Is it Time to Get a DALI?

Brian Liebel, PE, LC

AFTERIMAGE + s p a c e

brian@aispace.com

Rick Miller, PE, LC

RNM Engineering

June 18, 2003

Agenda

- Fluorescent Dimming Control Basics
- DALI – How it Works
- DALI – Parts and Pieces
- DALI – Commissioning
- DALI – Designing a System
- Summary of DALI (as it stands today)

Digital

- Works in bits, able to process a lot of information

Addressable

- Unique identity and operation

Lighting

- The technology being driven

Interface

- A way of interacting

Overview of DALI

- **Lighting technologies did not have a standard protocol for dimming in architectural settings.**
- **DMX 512 standard protocol for theatrical lighting has been established for years, and has led to the ability for all manufacturers to develop products around a standard system.**
- **DALI promises to do the same thing for architectural lighting systems.**

Overview of DALI

- **DALI is a non-proprietary protocol with specific design parameters for manufacturers to adhere to when producing devices and systems.**
- **The unique feature of 2-way communication may be valuable to the owner for maintenance and energy conservation purposes.**

Overview of DALI

- **Each ballast has its own address; therefore the system is highly flexible.**
- **The system uses a simplified wiring system, which promises to be cost-effective.**
- **The commissioning learning curve, lack of local controls, and lack of good monitoring capabilities are its biggest drawback at this time.**

Fluorescent Dimming Control Basics

Dimming System Control Concepts

Fluorescent Lamps:

- Desired Variable Output

Fluorescent Dimming Ballasts:

- Drives the Lamps, determines range, power consumption

Local Controls:

- Devices that control lighting within the space of the control

Centralized Panel Controls:

- Connection point for control wiring and some programming

Interface Components:

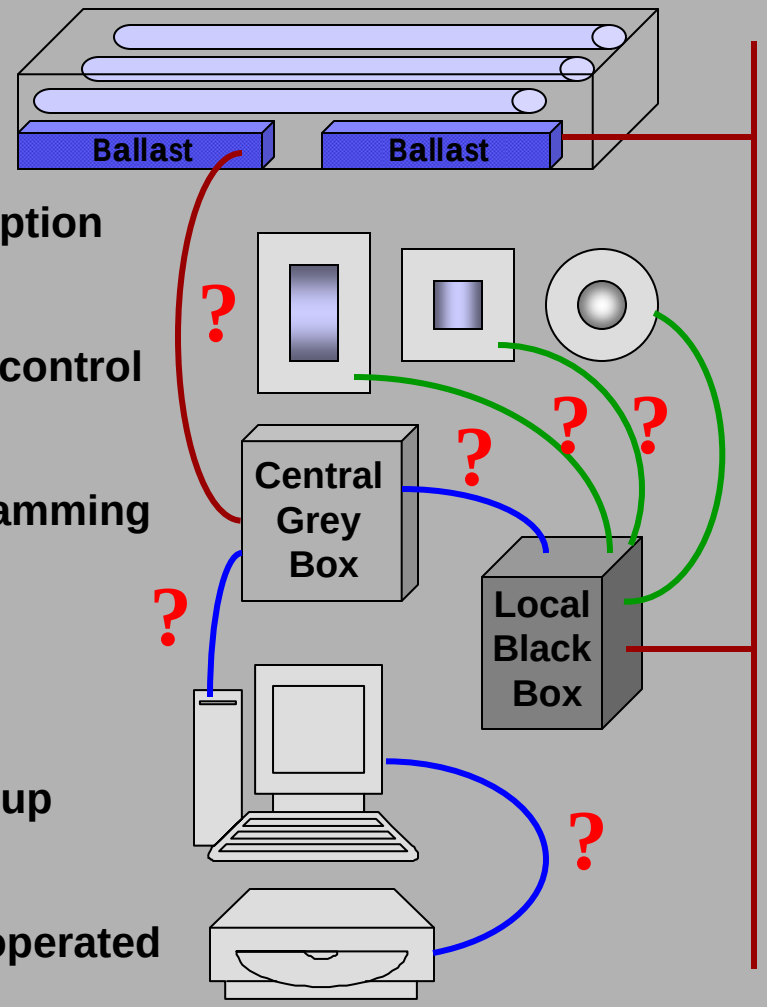
- Devices that convert one language to another

Computer Hardware:

- Most systems require hardware/software for setting up

Operating Software:

- Determines how system will be commissioned and operated



Topology:

- How components are wired together

Protocol:

- The Language and Logic of the control system

Fluorescent Dimming Components

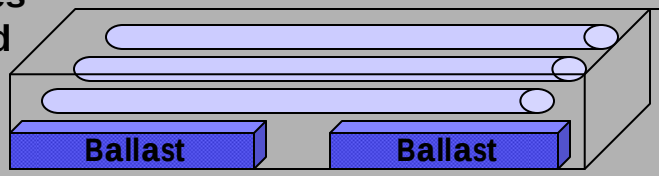
Fluorescent Lamps:
- Deliver Light

Fluorescent Ballast:
- Drives fluorescent lamps, determines dimmed level and power draw

Concealed Interfaces:
- Interfaces local, network, and/or centralized components

Central Grey Box

Local Black Box



Centralized Panels:
- Wiring Connections for control and/or power
- Hardwired or programmed for localized functionality

USER FRIENDLY

Occupancy Sensor:
- Wallbox
- Ceiling with Relay

Input: IN or OUT of space

Output: ON/OFF

Photocell:
- Ceiling mounted
- Sometimes integral in wall occupancy sensor
- Open or Closed Loop

Input: Lighting Level

Output: Continuous or switched level

CPU:
- Programming for overall functionality

Local Dimmer:
- Wallbox
- Handheld Remote
- Desktop Computer

Input: Human Preference

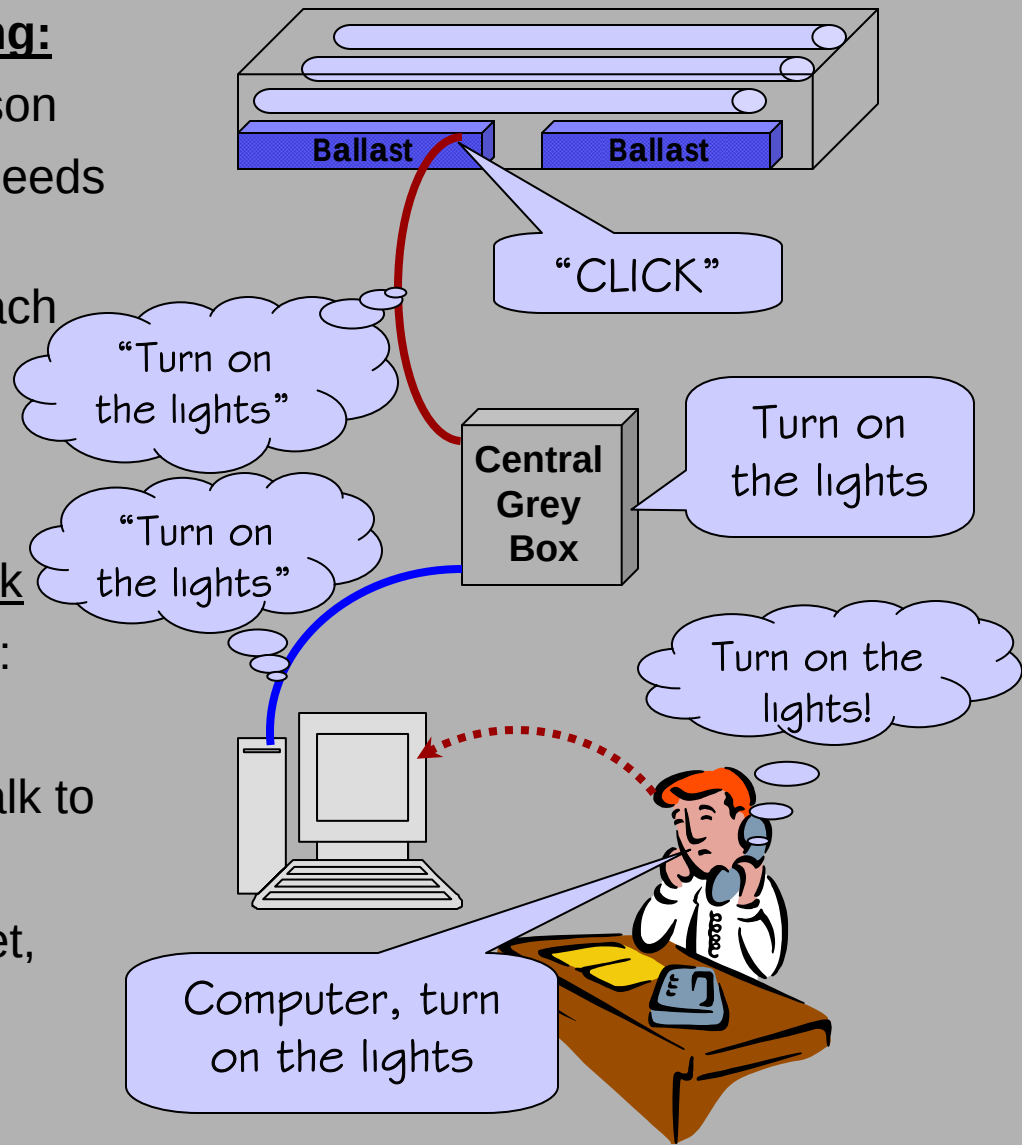
Output: Continuous or Switched Level

Software:
- User Interface for defining system settings

Protocol Concepts

Lighting Controls are like people talking:

- Each Devices can be considered a person
- Between each person, a conversation needs to take place
- In order for the conversation to work, each person must:
  - Speak the same language
  - Have complementary intellect
  - Know when its time to listen or speak
- If any of these conditions does not exist:
  - May need an interpreter or gateway
  - May need to find someone else to talk to
- The wiring is like air for sound
  - It must be able to accurately interpret, carry, and speak the language being spoken



Dimming System Control Protocols

- **A Protocol establishes a fixed set of parameters by which a system works.**
- **Protocols established in dimming systems cover both the electrical wiring method and the logic by which the system is driven.**
- **Prior to DALI, the industry had not standardized on a protocol, and each manufacturer developed a unique system that operated differently from other manufacturers.**

Dimming System Design Considerations

- **Do I need local or centralized control?**
- **Do I need the system to be monitored?**
- **Do I need to be able to control the system from a central control point or from remote sites?**
- **How does the system comply with Title 24?**
- **How easy is it to install, commission, operate, and maintain?**

Dimming System Protocol Considerations

- **Number and Type of local controls available**
  - **Occupancy Sensors**
  - **Photosensors**
  - **Wallbox dimmers**
  - **Computer Interface**
- **Proprietary or Universal Protocol for interfacing with other systems/manufacturers**
- **Warranty of product**
- **Reputation and Stability of manufacturer**

Fluorescent Dimming Ballast Considerations

- **Range of dimming**
- **Availability of #Lamps/Ballast (1,2,3,4)**
- **Establishes Language for Control System**
- **Energy Efficiency / Energy Consumption are function of the ballast: must look at load profile curves (compares % absolute light level dimmed to power consumption)**
- **Affects on Power Quality**
- **COST**

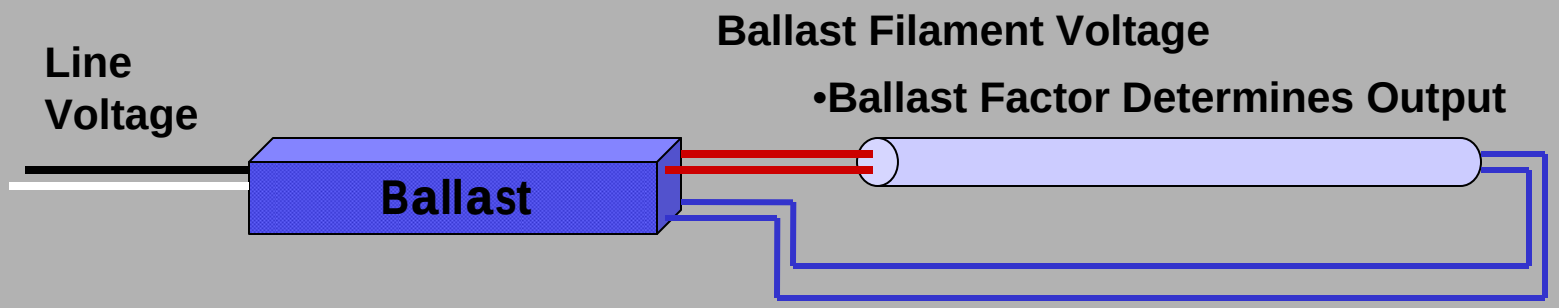
Fluorescent Dimming System Control Signals/Protocols

- **Dimming Signal Options:**
  - **Line Voltage Dimmer (Advance Mark X)**
  - **Line Voltage Proprietary (Lutron)**
  - **Low Voltage (0-10 Protocol)**
  - **Digital Proprietary Protocol (Easylight)**
  - **Digital Protocol (DALI)**

Dimming Ballast Comparisons

Ballast	Control Signal	Dimming Range
Advance Mark X	120V Inc. Dimmer	Down to 5%
Lutron Hi-Lume	Proprietary Line V.	Down to 1%
Lutron Eco-10	Proprietary Line V.	Down to 10%
Generic	0-10V	Down to 5%
Easylight	Proprietary Analog	Down to 10%
DALI	DALI	Down to 1% for Linear
		Down to 3% for CF

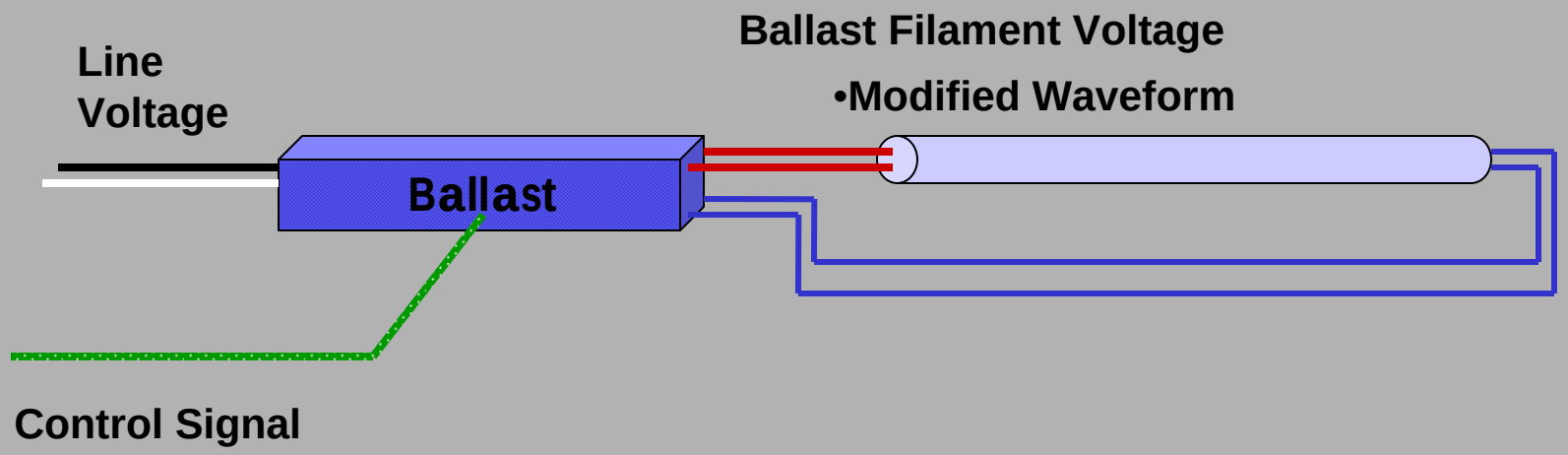
Fluorescent Operation



Basic ON/OFF Operation

- Ballast electronics are simple
- Ballast rated with constant Ballast Factor (BF) that determines the light output of the lamps
- Instant Start, Programmed Start, or Rapid Start Operation

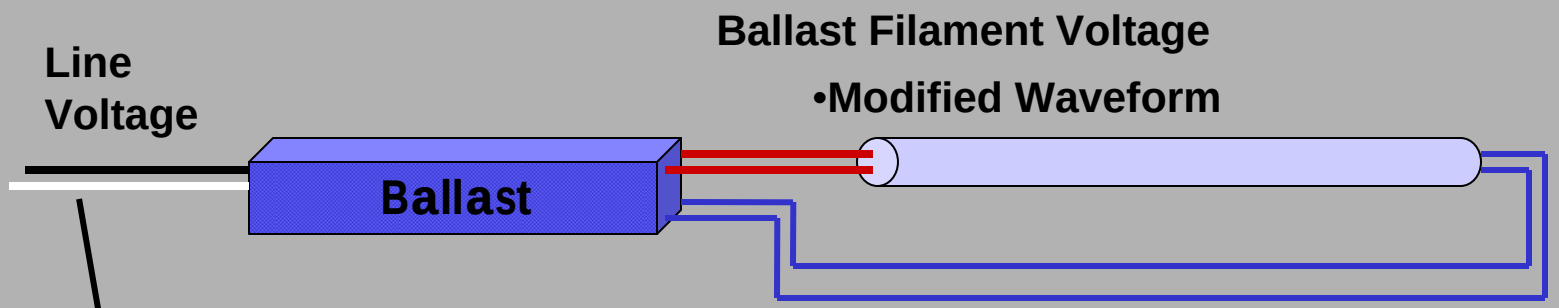
Fluorescent Dimming



Dimming Operation

- Takes input signal and changes the output power to lamps
- Control Signal determines the types of control devices that can be used
- Ballasts determines system efficacy and power quality

