

Designers Lighting Forum

Good LED dimming ain't brain surgery,
so get it right!?!

Manny Feris / Lutron Electronics

Every year, Lutron products saved 10 billion kWh - the carbon equivalent of 1.5 million cars off the road or installing 1,500 wind turbines. That's because dimmers save energy – and the more you dim, the more you save – even with LEDs – and sensors save energy too!

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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:

Learning Objectives - 1

LED bulbs and LED modules always need an LED driver - learn what a driver is?

Learning Objectives - 2

Almost every driver can be dimmed - learn what that means

Learning Objectives - 3

Every dimmer has a control protocol - learn what that means.

Learning Objectives - 4

Every spec can define good LED dimming - learn how to do it?!

BACKGROUND AND CONTEXT



LIGHTING/DIMMER CONTROL IS A SUSTAINABLE TECHNOLOGY

- Extending an already longer LED lamp/LED fixture life – with a dimmer:
 - saves time, effort and saves money on labor and lamp costs
- Save energy - save money on your electric bill
- Reduce carbon footprint (less in the landfill/fewer coal burning power plants)
- Save energy effortless, beautifully with light control
 - Dimmers are the only energy savings devices that enhance comfort, asks you to sacrifice nothing, adds a totally new convenience to your life and beautifies the space...while saving time, effort, money and the environment!

BAKING AND PHONE APPS AIN'T BRAIN SURGERY

Please consider the effort needed for these parts of our daily life 😊

Anyone who has ever tried to bake a cake knows that it can be a ruthless undertaking:

What flour(s)? What leavening agent? What sweetener?

What sequence/mixer do I use to combine these ingredients?

What pan size, and what do I do to make sure I can get the cake out of the pan!

What temperature and how long in the oven?

What decorations and is the cake cool enough to apply?

Anyone who has tried to install a new app on a new phone knows that it can be equally ruthless

Lighting, Lighting Design and Dimming Controls are also a part of our daily lives 😊

TODAY - LIGHTING REALITY IS ALL LED

Today, nearly every type of architectural lighting use LEDs – each with a driver as the “interface” between 120V/277V power and the solid-state LED module that produces those lumens we count so carefully.

Most LED drivers can be dimmed and dimming meets client needs, meets code requirements, provides energy savings and human needs design/human centric design/human centered design/holistic design.

Good dimming is self-evident – we know what we want to see - based on what good incandescent dimming has offered for over 60 years!

LEDs are more efficient and easier to dim than “legacy” lighting sources like fluorescent or HID - as long as you pay attention to basics.

It takes some effort...however, a **dimmed LED could last for 10 years**...so there's a great return on that investment.

“LEGACY” LIGHTING HAD “POWER SUPPLIES” TOO! YOU HAD TO CHOOSE THE RIGHT DIMMER FOR THE LIGHT SOURCE (INCANDESCENT, MAGNETIC LOW VOLTAGE, ELECTRONIC LOW VOLTAGE, FLUORESCENT)



Incandescent only
Required 120V Power

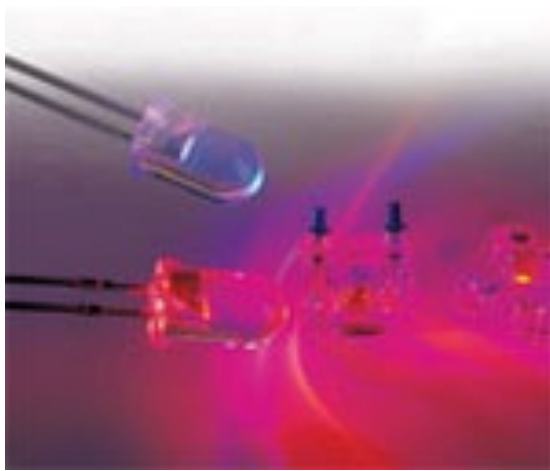


Low Voltage
required an ELV or
MLV **transformer**
(Step-Up
transformers for
Neon/Cold Cathode)



