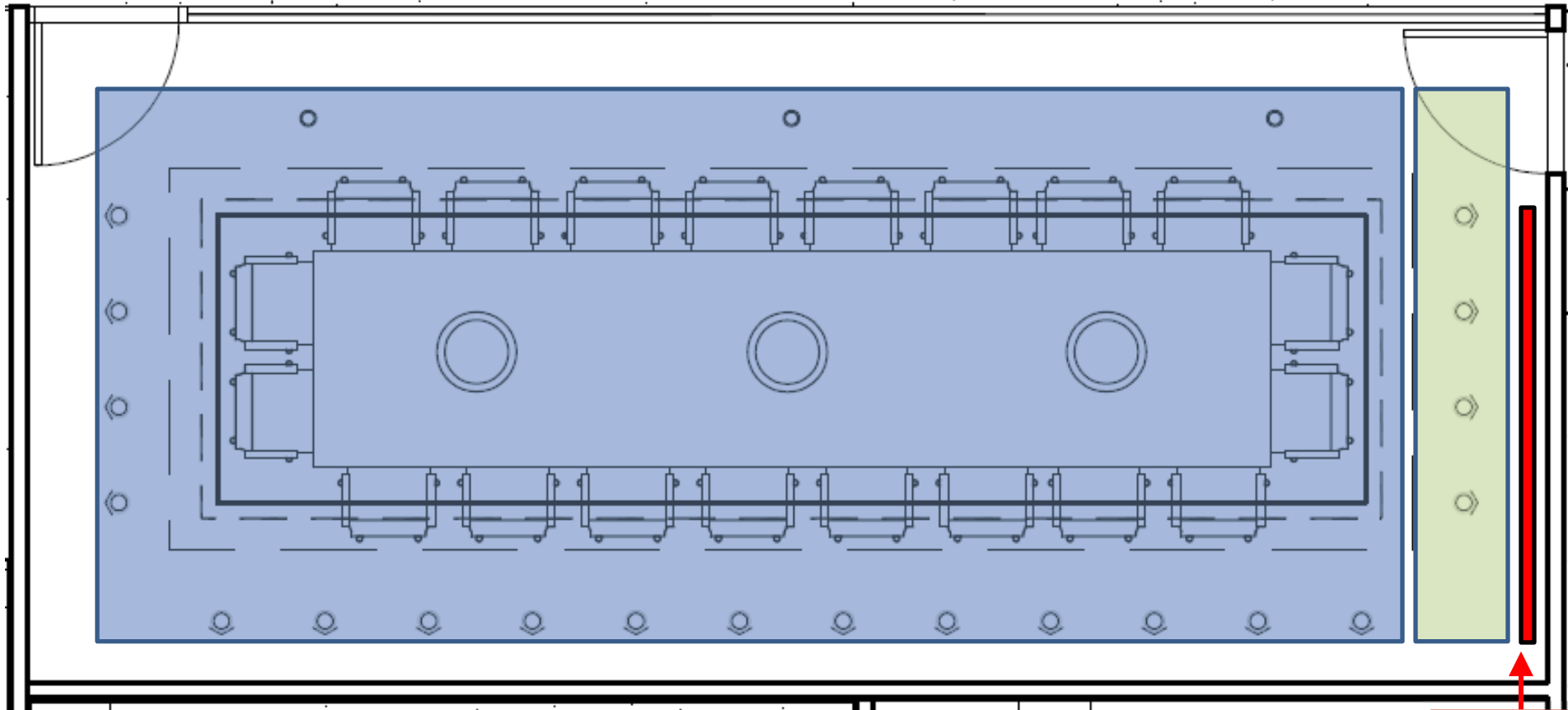
- **Rezoning:** Whether it's the Videoconference room where the monitors are moved to the other side of the room, or the office space that is reconfigured during or before occupancy, the need for flexibility in lighting zones is critical.

Videoconference Room: As Designed

Zone Legend

Screen Zone

Room Zone



Screen
and
Camera

Common Problems and Misaligned Expectations

- DALI Constraints
 - **Interoperability:** It is critical to understand that for non-traditional attributes (e.g. CCT), there is no agreement about common control protocol
 - **Protocol Revisions:** As successive versions of open protocols are released, compatibility between controls and devices (which is not guaranteed) is at increased risk

....Ok, so what do I do now?

1. Establish expectations for Sequence of Operations from the very beginning of the design process
 - A. Dimming and daylighting
 - B. Occupancy/vacancy settings
2. Clarify expectations of fixture package
 - A. Dimming level and control types
 - B. NEMA 410 compliance for inrush

This concludes The American Institute of Architects Continuing
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