Line Voltage Fluorescent Dimming

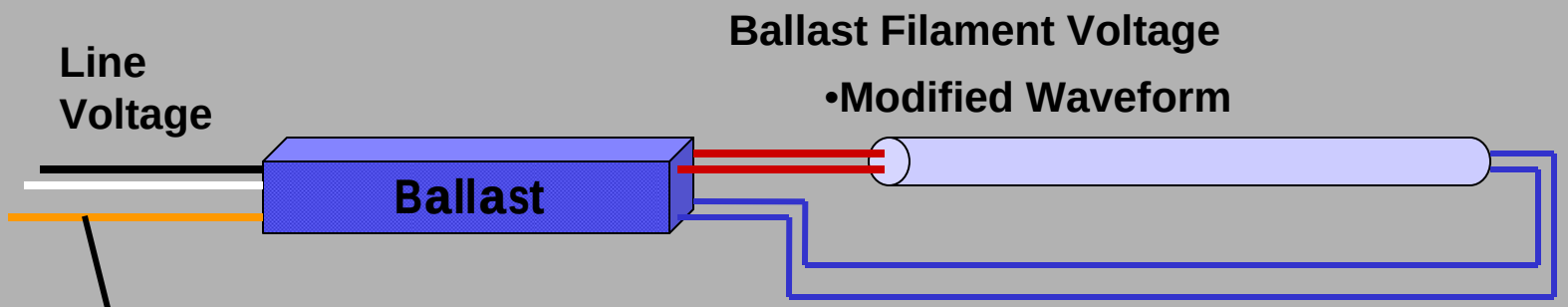


Requires 2 wires:

- **Dimming signal comes from common incandescent dimmer that modifies the waveform of the line voltage**

Advance Mark 10 Model

Line Voltage Fluorescent Dimming

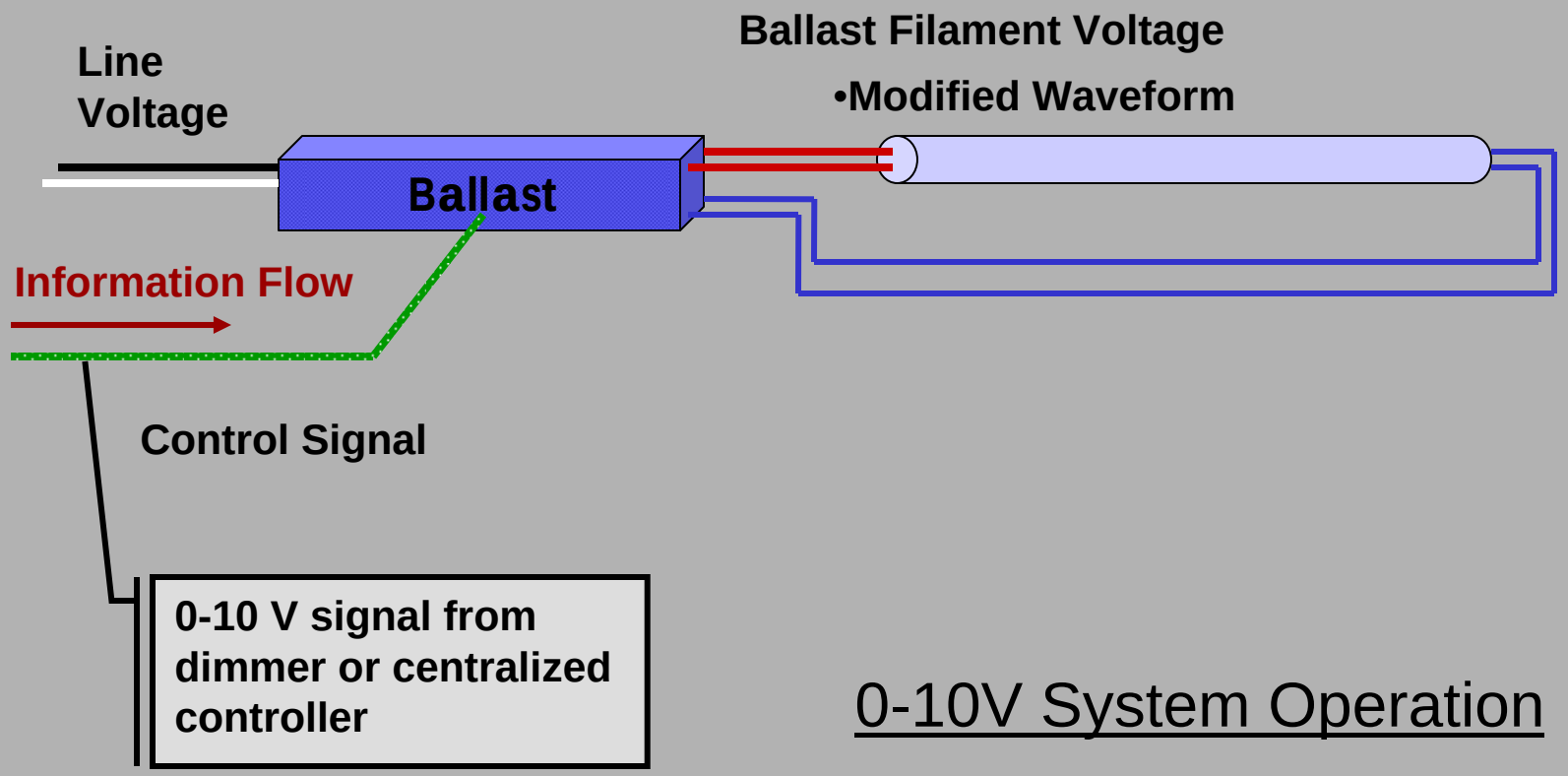


Requires 3 wires:

- **(1) ON/OFF Hot**
- **(1) Dimmed "Hot"**
- **(1) Neutral**

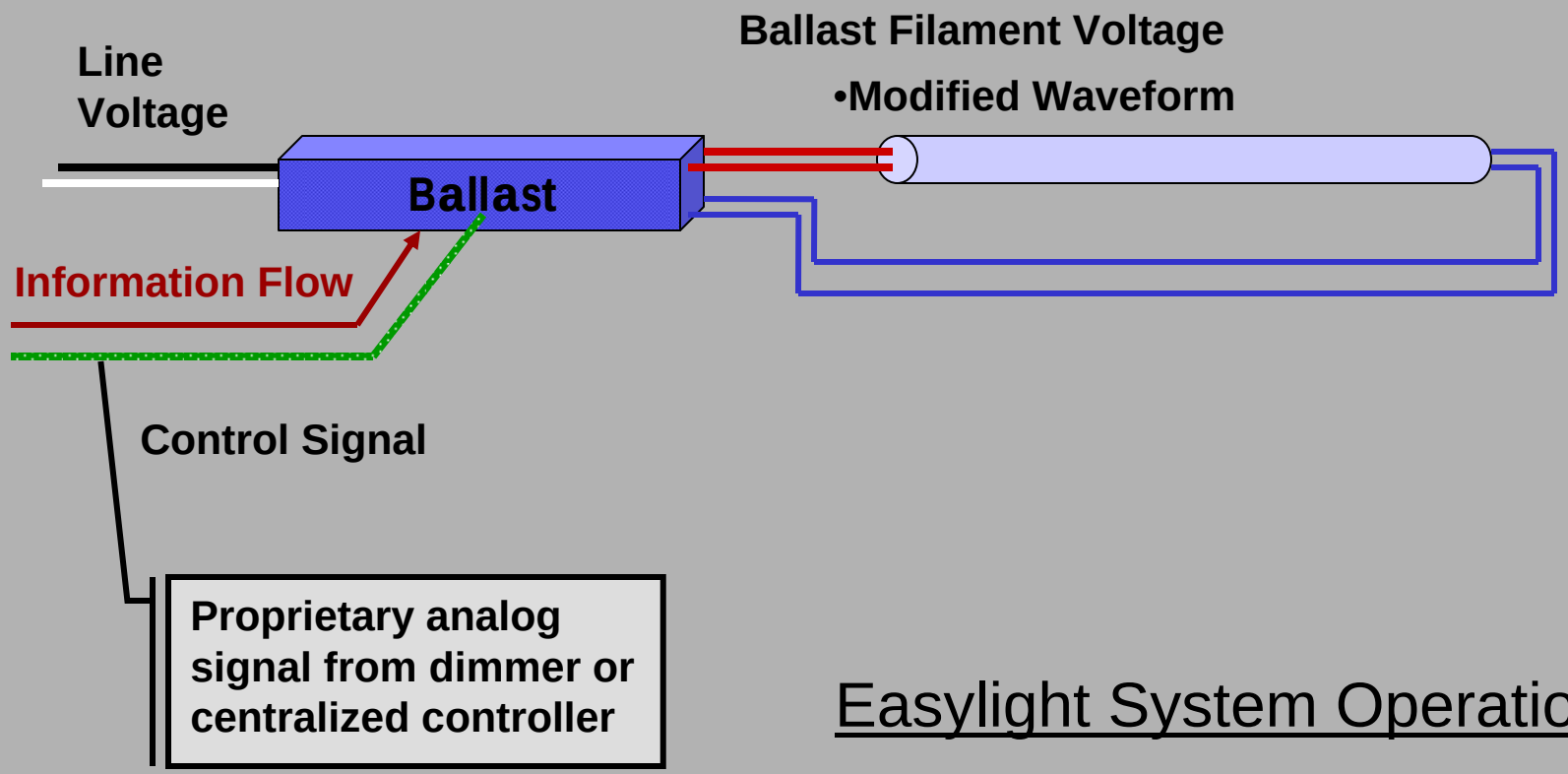
Lutron HiLume, ECO-10 Models

Low Voltage Fluorescent Dimming



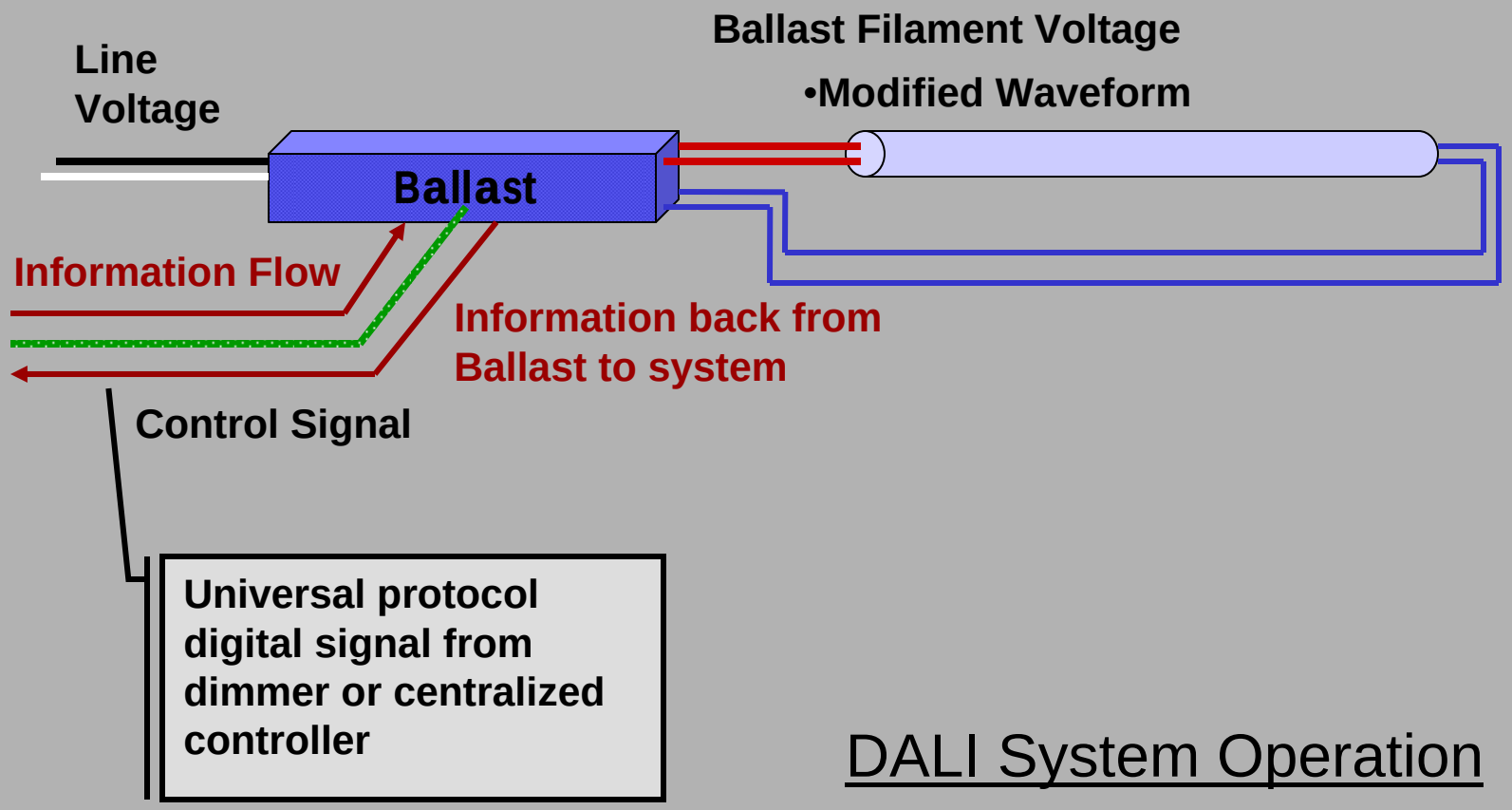
0-10V System Operation

Proprietary Analog Fluorescent Dimming



Easylight System Operation

Digital Addressable Dimming

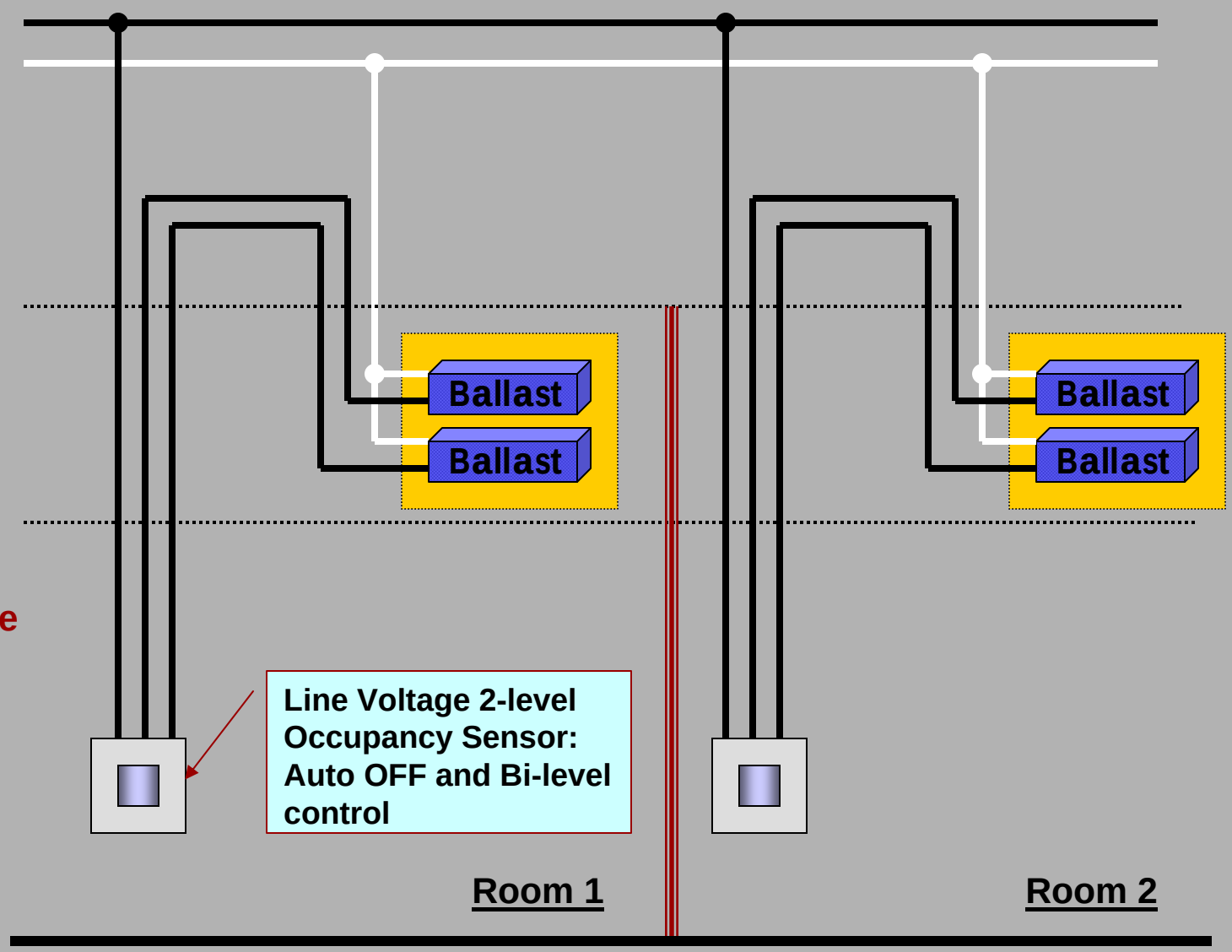


DALI System Operation

Title 24 Control Requirements

- Automatic shutoff requirement
- Local Switching requirement
- Bi-level switching requirement
- Daylight switching requirement