Fluorescent
(Linear or CFL)
required a **ballast**

LIGHT EMITTING DIODE (LED) = SOLID STATE LIGHTING (SSL)



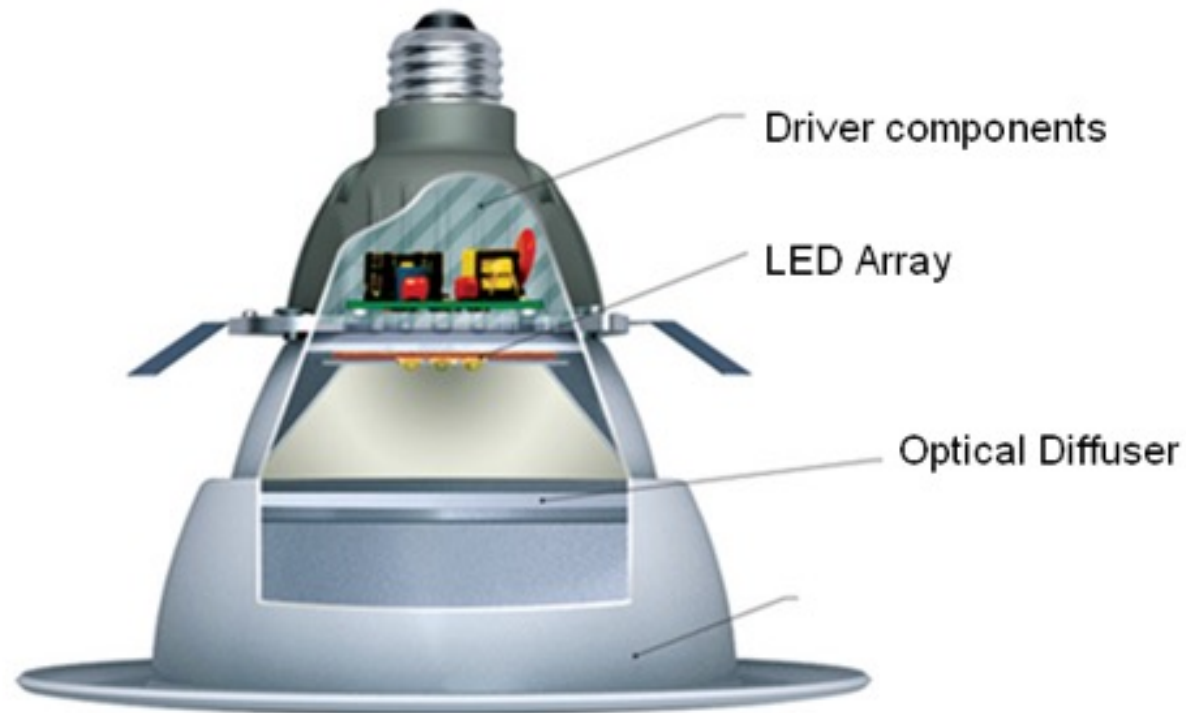
LEDs are available in many colors of white (actually different Blue LEDs with different Yellow Phosphors) or RGB (Red/Green/Blue) sometimes with a 4th Amber/Yellow/White LED for better “White”

LED life ranges from 5,000 – 100,000 hours (measured to 70% initial light output)

EVERY LED lamp/module/array/engine requires a driver to provide DC power to the LED – it can be located inside the fixture or remotely wired to the fixture...it’s always there behind the scenes!

THERE IS AN LED DRIVER BEHIND THE SCENES

LED Recessed Retrofit Lamp (there is a driver between 120V Power to the Edison Screw Base medium socket and the LED Array/Module):



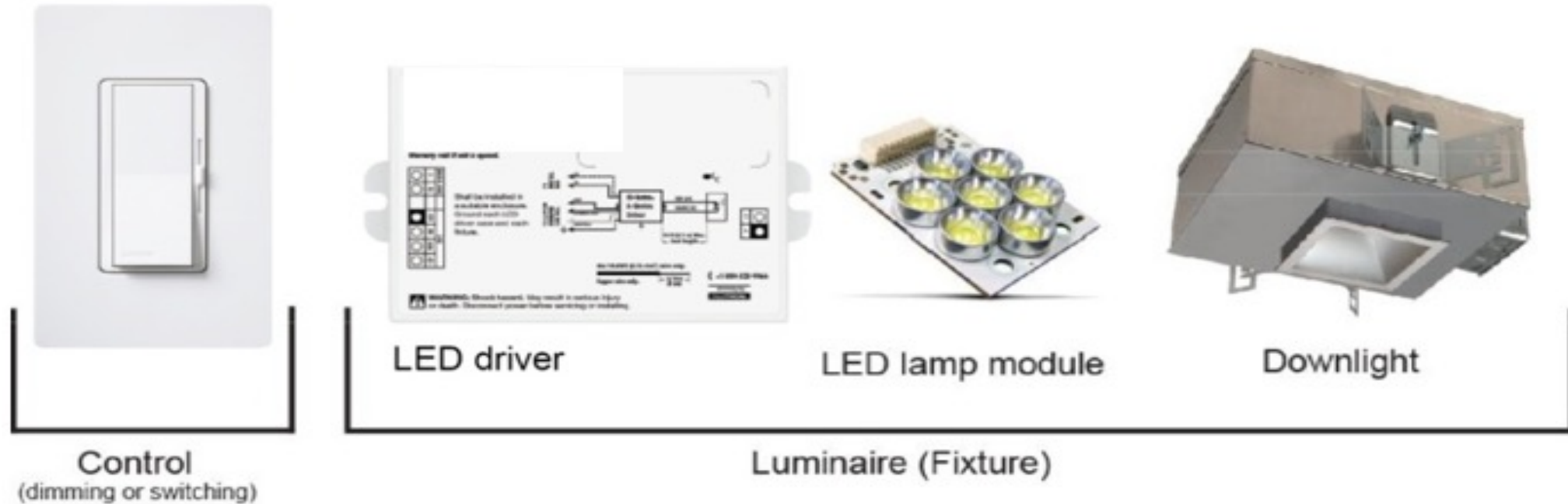
THERE IS AN LED DRIVER BEHIND THE SCENES

Many Linear Fixtures feature an onboard driver (COP = Chip On Board). They come in different lengths that can be daisy chain wired >100 feet direct connection to 120 VAC feed. This fixture offers dimming control with 0-10V.



THERE IS AN LED DRIVER BEHIND THE SCENES

LED Recessed Downlight (there is a driver between LED dimmer and LED module/array):



WHAT DOES AN LED DRIVER DO?...IT DOES 100% OF THE DIMMING!

Dimmer provides "Control Protocol"
to the driver:

- Analog (2-wire+G Forward Phase)
- Analog (2-wire+G Reverse Phase)
- Analog (3-wire+G)
- Analog Low Voltage 0-10V
- Digital DALI
- Digital EcoSystem
- Digital DMX)
- IoT

Line Voltage Input Power
120VAC
277VAC(Commercial)
347VAC(Canada)
220-240VAC(Int'l)



DIMMING or SWITCHING:
*Power Conversion, Regulation
and Filtering*



LED Module
(aka LED Engine or
LED Array)

Low Voltage DC Output (selected
by fixture manufacturer)