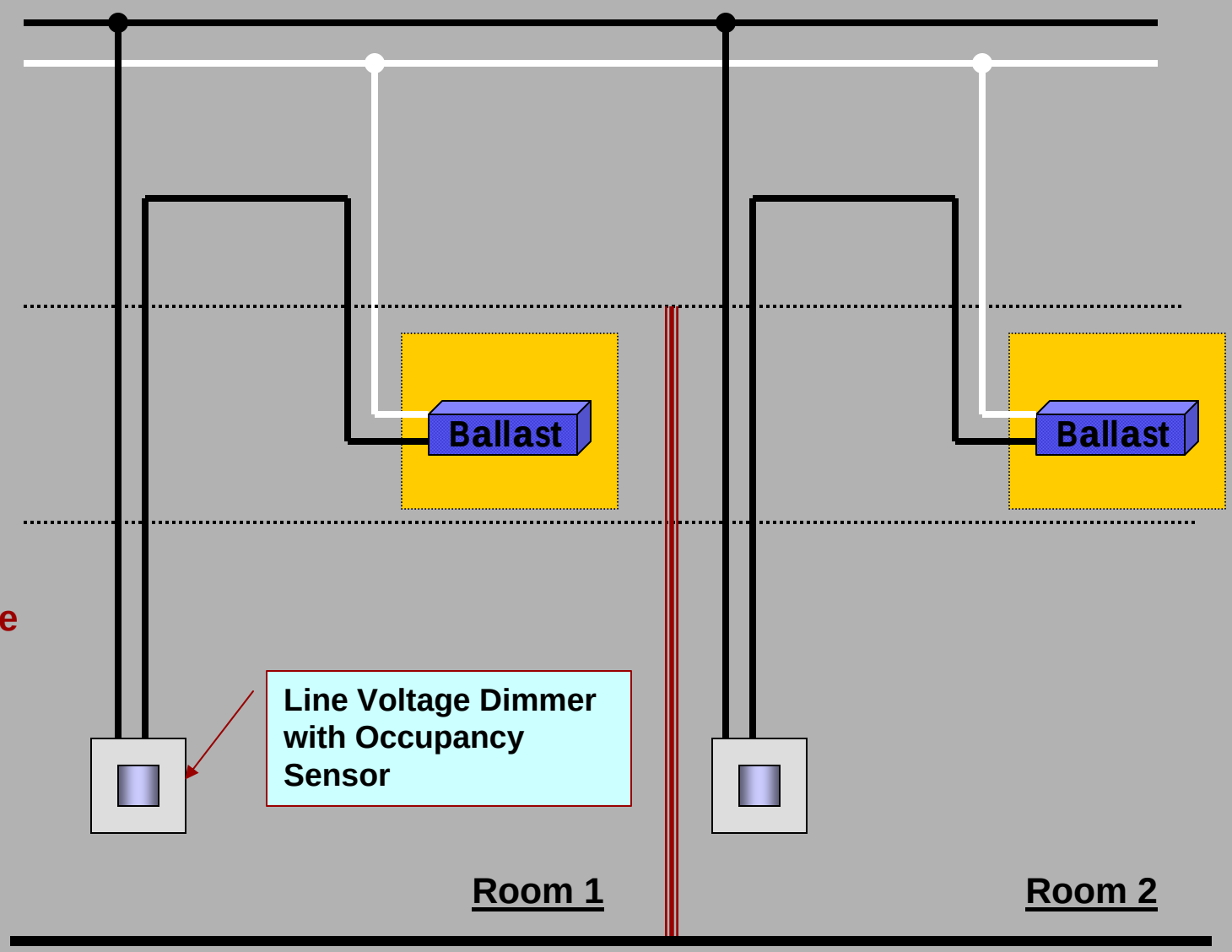
Standard Bi-Level On/Off



NOTES:

- All Line Voltage Components
- Local Control, No Networking Capability
- No Dimming, only Bi-Level

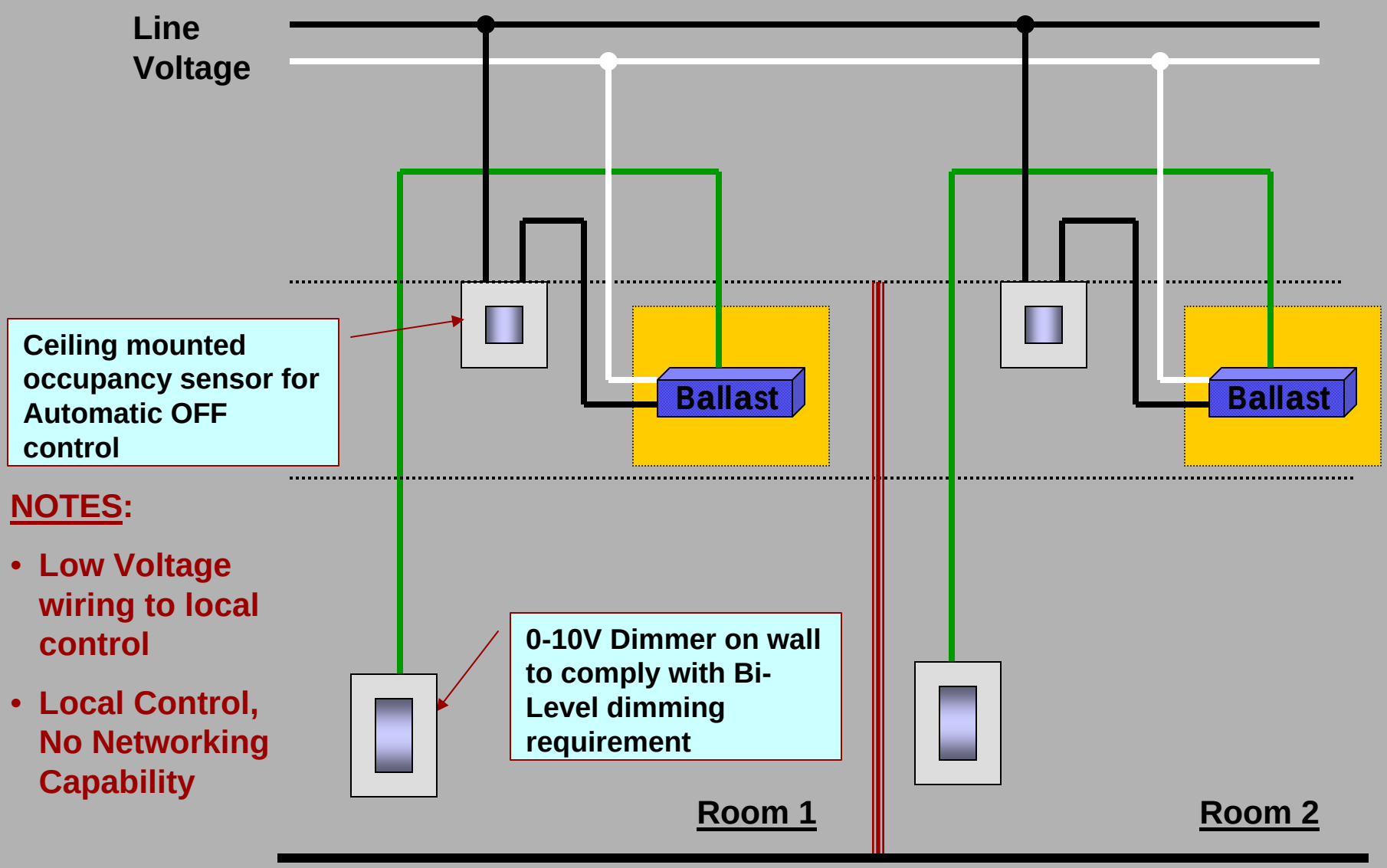
Line Voltage Dimming w/OS



NOTES:

- All Line Voltage Components
- Local Control, No Networking Capability
- Continuous Dimming

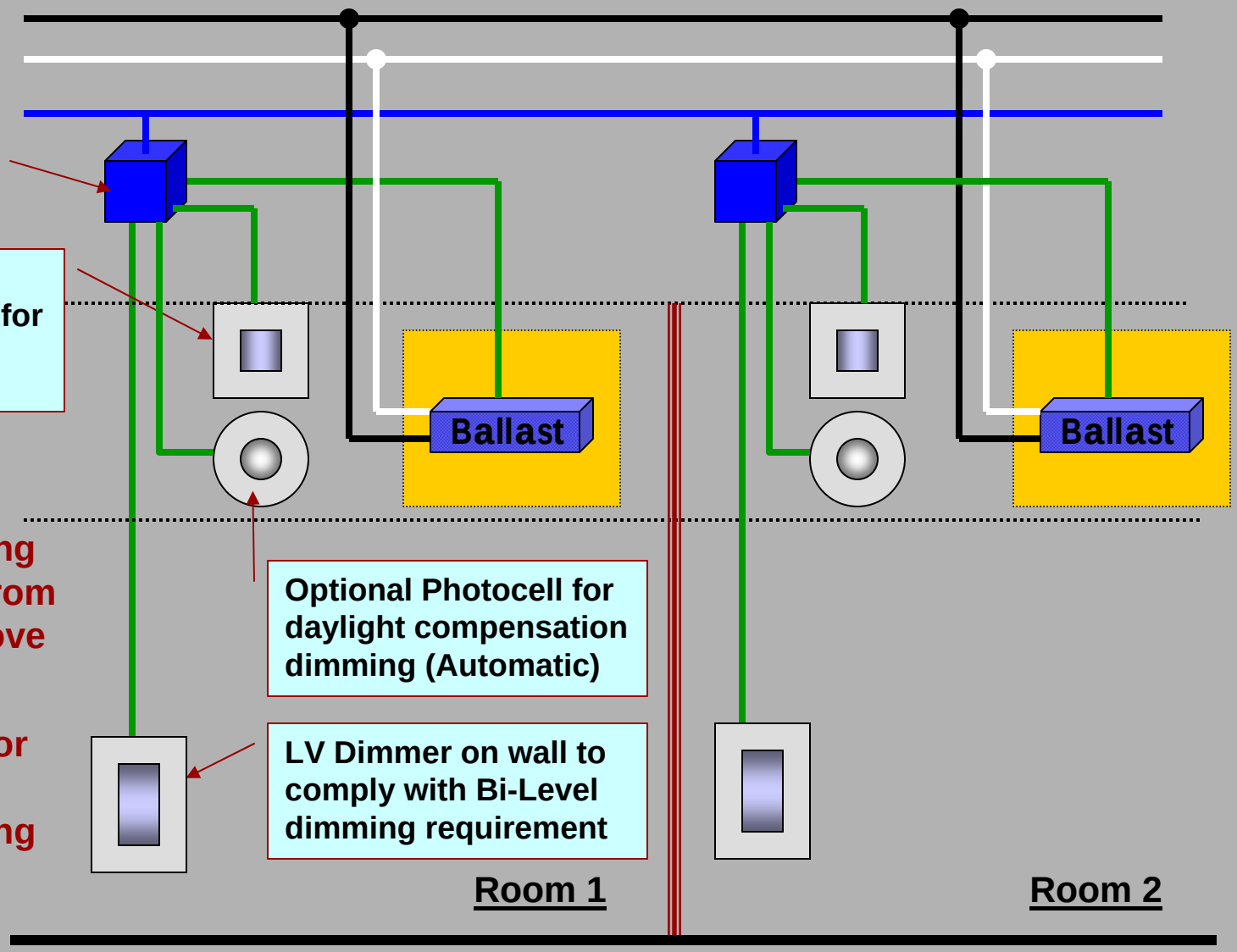
O-10V Dimming



NOTES:

- Low Voltage wiring to local control
- Local Control, No Networking Capability

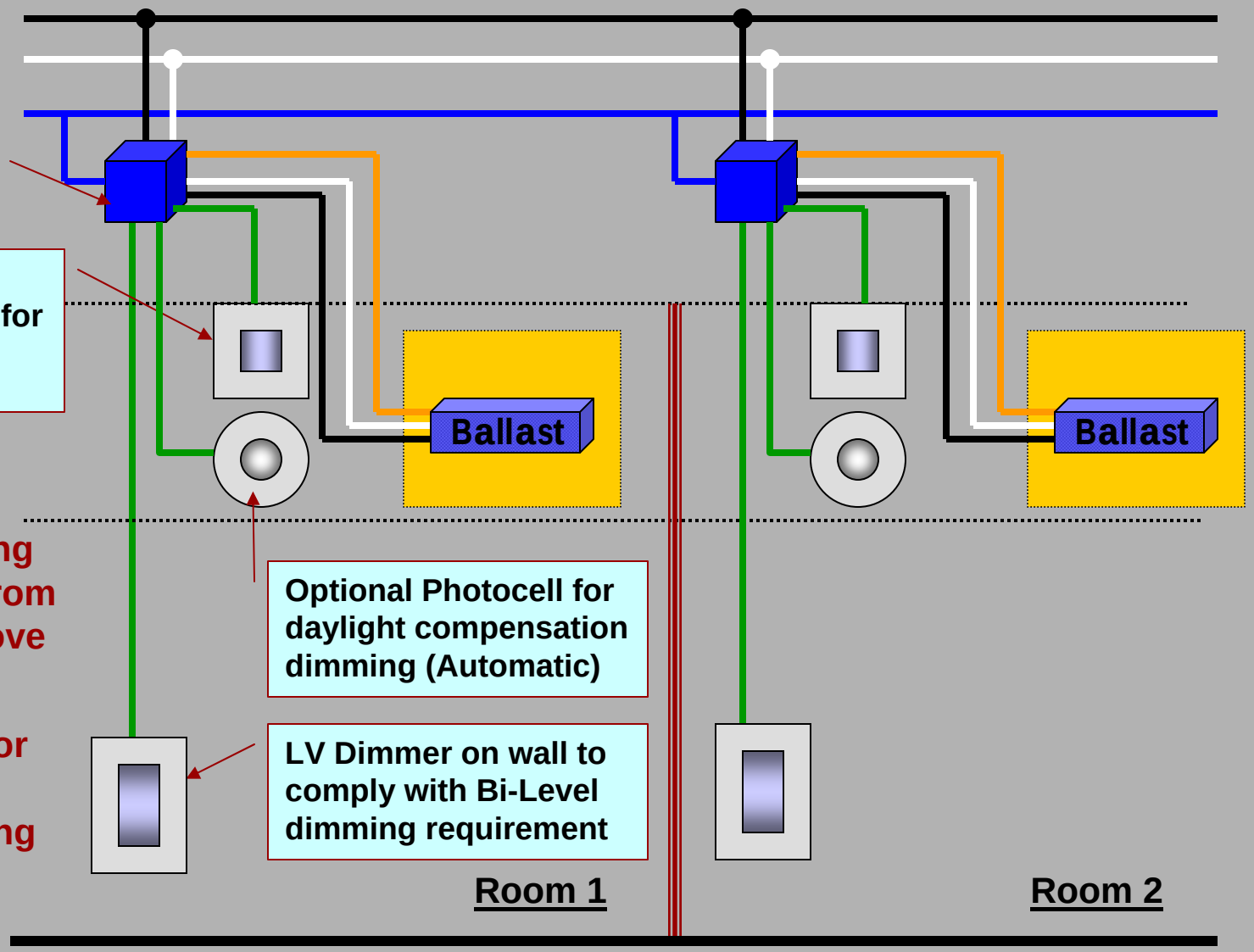
Networked LV Dimming



NOTES:

- Low Voltage wiring to local control from interface box above ceiling
- Network allows for centralized maximum dimming and load shed capability