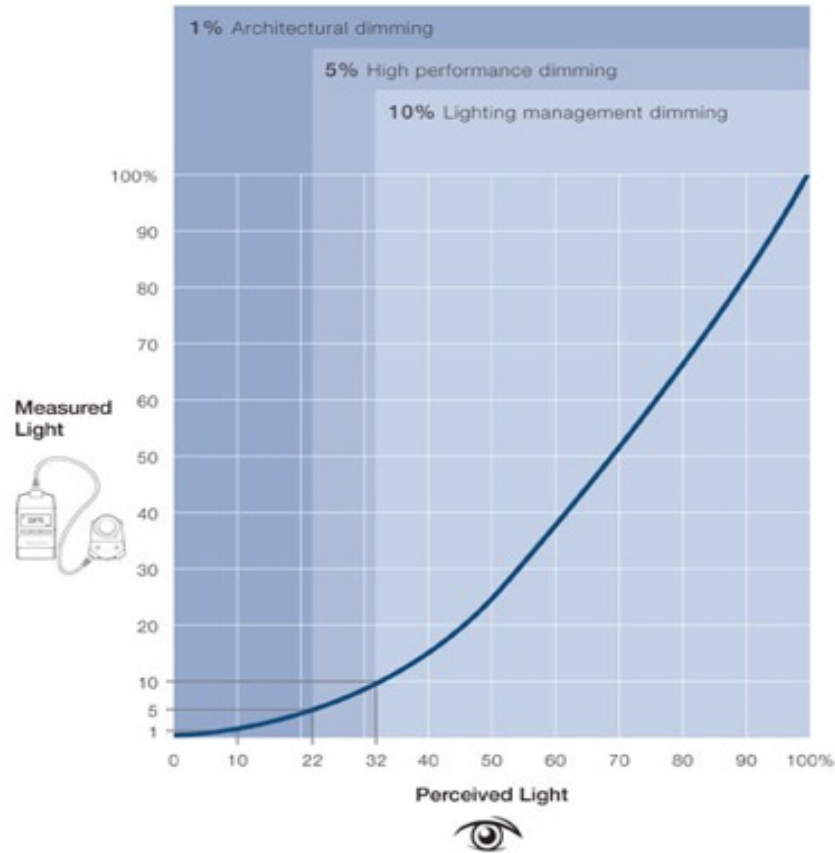
BACKGROUND - LED BULBS/FIXTURES AND DRIVERS

- LEDs are non-linear devices
 - Different current-voltage relationships in different regions of operation from OFF to Full ON
 - Small change in voltage can equal large changes in current from one LED to another
 - (Average) current must be **controlled by the driver**
- LEDs are unidirectional devices
 - (Forward) current only flows in one direction
 - Light output only for forward current

WHEN YOU SELECT AN LED DRIVER FROM THE FIXTURE SPEC SHEET...YOU SELECT IT ALL...THE DRIVER DETERMINES 100% OF THE DIMMING PERFORMANCE

- Dimming vs. Non-Dim
 - Smart Controls vs. Code Compliance
 - Dimming does not have a premium price
- Control Type (Control Protocol) i.e. the “language” between dimmer/control and driver...AND THE INTERCONNECTING WIRING:
 - 2-wire (Hot/Neutral +G)
 - 3-wire (Dimmed Hot/Switched Hot/Neutral +G)
 - Analog 4-wire (Hot/Neutral +G plus 2 LV 0-10V)
 - Digital 4-wire DALI, EcoSystem, DMX (Hot/Neutral +G plus 2ire data link)
- Dimming range suitable for your application
 - 10% dimming: lobbies, open office, atriums, and...
 - 1% dimming: restaurants, hospitality, conference room, and...
 - 0.1% dimming: residential, AV spaces, and....

WHY LOW-END MATTERS – THE DIFFERENCE BETWEEN MEASURED AND PERCEIVED LIGHT



- **Measured light:** the amount of light as shown on a light meter
- **Perceived light:** the amount of light that your eye interprets due to dilation

- **20% measured = 45% perceived**
- **10% measured = 32% perceived**
- **1% measured = 8% perceived**
- **0.1% measured = 3% perceived**

- **LEDs are MORE efficient when they're cool – low-end dimming means MORE lumens/watt**

Formula: $\text{Perceived Light (\%)} = 100 \times \sqrt{\frac{\text{Measured Light (\%)}}{100}}$

Source: IESNA Lighting Handbook, 9th Edition, (New York: IESNA, 2000), 27-4.

ANALOG CONTROL TYPES/CONTROL PROTOCOLS & WIRING “LANGUAGE” FOR LED DRIVERS

Analog Control – Requires:

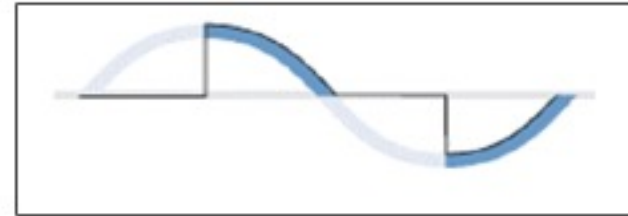
- 1) Point-to-Point wiring for each fixture in a control zone;
- 2) Dedicated Occupancy/Vacancy/Daylight sensors for each control zone; and,
- 3) Limited driver quantities per switch/dimmer and 16A circuit

TYPICAL OF:

- Analog 2-wire+G (Forward Phase, MLV, Triac, Leading Edge, Incandescent)
- Analog 2-wire+G (Reverse Phase, ELV, Trailing Edge)
- Analog 3-wire+G (Dimmed Hot/Switched Hot/Neutral)
- Analog Low Voltage 0-10V (4-wire: 120/277V Hot, Neutral+G plus 2 x LV for 0-10V control (aka 1-10V and 10-0V))

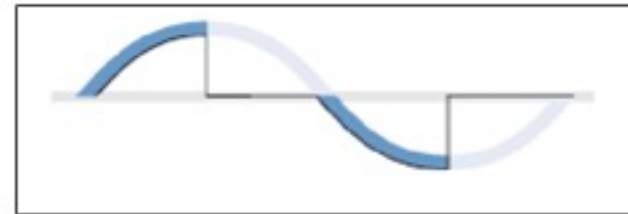
ANALOG 2-WIRE LINE VOLTAGE DIMMING

- Forward Phase (Leading Edge /Triac /Incandescent)
 - Most Common Dimming Method (>150 million dimmers in use)
 - **Originally developed for incandescent**
 - Also used for magnetic low voltage transformers (“MLV”)



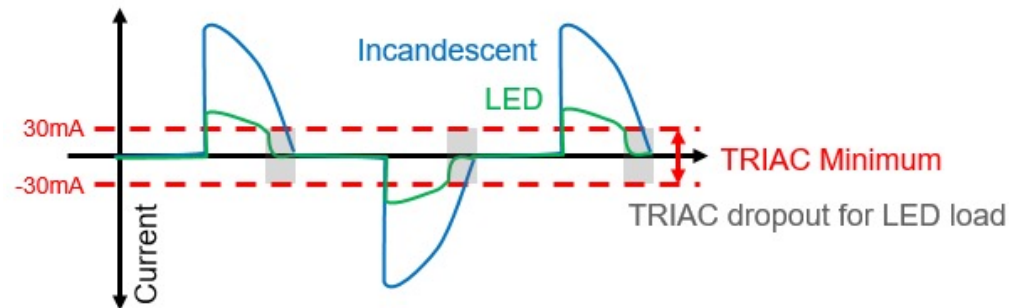
- Reverse Phase (Trailing Edge)
 - Typically used for electronic low voltage transformers (“ELV”)
 - Smaller installed base, requires a neutral wire

Both images show 50% dimming and the energy savings when the power is at OFF



ANALOG 2-WIRE LINE VOLTAGE DIMMING AND MINIMUM LOAD

LED Fixtures can be as small as ONE WATT each and many Forward Phase/Reverse Phase dimmers (originally designed for Incandescent) have a 5 Watt or even a 25 Watt “Minimum Load Requirement”



Many LED fixture loads are also below the minimum capacity for drivers and have to be controlled as 2, 3 or 4 fixtures wired IN SERIES by the contractor in the field to a single remote mounted driver