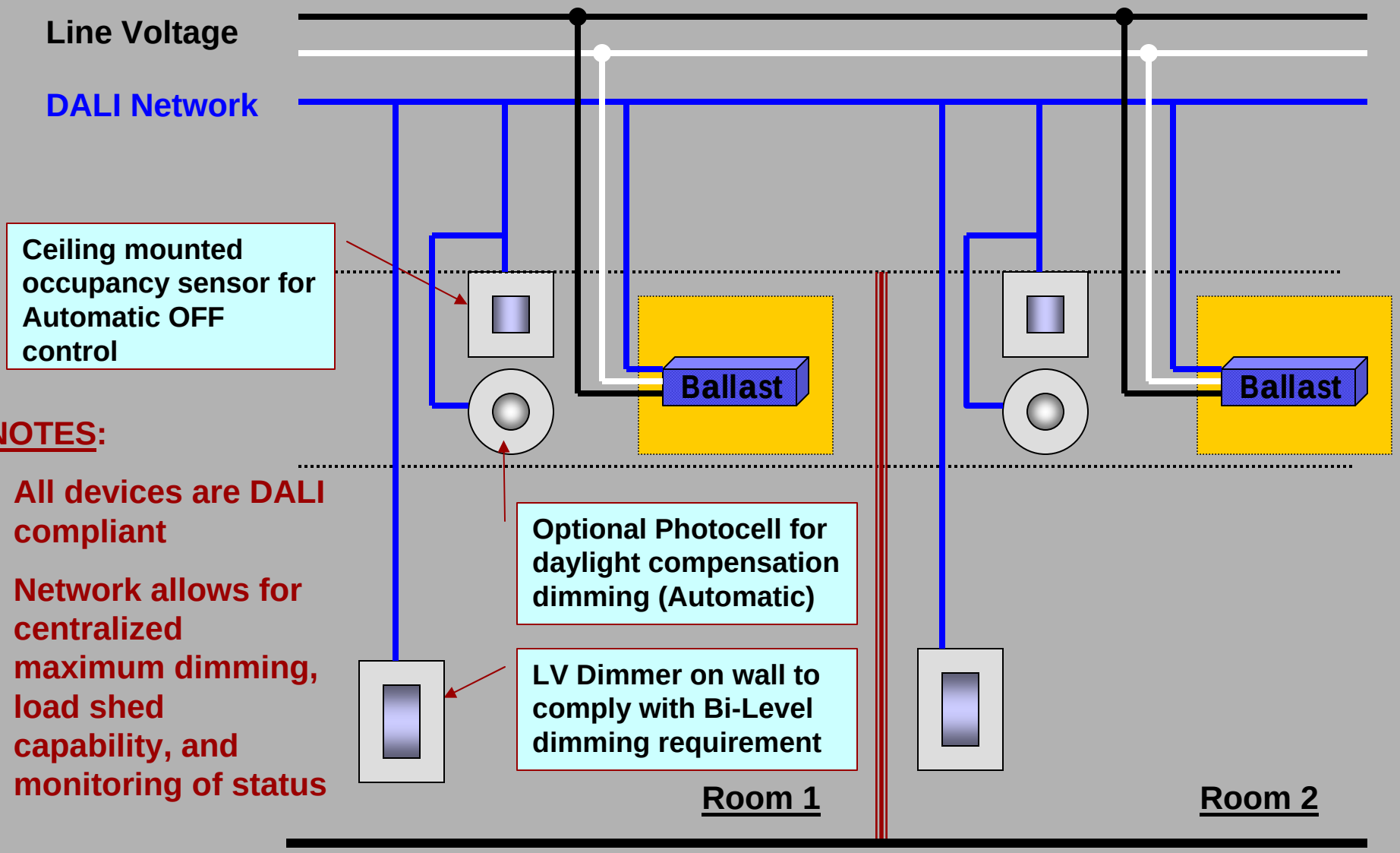
Proprietary Line Dimming



NOTES:

- Line voltage wiring to local control from interface box above ceiling
- Network allows for centralized maximum dimming and load shed capability

DALI Dimming



NOTES:

- All devices are DALI compliant
- Network allows for centralized maximum dimming, load shed capability, and monitoring of status

Making the case for Fluorescent Dimming Systems

User Satisfaction:

- **Using dimming systems will result in better visual comfort, especially in office environments with computer usage.**
- **Using dimming systems will result in overall user satisfaction by allowing individuals to have more control (unless the system is too complicated).**
- **Reductions in lighting are better if they are uniform and gradual, as opposed to stepped dimming.**

Making the case for Fluorescent Dimming Systems

Energy Conservation:

- **Using dimming systems generally results in lower energy costs. The level varies with application.**
- **Many fluorescent systems are overlit for their environments - It is difficult to quantify the amount of overlit space due to ranges in IES recommendations and user preferences.**
- **When tied with other components, additional energy savings are obtained through daylight controls and diurnal cycling control concepts.**

Making the case for Fluorescent Dimming Systems

Building Management:

- **User Satisfaction results lead to fewer complaints and potentially added health benefits (lower glare, better vision, less eye strain, fewer headaches, etc)**
- **Energy benefits can be substantial, and can have a positive ROI when considering the long-term costs.**
- **Versatility in changing lighting levels based on use in large spaces is a long-term benefit.**

Making the case for Fluorescent Dimming Systems

<u>Scotopically Enhanced Lighting Applications</u>:

- **In retrofit or new construction, the added incremental energy savings from Scotopically Enhanced Lighting are sometimes best achieved through dimming.**
- **In parabolic lighting, it is necessary to dim the lights to bring down the apparent brightness.**
- **Recent research indicates that direct/indirect lighting may provide increase visual comfort, in conjunction with scotopically enhanced lighting.**

Making the case for Fluorescent Dimming Systems

Economics – First Costs:

- **First Cost Increases: BALLASTS are generally the biggest adder on the first cost. These costs are difficult to quantify, since they are blended with fixture costs in new construction. In addition, some dimming systems are overly complicated and ADD to the component cost of new systems.**
- **First Cost Decreases: Many dimming systems simplify wiring to comply with the automatic shutoff, bi-level switching, and daylight zone control requirements of Title 2; Many dimming system components (i.e. panels and hardware) are very competitive with intelligent ON/OFF relay panels.**

Making the case for Fluorescent Dimming Systems

<u>Economics: Generally unrecognized costs</u>:

- **Engineering: It takes a bit longer to engineer dimming systems due to the increased complication of coordinating all the parts and pieces.**
- **Commissioning: This number can be significant. Fine tuning dimming systems and making sure all the components are working as engineered takes time. General Rule of Thumb: The more versatile the system, the more complicated to commission.**

Making the case for Fluorescent Dimming Systems

<u>Economics: Long-term savings</u>:

- **Energy: In some retrofit scenarios, the savings can be significant, especially in cases where the space has T12 lamps, is overlit, or is using Scotopically Enhanced Lighting as the retrofit.**
- **User Satisfaction: It is widely recognized that dimming systems result in higher user comfort and satisfaction. While no hard economic numbers are obtainable, we can say that better visual comfort and user satisfaction have positive economic benefits for management.**

Making the case for Fluorescent Dimming Systems

	Option 1	Option 2	Option 3	Option 4	Option 5
Scheduling Control	●	●	●	●	●
Load Shedding & Daylight Dimming		●	●	●	●
Layout: One Fixture per User			●	●	●
Workspace Occupancy Sensing				●	●
Personal Dimming					●
Total Cost Savings	5%	10%	40%	60%	70%

Chart courtesy of Lightolier

Making the case for Fluorescent Dimming Systems

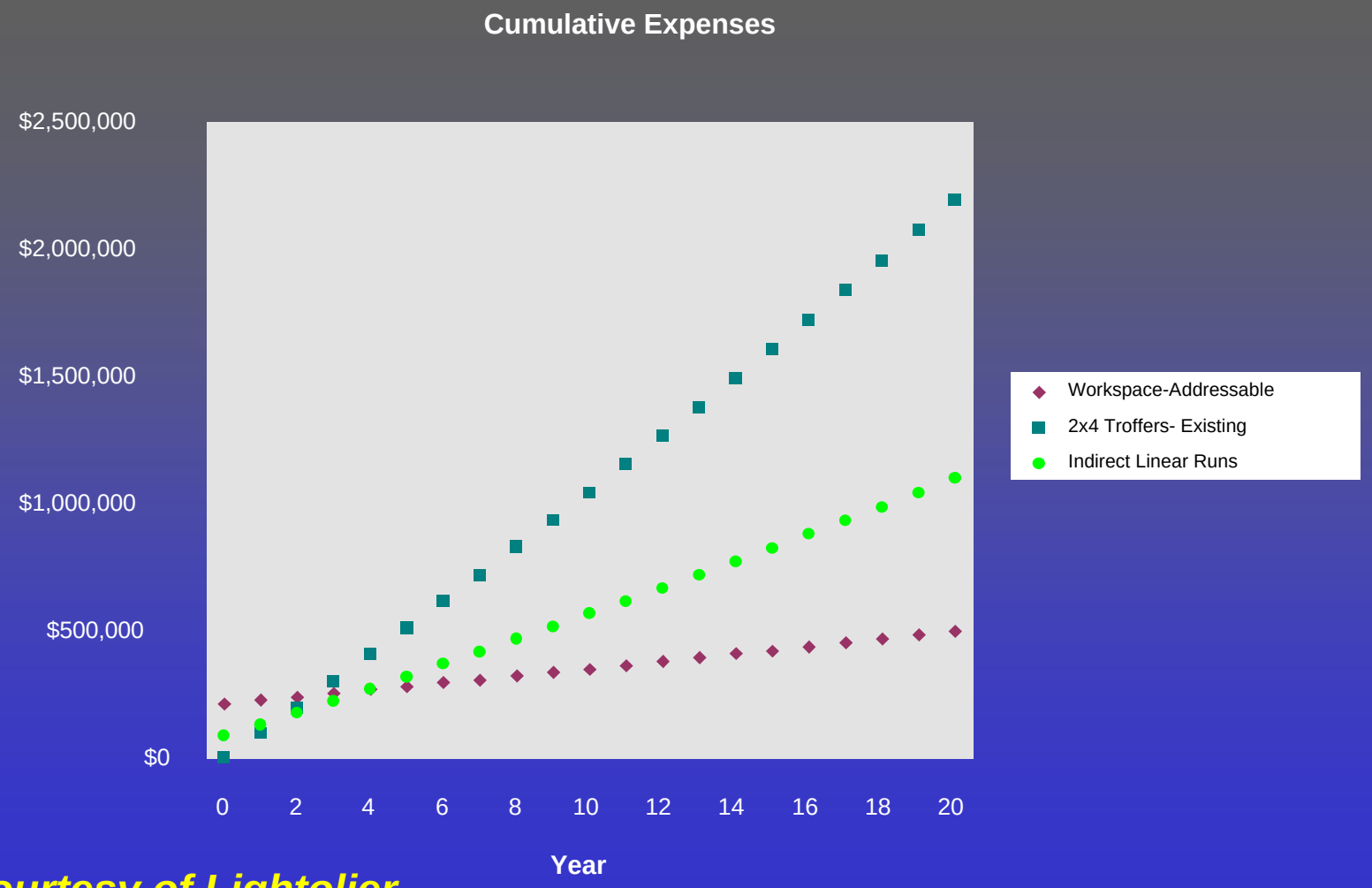
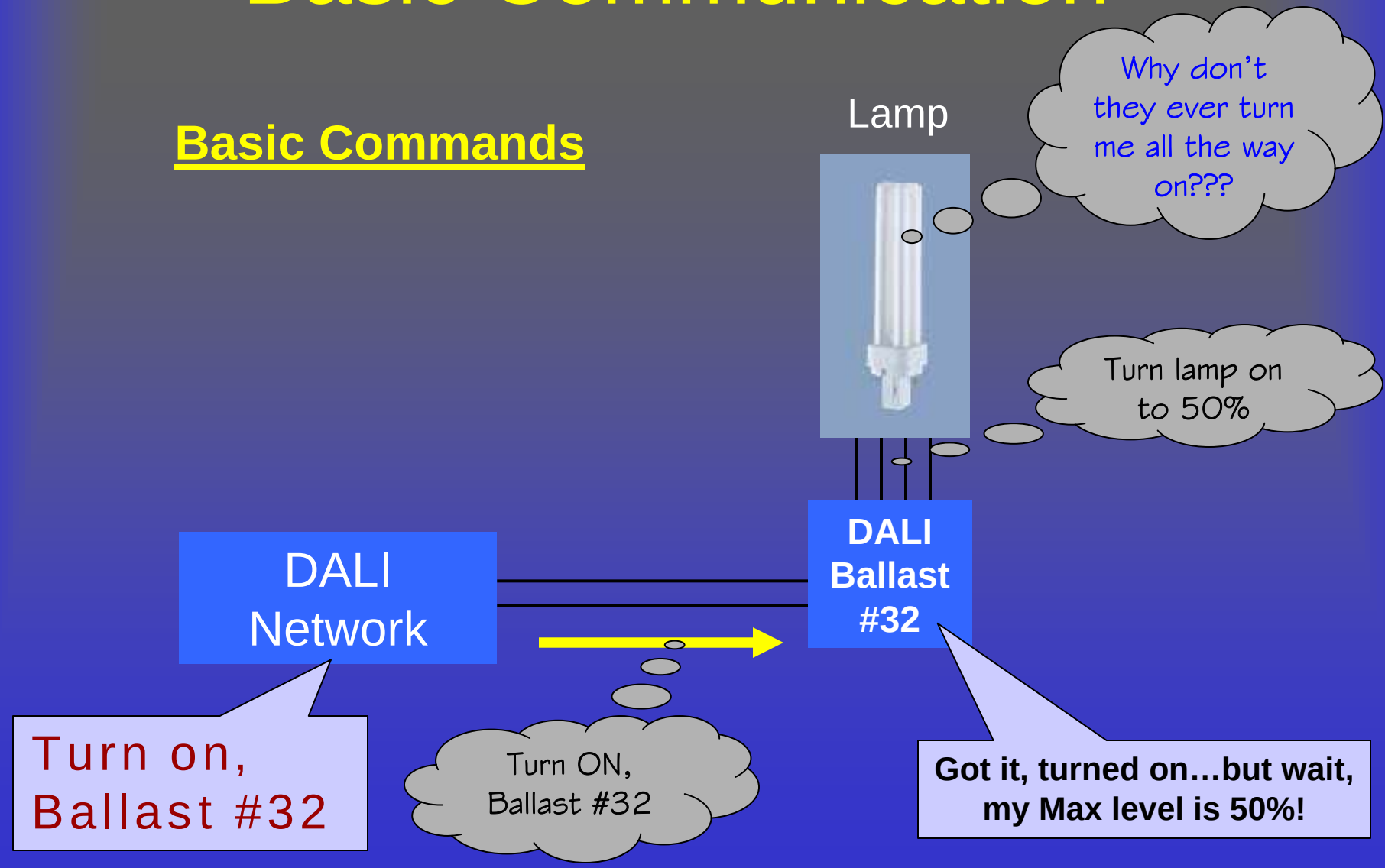