DIGITAL CONTROL TYPES/CONTROL PROTOCOLS & WIRING “LANGUAGE” FOR LED DRIVERS

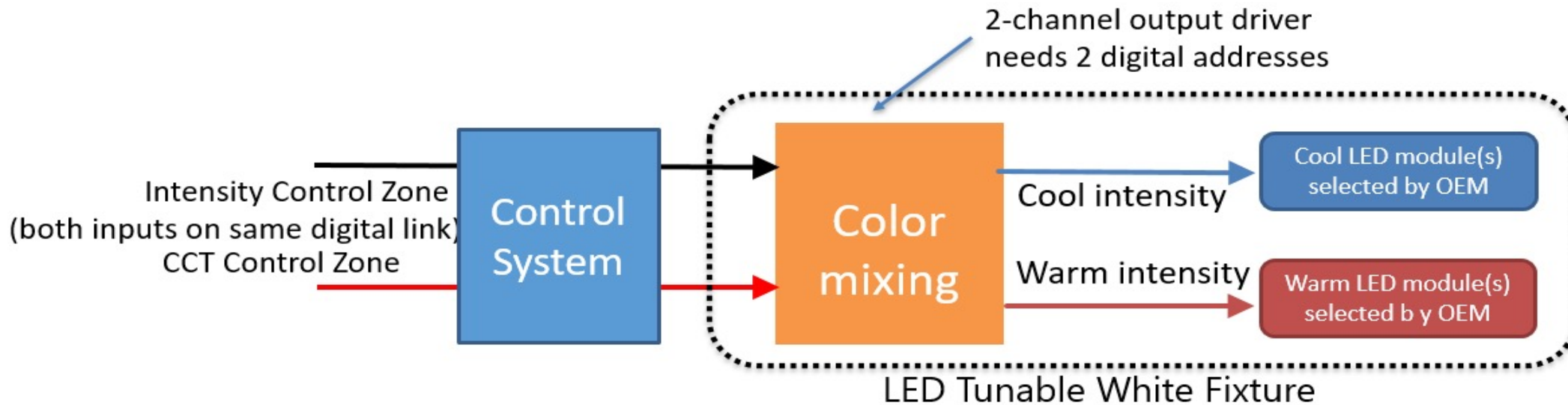
Digital Control – Provides:

1. No hard wiring required to create control zones; each driver/fixture is assigned/addressed individually;
2. One driver can have TWO digital addresses for Tunable White control
3. Shared sensor outputs on LV data link (i.e. any sensor can control any one or all 64 driver/addresses on the data link)
4. Full power load on 120V/277V 16A circuit – fewer circuits needed and no driver limits per switch/dimmer
5. LV Data Link can be wired Class 1 or Class 2 with no polarity issues

TYPICAL OF:

- Digital DALI (Hot, Neutral +G, 2 x LV Data Link)
- Digital EcoSystem(Hot, Neutral +G, 2 x LV Data Link)
- Digital DMX(Hot, Neutral +G, 2 x LV Data Link)

DIGITAL CONTROL PROTOCOLS ALLOW SIMPLER WIRING FOR TUNABLE WHITE LED DRIVERS



- Raise/Lower and daylight dimming is possible.
- Timeclock control is simplified.
- CCT and intensity can both be adjusted independently

WHY SPECIFY DIMMER CONTROLS FOR LED FIXTURES?

THE SAME REASONS YOU USED DIMMERS FOR INCANDESCENT!

Lighting Controls enable you to re-focus a room by creating different preset “scenes” to suit activities or moods...at the touch of a button or automatically

- Task lighting is great...but not always necessary
- Ambient lighting can be overpowering
- Decorative lighting sparkles even more when it has just a soft glow
- Accent lighting has more punch...when other lighting is subdued
- Available daylighting allows automatic dimming of ALL the LEDs

WHY SPECIFY DIMMER CONTROLS FOR LED FIXTURES?

THE SAME REASONS YOU USED DIMMERS FOR INCANDESCENT!

- Client needs...desire for easier control locations/options, use of phone/tablet technology, interest in green design and increased productivity
- Enhance the beauty and use of your spaces - marry function (improved flexibility) and style to show your designs in their very best light 😊
- Easier use of Daylight Harvesting control options
- Easier use of Occupancy/Vacancy sensor controls
- Enhanced Security and interface with Security/Fire Alarms
- Astronomic Timeclock settings
- Even lower maintenance costs
- Energy savings every day that make the first step towards Sustainable Design

WHAT TO EXPECT - DIMMER CONTROLS FOR LED DRIVERS

THE SAME YOU EXPECTED FOR INCANDESCENT – **NONE** OF THESE ISSUES:

Flicker: The unexpected/intense modulation of light level

Shimmer: The unexpected low intensity, high frequency modulation of light

Pop-on: The light turns on at a higher level and lowers back down

Drop-out: Light should turn off when the control is turned off

Dead Travel: Adjusting the control with no change in light level

Audible Noise: From LED driver or dimmer control

Popcorning: Mismatched start times of same fixtures in one space

Delayed Start-Up: > 2 seconds from button press until illumination

HOW TO SPECIFY DIMMERS TO DEFINE GOOD LED DIMMING

IT STARTS THE SAME AS WITH INCANDESCENT!

1. Start with the RCP (Reflected Ceiling Plan) and the Lighting Fixture Schedule
2. Group LED light fixtures to create lighting control zones as needed for the use of the space, but
PLEASE DO NOT MIX LED FIXTURE TYPES IN ANY ONE CONTROL ZONE
(NOTE: Control zones = Control channels = Control Groups)
3. Create a Control Zone Schedule with a column for “Control Type” that identifies what “control protocol” the LED light source/driver needs for control , e.g. 0-10V vs. Forward Phase
4. The Control Zone Schedule should also identify how many watts are controlled in each separate control zone by adding up the wattage of all the fixtures in that control zone
5. Please create SEPARATE Control Zones as needed, for example:
 - a. Pendant lighting Downlight (Direct) – one driver for 4’ section OR 3 drivers for a 12’ section
 - b. Pendant lighting Uplighting (Indirect) - one driver for 4’ section OR 3 drivers for a 12’ sectionor
 - a. Cove Lighting – Tunable White Intensity – one output of a 2-channel driver
 - b. Cove Lighting – Tunable White CCT – second output of a 2-channel driver

HOW TO SPECIFY DIMMERS TO DEFINE GOOD LED DIMMING

OTHER ISSUES TO CONSIDER...AND DOCUMENT

6. One dimmer system can control multiple zones each with different LED drivers (control types/control protocols) to allow the client to use a single button on a keypad (or a phone) to change many different LED driver types used in different control zones...

HOWEVER, this will mean different dimmers with different wiring per control zone...to match the LED driver requirements