Chart courtesy of Lightolier

DALI – How it Works

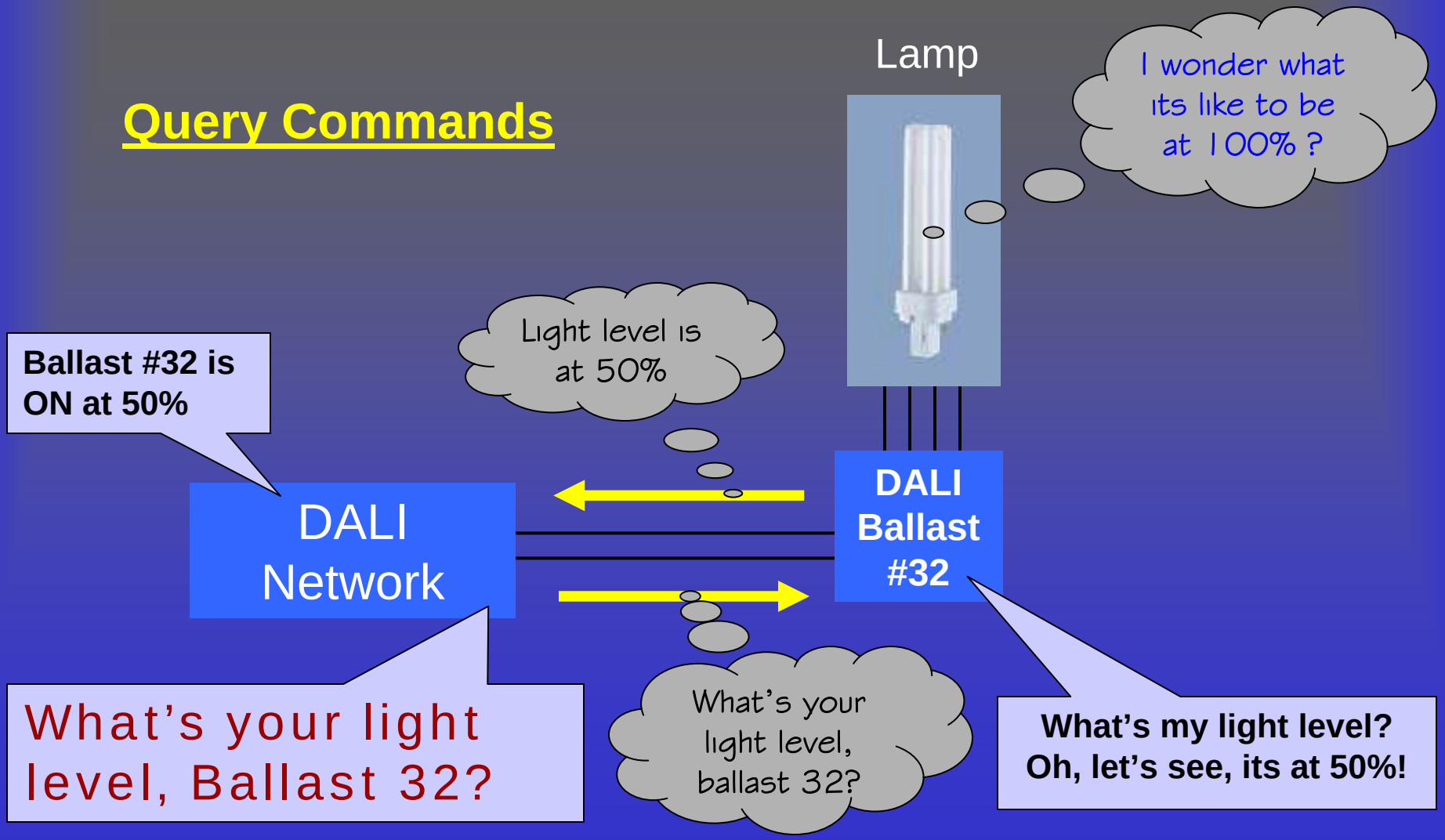
Basic Communication

Basic Commands



Basic Communication

Query Commands



DALI Protocol

- DALI is not a product
- DALI is a protocol (a set of rules) (from ballast perspective)
  - Power connection
  - Lamp response
  - Control interface
  - Command set

Protocol: Power Connection

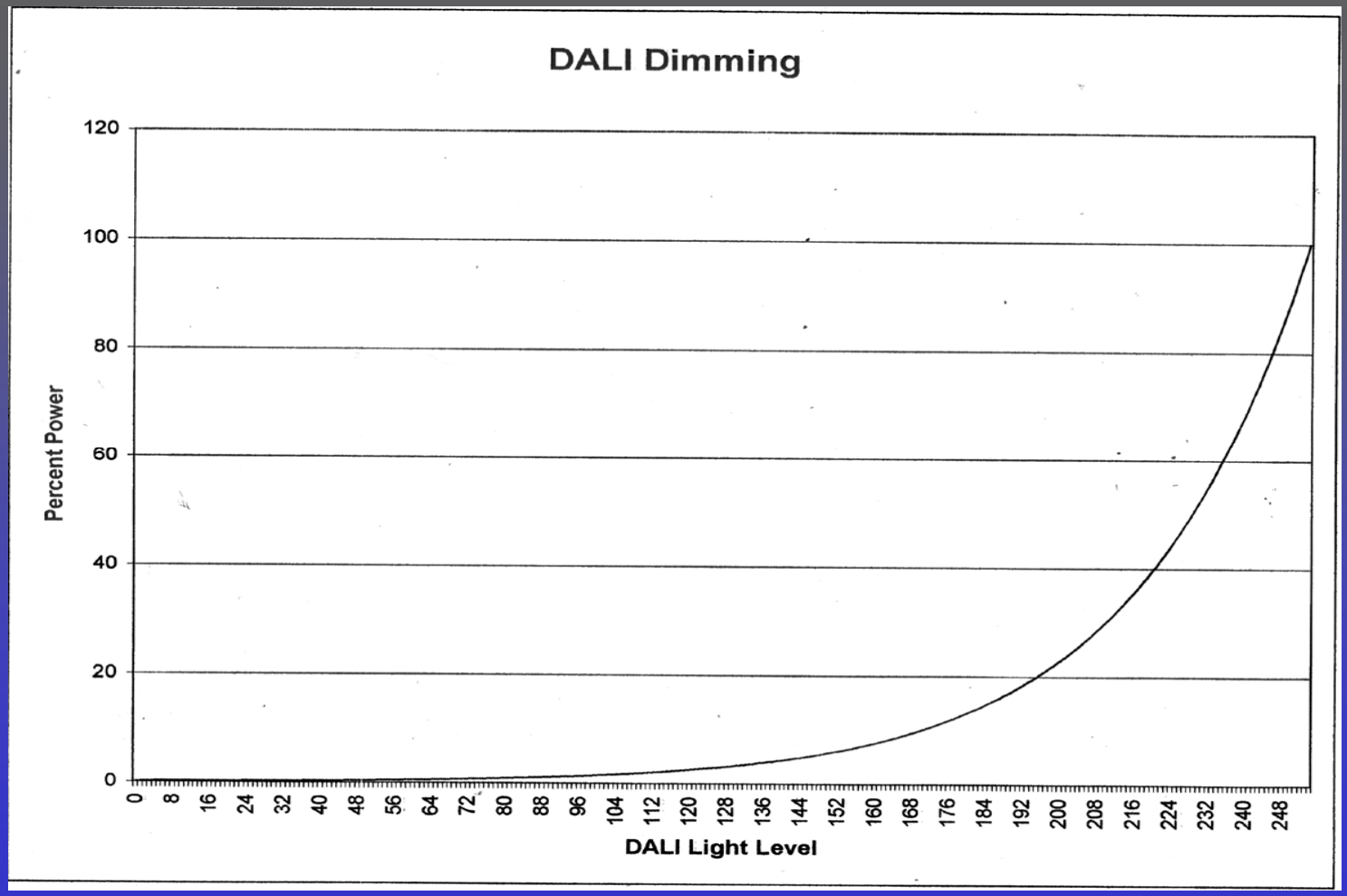
- Initial application of voltage – lamps go to full output or other preset level
- Universal voltage input – 115V to 300V, 50Hz to 60Hz
- High power factor
- Low harmonics
- Transient protection

Protocol: Lamp Response

- Precise dimming curve
  - Logarithmic curve
  - Range:

    0.1% to 100% for incandescent,
    1% to 100% for linear fluorescent,
    3% to 100% for CF
  - 254 steps (2.8% increase per step)
  - Based on lamp arc power
  - (This is not lamp lumen output)

Protocol: Lamp Response



Protocol: Control Interface

- Intent
- Electrical
- Media
- Wiring
- Bits and Bytes
- No Collision Detection

Control Interface: Intent

- Low cost
- Simple
- Low interference
- Interchangeable

Control Interface: Electrical

- Voltage – 0 VDC to 16VDC
- Voltage drop – must not exceed 2 volts
- Loss of control voltage – lamps go to preset level
- Current – 2 ma consumption, able to sink 250 ma
- Power – Remote power supply of <250 ma
- Speed – 1,200 bits/sec (compare to Ethernet at 100Mb/s)
- Must be able to withstand live voltage

DALI Ballast Block Diagram

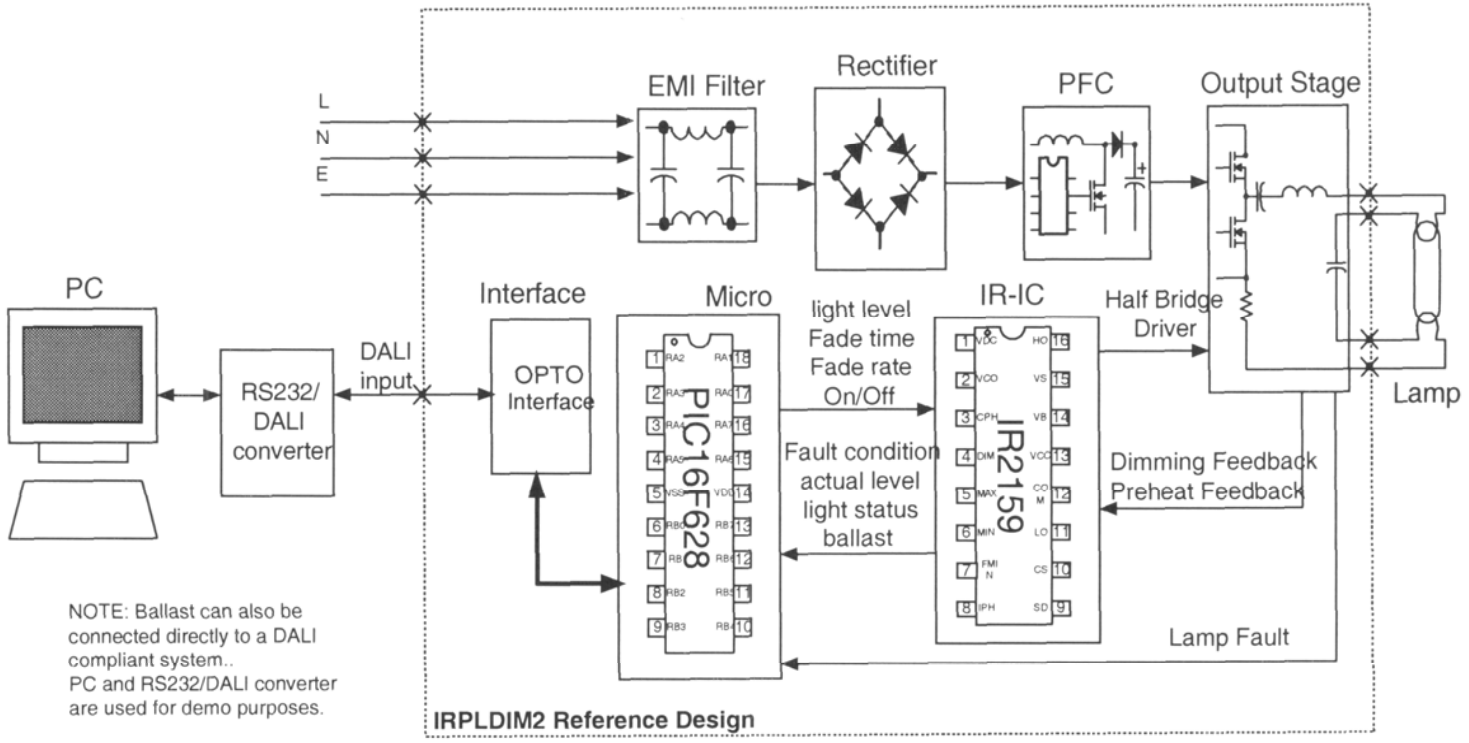
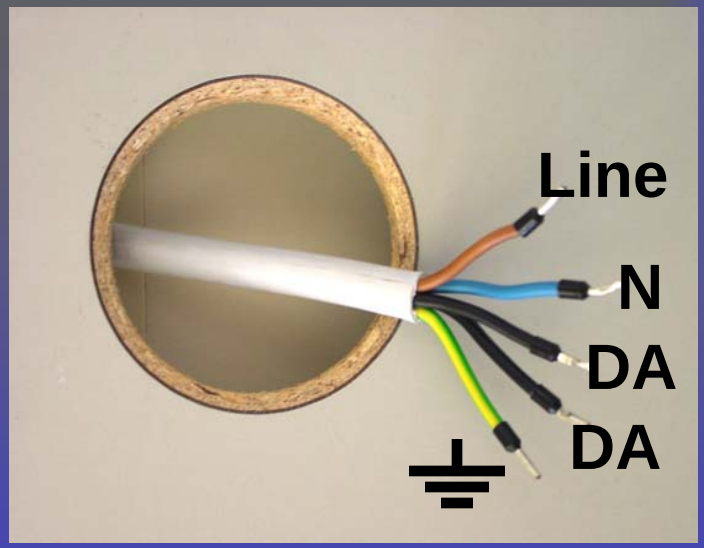


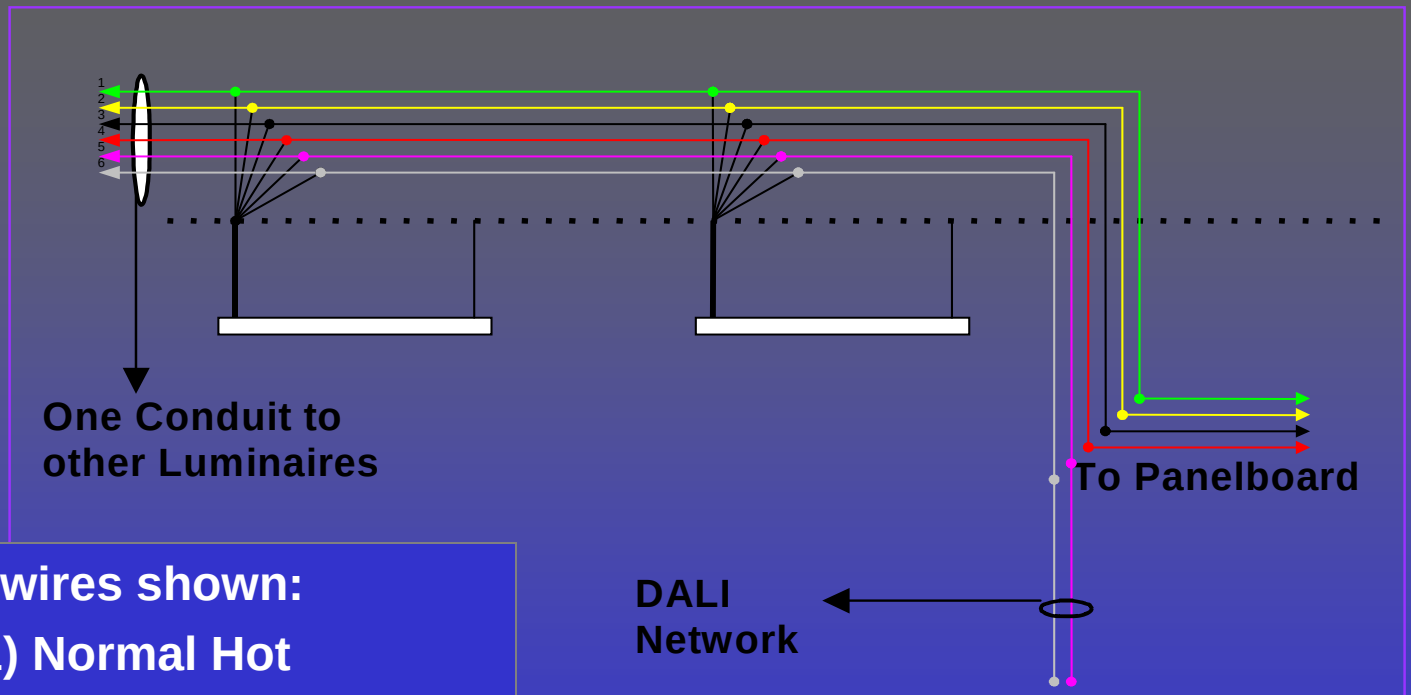
Fig. 3 IRPLDIM2 Block diagram

Control Interface: Media

- 2 wire power & network
- Twisted Pair/Shielded Pair not required
- Non-polarized
- No end-of-line resistor
- Standard material and methods
- Class 1 or 2 wiring (in or outside of conduit)
- Low voltage and power limited (3 W per bus)
- Open topology: chain, star, tree



Electrician’s Wiring Diagram



6 wires shown:

(1) Normal Hot

(1) Emergency Hot

(1) Neutral

(1) Ground

(2) DALI

Control Interface: Bits and Bytes

- Address (one specific ballast)
  - 0AAAAAA1 + CCCCCCCC , 0AAAAAA0 + arc power
- Broadcast (all ballasts)
  - 11111111 + CCCCCCCC , 11111110 + arc power
- Group
  - 100GGGG1 + CCCCCCCC , 100GGGG0 + arc power
- “Go To Scene”:
  - 0AAAAAA1 + 0001SSSS
  - 11111111 + 0001SSSS
  - 100GGGG1 + 0001SSSS

Control Interface: No Collision Detection

- Assumes only one sending device
- Ballasts talk only when queried
- No checking for simultaneous commands
- Control manufacturers must provide collision detection

Protocol: Command Set

- Current command set is for ballasts only.
- >100 commands defined (with space for future commands)
- Ability to program, control and monitor status information

Ballast Commands:To Ballast

- Off
- Step Up
- Step Down,
- On and Step Up
- Set Max
- Step Down and Off
- Set Min
- Go to Max
- Go to Min
- Up to Max
- Down to Min
- Fade to Level
- Set Actual Level
- Set Power On Level
- Set System Failure Level
- Set Fade Time
- Set Fade Rate
- Set Scene
- Go to Scene
- Remove from Scene
- Set Group
- Remove from Group

Ballast Commands: Information from Ballast (Query)

- Actual Level (DALI)
- Power ON Level
- System Failure Level
- Max
- Min
- Group Assignment
- Scene Level
- Fade Time
- Random Address
- Version Number
- Device Type

Device Types

- Type 0 – Standard (fluorescent)
- Type 1 – Emergency lighting
- Type 2 – HID lamps
- Type 3 – Low voltage halogen lamps
- Type 4 – Line voltage incandescent lamps
- Type 5…255 – Future device types

DALI – Parts and Pieces

DALI System Components

Ballasts

- Tridonic
  - Linear fluorescent
    1/2 F32T8 & 1/2 F54T5HO.
  - CFL
- Advance
  - Linear fluorescent
    1/2 F32T8 & 1/2 F54T5HO.
- Sylvania
  - Tridonics underneath

Centralized Controls

- Tridonics
  - Busmaster panels
  - DALI RS232
  - Palm-Dim
  - Win-Dim
  - Win-Dim net
- Starfield (Near Future)
  - DALI to Ethernet capability
- Lightolier
  - Tridonics equipment

DALI System Local Controls

Starfield

- Local Dimmers
- Scene Controls
  - In Conference rooms to match A/V controls
- Switch / relays
  - Shade Controls
  - Projector Lift
  - Screen up/down

Watt Stopper

- Scene Controls
  - 4 button scene switches
- Relay Modules
  - Non dimmed lighting

Leviton

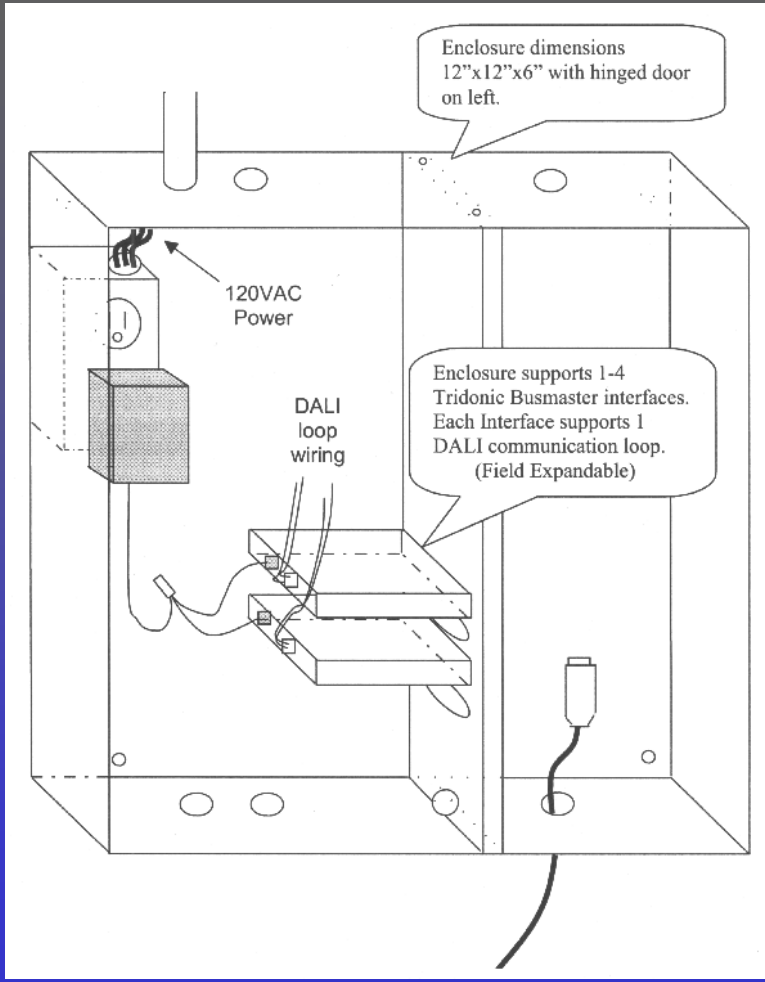
- Scene Controls
  - 4 button scene switches

DALI Loop Controller

(Bus Master)

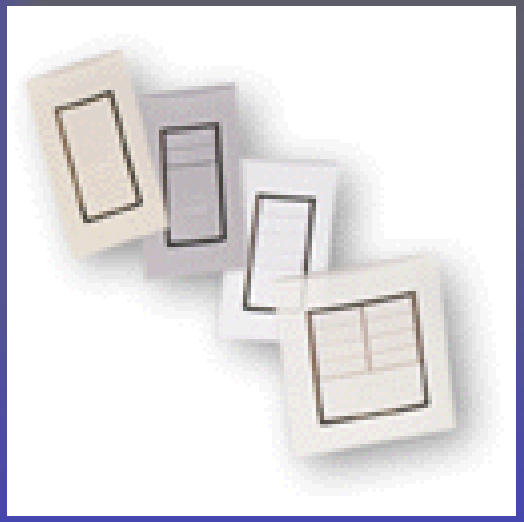
- Required for any DALI System
- Provides power for the DALI dataline
  - Actual power supplied was 150 ma, not 250 ma as specified.
  - Ballast quantity or power consumption dictates bus quantities.
- Provides protocol translation from DALI - RS-232
- One required for every 64 DALI ballasts

Busmaster Enclosure Installation



RS232 Connection

Scene / Group Switches

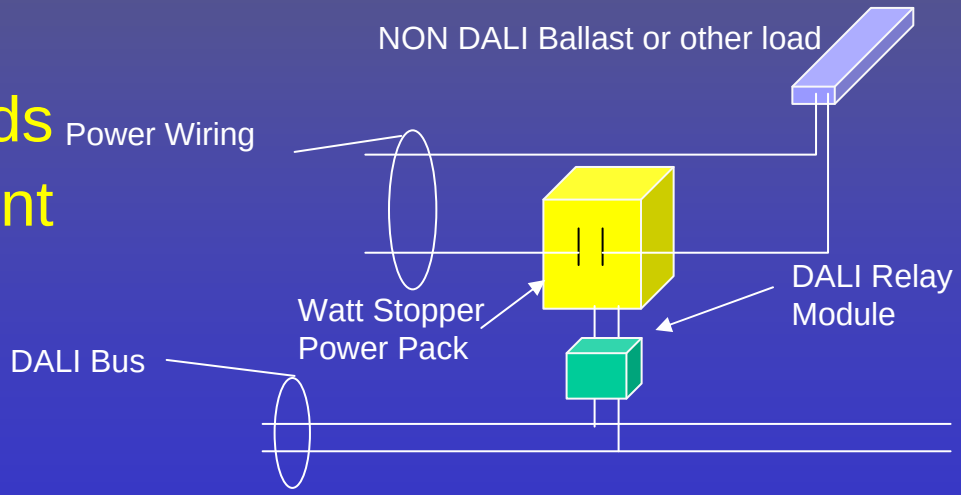


Single gang four button switches

- Individual office control.
  - Ballast and non dimmed CFL control
- Open Office Control
  - Arrive / Depart Group Control
- Includes group raise / lower function.

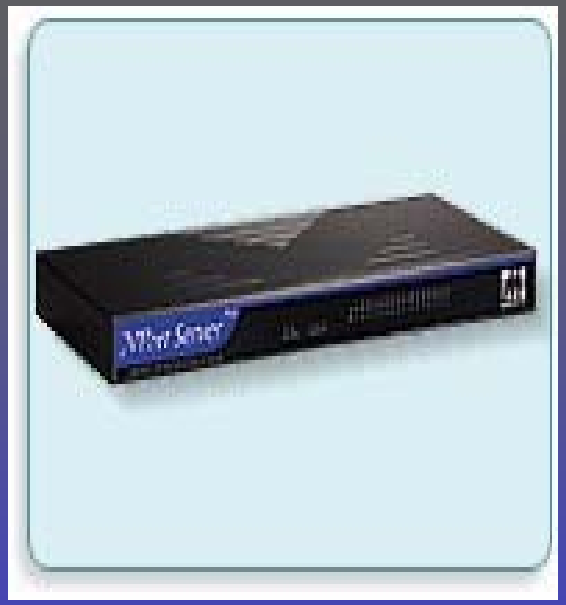
DALI Relay Controls

- Available in Power Packs or switch configuration.
- Used for ON/OFF control off non DALI loads.
- Used for:
  - Non DALI lighting loads
  - Audio Video Equipment
  - Shades / Blinds



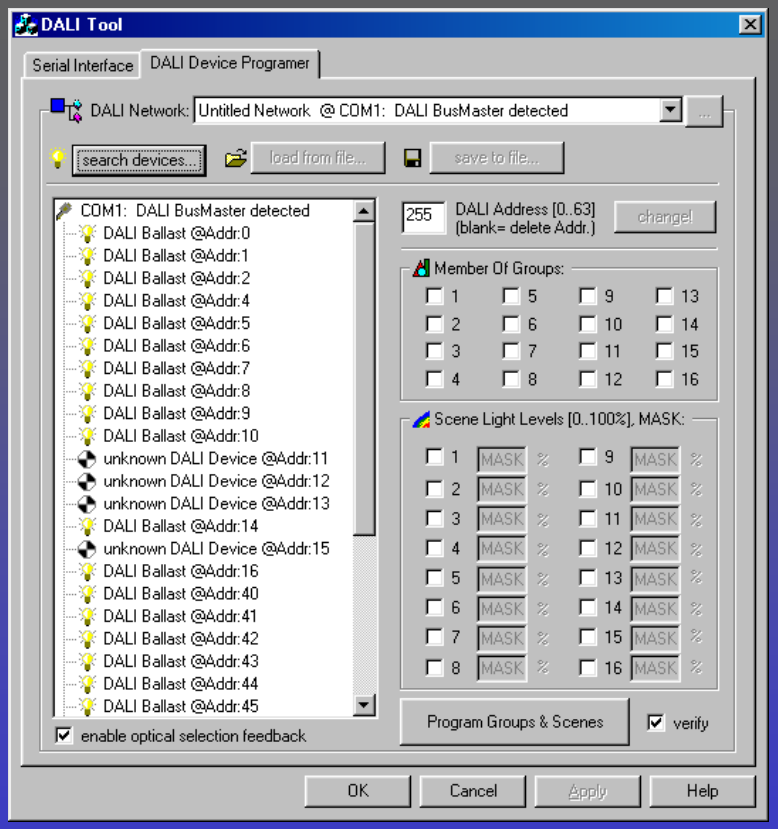
Router

- Used to convert eight RS-232 DALI bus controllers to single Ethernet I./P address.
- Expensive and provides little value.

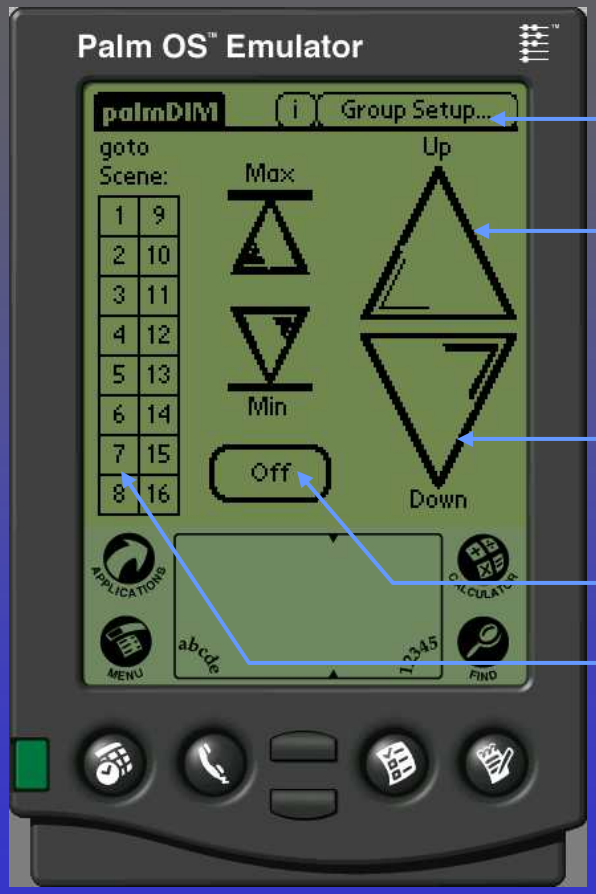


Software for Commissioning

- Assigned unique address for each ballast
  - Address routine brings one ballast to 100%, dims all other ballasts on network.
- Supports replacement or addition of ballasts
- Allows manual control of ballasts
- Configures scenes and groups.



Palm Pilot Interface



Select groups

dim up and down

Off

Select light scenes

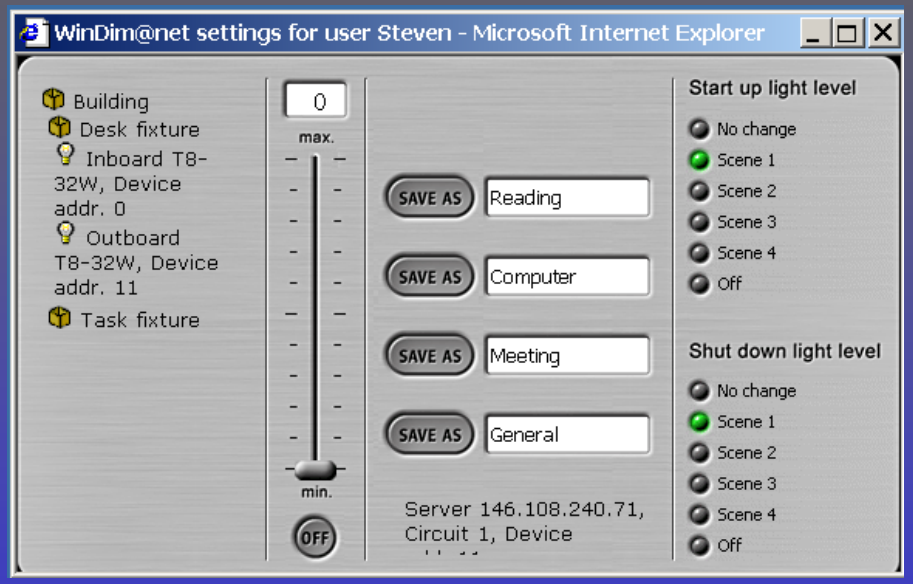
Software for Operation

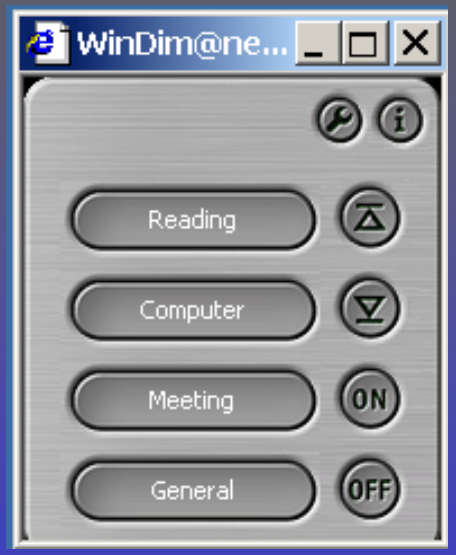
- PC based
  - Manages single DALI bus control
  - Allows monitoring and control

Server Features

- Manages multiple DALI bus controls
- Provides
  - Scheduling
  - Multi bus communication.
  - Allows employee workstations to interface to DALI network.
- Stores historical data

User Interface





Monitoring

- System must poll data from each ballast on regular interval:
  - Slows system down.
  - Must determine appropriate interval for taking readings. Cannot take any more that 1 reading every 5 minutes.
- Data received is crude:
  - Only recognizes state and level of dimmed ballast
  - Does not know what kind of ballast it is: 120V, 277V. 1- or 2-lamp (each has a different power consumption).
  - Requires extensive work in building database structure in order to get meaningful data.

Auxiliary Components

- Power Supply
  - Voltage – 16VDC
  - Power – <250 ma
- Controller Units
  - Scene Controller
  - Daylight Harvesting Controller
  - Occupancy Controller
- Computer Interface (optional)

Auxiliary Components (Cont'd)

- Gateways
  - DALI – RS232
  - DALI - Ethernet
  - RS232 – Ethernet hub
  - In separate cabinet from the branch circuit panelboard

Summary – Parts and Pieces

- Local Controls are sparse.
  - DALI Occupancy Sensors
  - Local Override that provides REAL time override
  - One manufacturer doesn’t have everything yet.
- Software of system is not intuitive or easy.
  - Significant IT personnel involvement and training.
  - Potentially longer commissioning time as compared to other systems.
  - Scheduling needs additional development.
  - Monitoring capability is marginal and extremely difficult to glean useful information from.