7. Determine your application (single room control, complete office/home, restaurant, hotel)

8. Identify where you want to be able to control the lights – one location? Multiple locations?

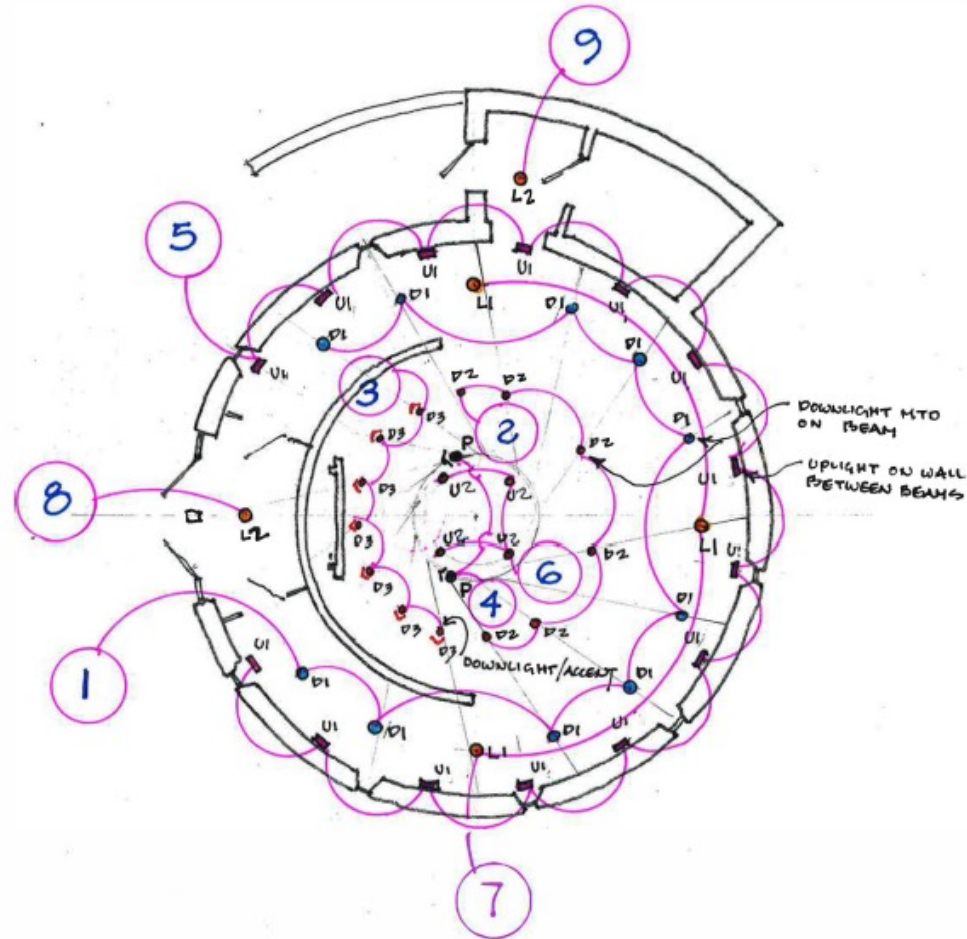
a. One zone controlled by one dimmer (single pole)

b. One zone controlled by one dimmer and one switch (3-way dimmer, 3-way switch)

c. One zone controlled by two dimmers (requires multi-location dimmers)

9. Select the style and color of controls (dimmer and/or keypads) in the room

SAMPLE CONTROL ZONE /CONTROL CHANNEL/ CONTROL GROUP LAYOUT



SAMPLE CONTROL ZONE SCHEDULE...AND MORE!

Visiting hours		channels									
		Downlight			Uplight		Lanterns			Mosaic Accents	
		light type			light type		light type			light type	
		D1	D2	D3	U1	U2	L1		L2	L2	P
1	Visiting hours	30	30	30	30	30	30	60	60	60	
2	Daily Mass	60	60	60	60	60	90	60	60	60	
3	Sunday Mass	90	90	90	60	90	60	60	60	90	
4	Weddings	90	90	90	60	90	90	60	60	60	
5	spare	0	0	0	0	0	0	0	0	0	
6	spare	0	0	0	0	0	0	0	0	0	
7	spare	0	0	0	0	0	0	0	0	0	
8	spare	0	0	0	0	0	0	0	0	0	
quantity per group		10	6	7	14	4	3		1	1	2
target descriptions		Perimeter circle	Inner circle	Mosaic wall	Perimeter circle	Oculus	Lantern Glow	Lantern Down	Entrance	Vestibule	Mosaic panel

LED DRIVER PRODUCT RELIABILITY & TECHNICAL SUPPORT

WHAT TO ADD TO BOILERPLATE LIGHTING FIXTURE SPECS:

LED Drivers must be designed for the same lifetime and application as the LEDs (5/10 year warranty, Maximum Tcal, operating hours – as measured by the driver!)

100% of the driver products must be end-of line factory tested...under full load

Million cycle operation provided for the most demanding applications

LED Driver product testing occurs on real LED loads and under extreme environmental conditions

Engineering support is available 24/7



Any changes to fixture/driver specs must warranty 100% compatibility between dimmer controls and drivers (including inter-connecting wiring).

Thank you

Any Questions?

Manny Feris /Lutron Electronics

mferis@lutron.com 917-270-1059

This concludes The American Institute of Architects Continuing
Education Systems Course