DALI – Commissioning

DALI Programming

- Each DALI loop can support up to 64 individual addresses
- When in initial programming mode:
  - Each ballast generates a 24 bit random address
  - Control unit then assigns a 6 bit short address (0 to 63) to each ballast
  - May reassign a 6 bit address to each ballast
  - Alternate Method: May assign a 6 bit address by disconnecting a lamp from the ballast

DALI Programming (Cont'd)

- Group Addressing
  - Each DALI loop can support up to 16 individual groups
  - Each ballast may belong to any or all of the 16 available groups
- Scene Setting
  - Each ballast may have as many as 16 preset levels (scenes)
  - Scenes may be applied to ballasts
  - Scenes may be applied to groups

Commissioning

- DALI Ballast Manufacturer
- DALI Controller Manufacturer
- Luminaire Manufacturer
- Architect
- Lighting Designer
- Electrical Engineer
- Electrician
- Manufacturer’s Representative
- Programmer
- Systems Integrator
- Commissioner

Commissioning:

- DALI Product Manufacturer
  - Test product prior to shipment
- Luminaire Manufacturer
  - Test assembly prior to shipment
  - Could preprogram addresses, groups, scenes
- Electrician
  - Require high quality splices and terminations
  - Document power wiring and control wiring
  - Verify power wiring and lamping
  - Verify DALI loop – broadcast raise/lower, count ballast quantity

Commissioning: (Cont'd)

- Lighting Designer / Electrical Engineer
  - Determine preset levels for scenes
- Programmer
  - Assign and document groups
  - Assign and document scenes
- Systems Integrator
  - Combine with IT or AV?

Commissioning: (Cont'd)

- Manufacturer's Representative
  - May be the Commissioner
- Commissioner
  - Two people with walkie-talkies
  - Document groupings
  - Flash addressed ballast until that ballast is found
  - Cycle through addresses to find ballast address
  - Document ballast addresses on lighting plans

The Goal of Commissioning

- Verify all components are installed properly and working as specified.
- To ensure that the owner has complete documentation on the system as it was installed.

DALI Commissioning

- Many more points than ever before
- More capabilities means more settings to deal with
- All components must be completely installed
- If power is shut off to DALI bus, all lamps go to 100% by default (this can be reprogammed)
- Use “Broadcast” command to verify wiring integrity
- Reassign short address in logical sequence

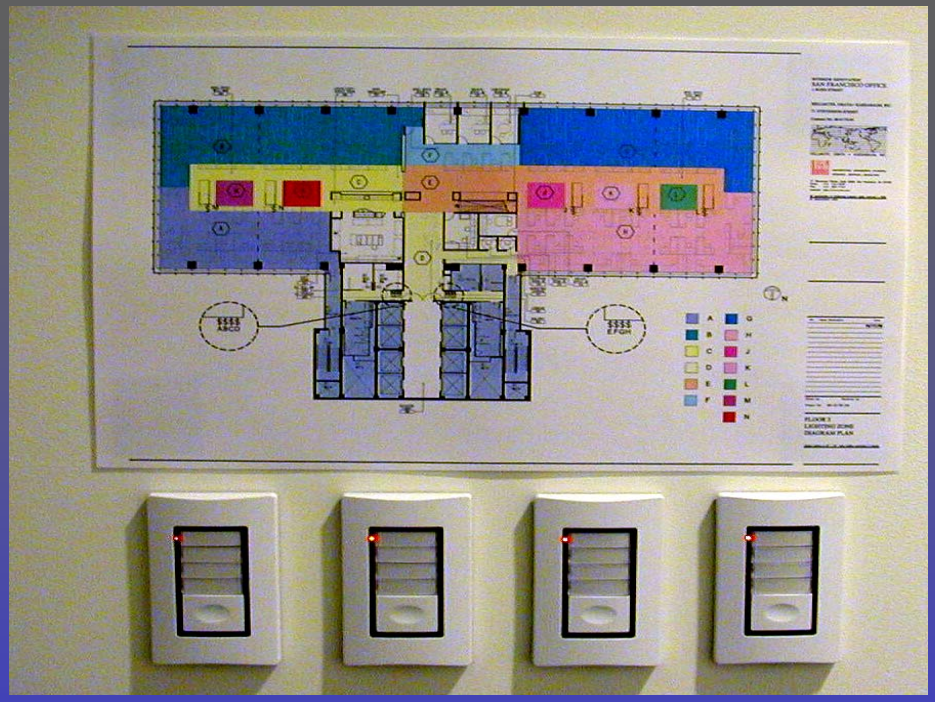
DALI Requirements

- All components must be completely installed
  - Line Voltage Wiring, DALI Communication Bus, All Ballasts and Fixtures, and any DALI Override devices
  - No Faking It!

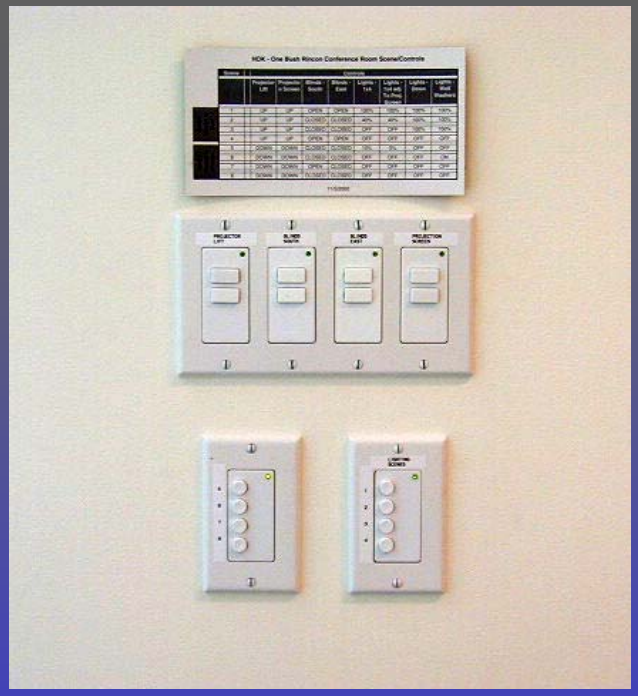
Start by reviewing the Hardware

5 Bus Masters and a Router in a Custom Enclosure

And the switches



Four 4-Button Master Switches in Entry

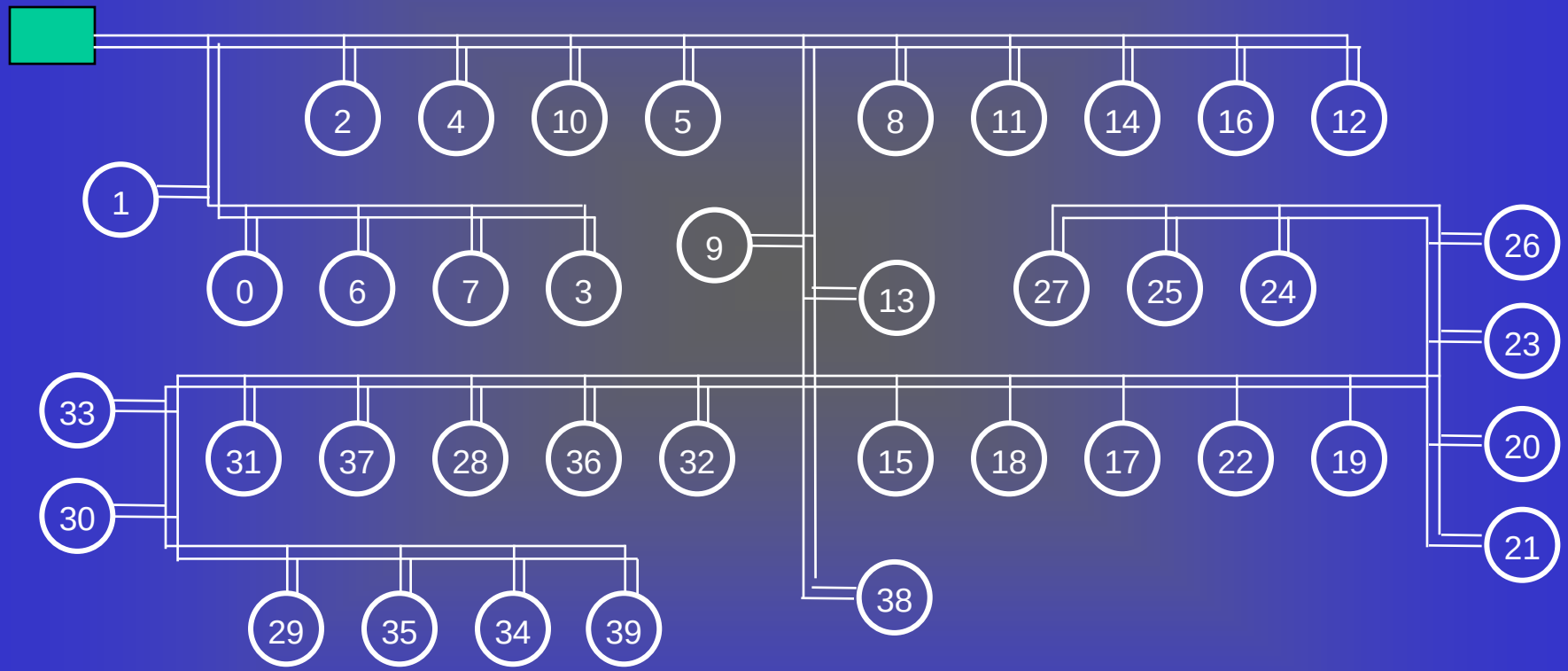


Four Interface and two 4-Button Switches in Conf. Room

Once everything is ready

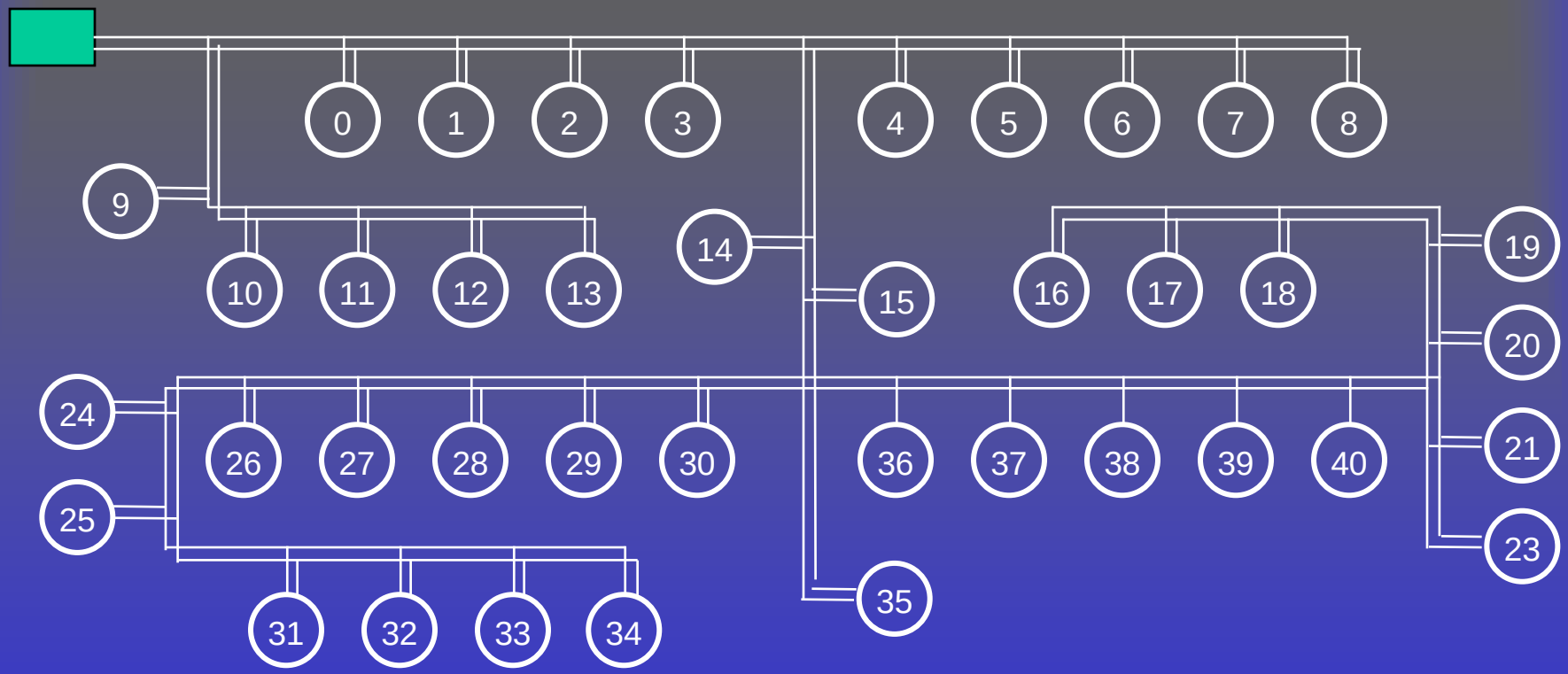
- Each ballast address assigned by software wizard, so they are not readily apparent.
- Different loops will take different amounts of time. Troubleshooting can be tedious.
- Start with a Clean Reflected Ceiling diagram and a sharp red pencil.

Random Addressing automatically per DALI protocol



Prepared by: Charles Knuffke

Readdress Sequentially
manual effort, well worth the time



Setting Up the System

- Ballast are assigned to groups, and levels (from 0-255) are set for various scenes. Groups are exclusive, and easy to track.
- Commands from WinDim can be used to communicate to devices in 3 address manners
  - Broadcast = All Devices
  - Group = Specific Group from 1-16
  - Address = Specific Ballast

Programming Spreadsheet

Dali Loop	Group	#	Room	Other	S1 (#64)	S2 (#65)	S3 (#66)	S4 (#67)
2B	1	3	210 Conference		254	243	229	204
2B	1	10	210 Conference		254	243	229	204
2B	1	17	210 Conference		254	243	229	204
2B	2	11	211 Storage IT		254	243	229	204
2B	2	15	211 Storage IT		254	243	229	204
2B	3	1	212 Coffee		254	243	229	204
2B	3	8	212 Coffee	Relay	254	254	0	0
2B	3	14	212 Coffee		254	243	229	204
2B	4	5	213 Conference	Relay	254	254	0	0
2B	4	12	213 Conference Cove		200	100	150	0
2B	4	0	213 Conference Pend.		254	100	150	100
2B	4	16	213 Conference Pend.		254	100	150	100
2B	5	31	215 Library		254	243	229	204
2B	5	6	215 Library No. Down	Relay	254	254	0	0
2B	5	2	215 Library Pend.		254	243	229	204
2B	5	7	215 Library Pend.		254	243	229	204
2B	5	13	215 Library Pend.		254	243	229	204
2B	5	18	215 Library Pend.		254	243	229	204
2B	5	4	215 Library So Pendant		254	243	204	170
2B	5	19	215 Library So. Pendant		254	243	204	170
2B	5	20	215 Library Stack		254	243	229	204
2B	5	21	215 Library Stack		254	243	229	204
2B	5	22	215 Library Stack		254	243	229	204
2B	5	23	215 Library Stack	Emergency	254	243	229	204

Troubleshooting

Dali Loop	Com Port	# Dali Points	Fixt. Addresses	Issues
2A	Com 11	41	0-40	1) ~~208 E. Fixture - Address 2? - not changing light levels. Bad Ballast. Replace.~~
2B	Com 12	19	0-31,40	1) ~~Address 4 not found - relay? 10/31 Found controlling West End 221 accents in D area, should be moved from B to D loop, (readdressed to 37).~~ 2) ~~So. pendant in library 1 ballast ON always (Address 6 on D loop see note 2D, Note 3)~~ 3) ~~2 library ballasts pendant no address - believe their power circuit has been wired thru a relay instead of direct.~~ 4) ~~10/29 New address 19 showed up - relay? - not yet found. 10/31 Kitchen Undercabinet light Address 19 should be moved from B to loop C, (readdressed to 39)~~ 5) ~~10/31 Switch in Conf. Room 213 has no voltage.~~ 6) ~~Library Pendant Emergency Ballast #40 not responding - used to work when on D loop~~ 7) ~~1 Ballast in Library Area not hooked up. Done 12/16/02.~~ 8) ~~3 Ballasts in new Library fixtures (20,22,23) have stopped responding. 1/22/03 Ken replaced ballasts, short found and fixed.~~
2C	Com 13	37	0-37	1) ~~Logo Line Voltage thru relay?~~ 2) ~~Address 25 wired to NC?~~ 3) ~~New relay installed for kitchen lights. 10/31 Found on B loop, needs to be moved.~~ 3) ~~Can't find 22 ballast? (12/11/02 No longer problem)~~ 4) ~~229 Conf. Downlights not responding - please check relay. 12/11/02 No longer problem)~~ 5) ~~230 West Emergency not responding.~~ 6) ~~11/8 Appears to be bad lamp in address #11 - near column 11D (12/11/02 No longer problem)~~ 7) 11/8 For S. Purdy - why only 2 (24,39) relays showing in address wizard, when there are 5 in loop
2D	Com 14	36	0-36	1) ~~7 addresses not found in Medium Conf room~~ 2) ~~Open office relay also not identified.~~ 3) ~~10/31 Move Emergency Pendant Light address 6 in Library from Loop D -> B (readdressed to 40)~~ ~~4)~~ 11/8 Emergency Ballast in fixture by A9 used to respond as address 29, now no response.
2E	Com 15	13	0-12	None!
2L	Com 16	18	0-16	1) ~~Can't find Wallwash relay.~~ 2) ~~How to check the starfield devices - probably powered down.~~
3F	Com 8	32	0-31	~~1) 11/8 Address 7 near column 5D not responding - bad connection, ballast or lamp? Done 12/16/02~~
3G	Com 9	48	0-47	None!
3H	Com 10	39	0-38	~~1) Address 19 ballast near columns 11-12 not responding - could be bad lamp or ballast. Done 12/16/02.~~

Addressing Format

#	IP Address	COM	Loop	Group	Add.	Room	Other	Location	Fixture	Ballast	Type
1	172.22.25.32	11	2A	8	0	209 Center	Emergency	Inboard	F1	1/F32T8	2
2	172.22.25.32	11	2A	8	1	209 Center	Relay 277V	No window	6-F3	CFM32	0
3	172.22.25.32	11	2A	5	2	208 Private		Window	F1	1/F32T8	2
4	172.22.25.32	11	2A	6	3	209 West		Window	F1	1/F32T8	2
5	172.22.25.32	11	2A	6	4	209 West		Window	F1	1/F32T8	2
6	172.22.25.32	11	2A	1	5	203 Mail	Relay 120V	No window	2-F2,4-F15	CFM32,F32T	0
7	172.22.25.32	11	2A	2	6	204 Reception	Relay 277V	Inboard	2-F2,11-F3	CFM32	0
8	172.22.25.32	11	2A	3	7	206 Private		Window	F1	1/F32T8	2
9	172.22.25.32	11	2A	2	8	204 Reception		Window	F1	1/F32T8	2
10	172.22.25.32	11	2A	7	9	209 North		Window	F1	1/F32T8	2
11	172.22.25.32	11	2A	8	10	209 Center		Inboard	F1	1/F32T8	2
12	172.22.25.32	11	2A	8	11	209 Center		No window	F1	1/F32T8	2
13	172.22.25.32	11	2A	6	12	209 West		Window	F1	1/F32T8	2
14	172.22.25.32	11	2A	8	13	209 Center		No window	F1	1/F32T8	2
15	172.22.25.32	11	2A	8	14	209 Center	Emergency	No window	F1	1/F32T8	2
16	172.22.25.32	11	2A	8	15	209 Center		No window	F1	1/F32T8	2
17	172.22.25.32	11	2A	8	16	209 Center		Inboard	F1	1/F32T8	2
18	172.22.25.32	11	2A	7	17	209 North		Window	F1	1/F32T8	2
19	172.22.25.32	11	2A	7	18	209 North		Window	F1	1/F32T8	2
20	172.22.25.32	11	2A	6	19	209 West		Window	F1	1/F32T8	2
21	172.22.25.32	11	2A	8	20	209 Center	Emergency	Inboard	F1	1/F32T8	2
22	172.22.25.32	11	2A	4	21	207 Private		Window	F1	1/F32T8	2
23	172.22.25.32	11	2A	4	22	207 Private		Window	F1	1/F32T8	2
24	172.22.25.32	11	2A	3	23	206 Private		Window	F1	1/F32T8	2

Troubleshooting

- Verify ~16VDC on the DALI bus to the ballasts, and verify ballast wiring.
- Use the software to detect failures, and send override commands from the software
- Dataline switch, in addition to overriding groups, has two testing features that helped
  - Broadcast On/Off
  - Raise Lower entire Group

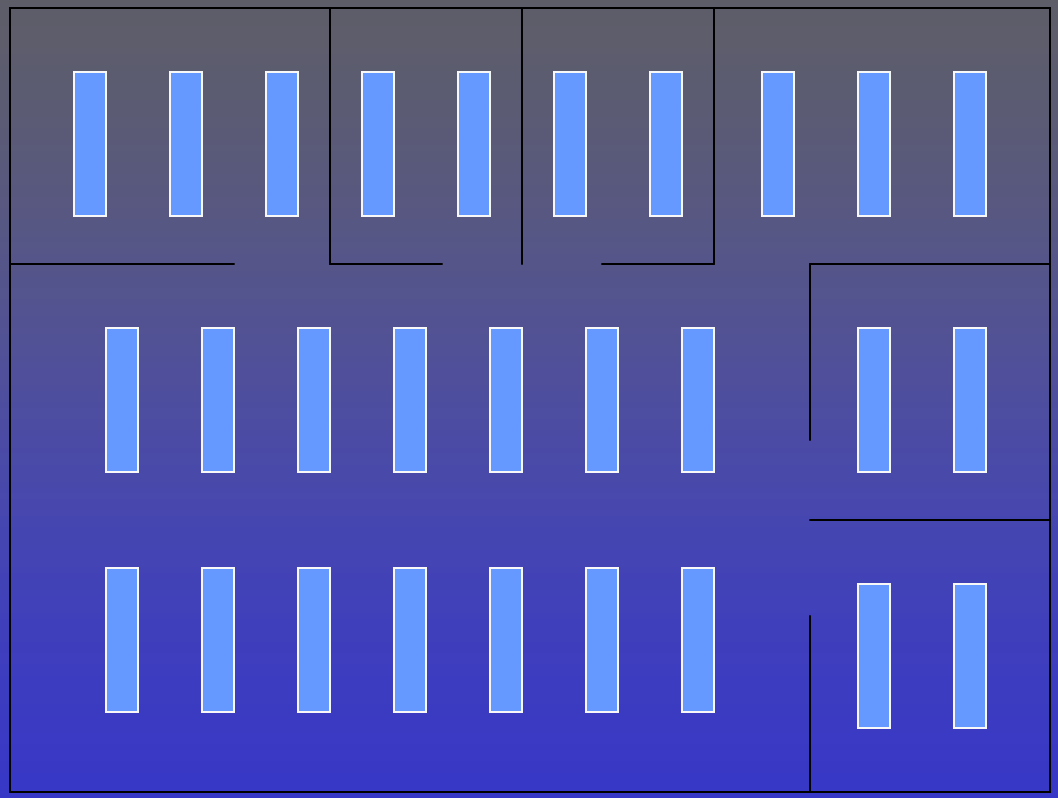
DALI – Designing a System

Lighting Plan for Open Office

- CEC Title 24: mandatory
  - Two level or dimming
  - Occupancy / Auto Off
  - Daylight Harvest
  - Time-of-Day off with timed manual override
- Adjust for individual comfort
- Weekend function
- Security function
- Power reduction

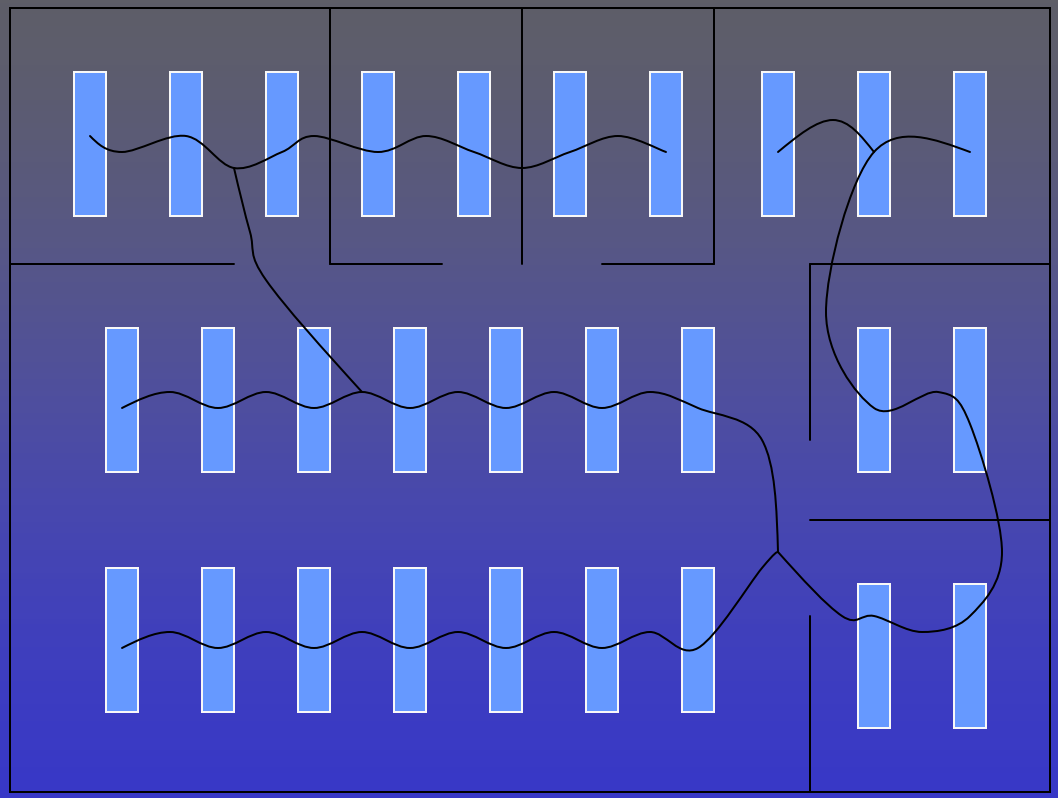
STEP 1:

Design fixture layout or retrofit existing fixtures with DALI compatible ballast.



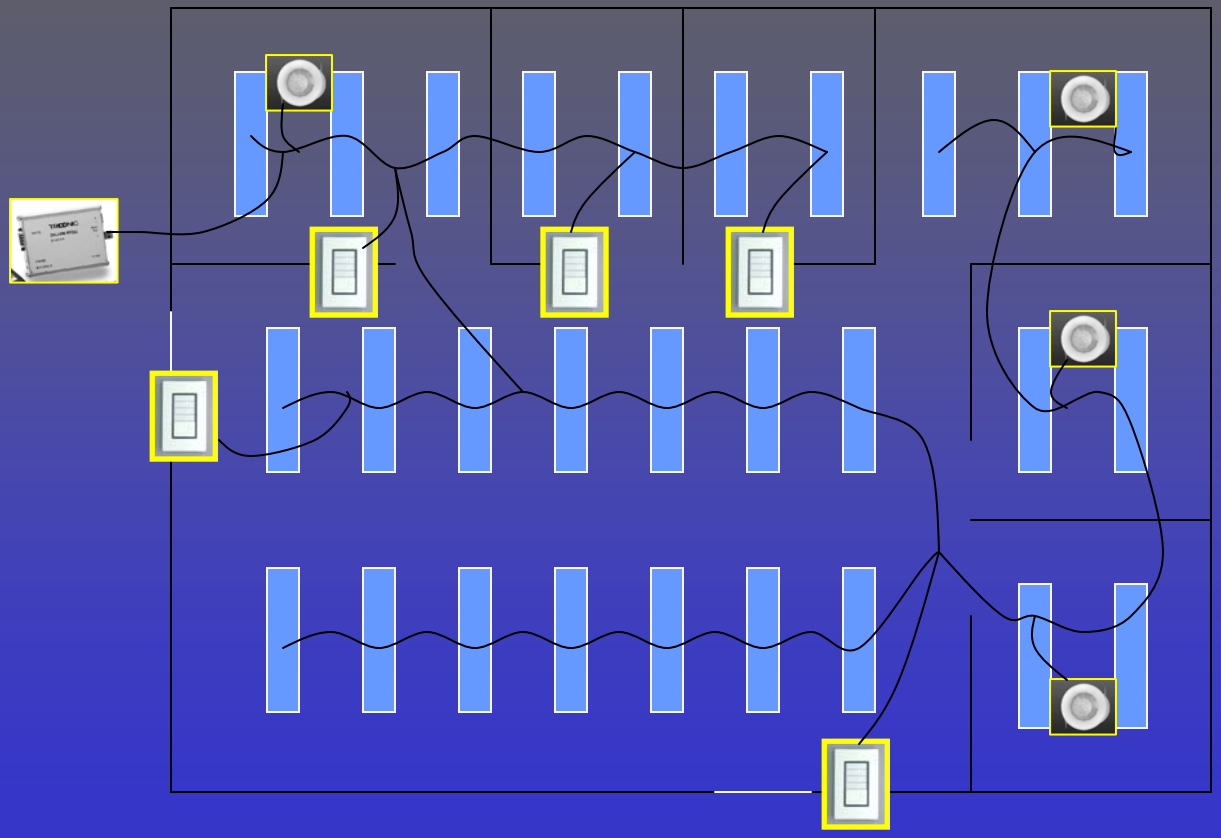
STEP 2:

Layout DALI network (2 wires) to each fixture independent of circuit wiring. Each DALI loop can support up to 64 ballast. Loop wires can be located in same conduit with power wiring



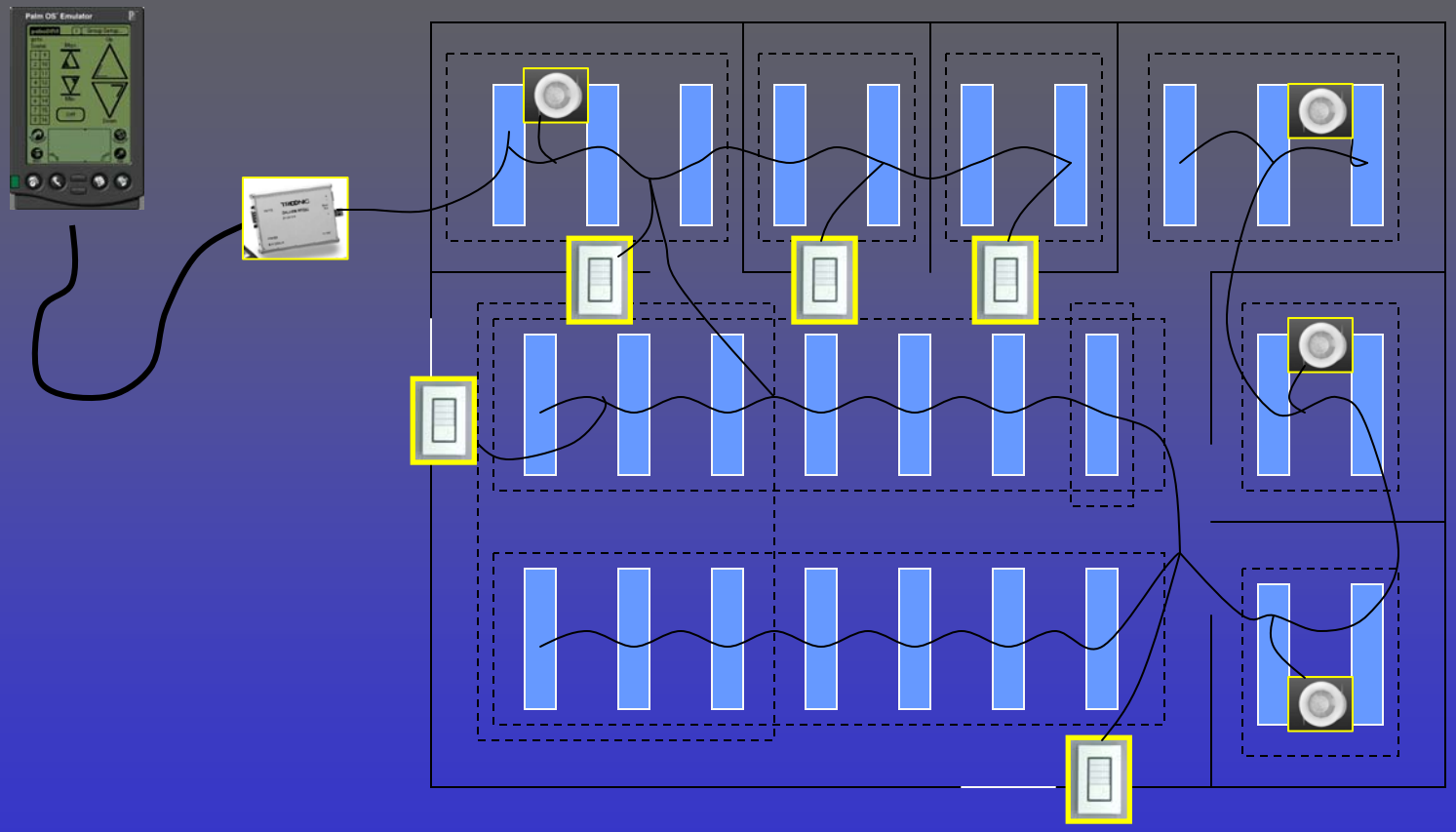
STEP 3:

Design controls into space and determine easiest connection to DALI bus. Identify placement of bus power supply and optional network interface.

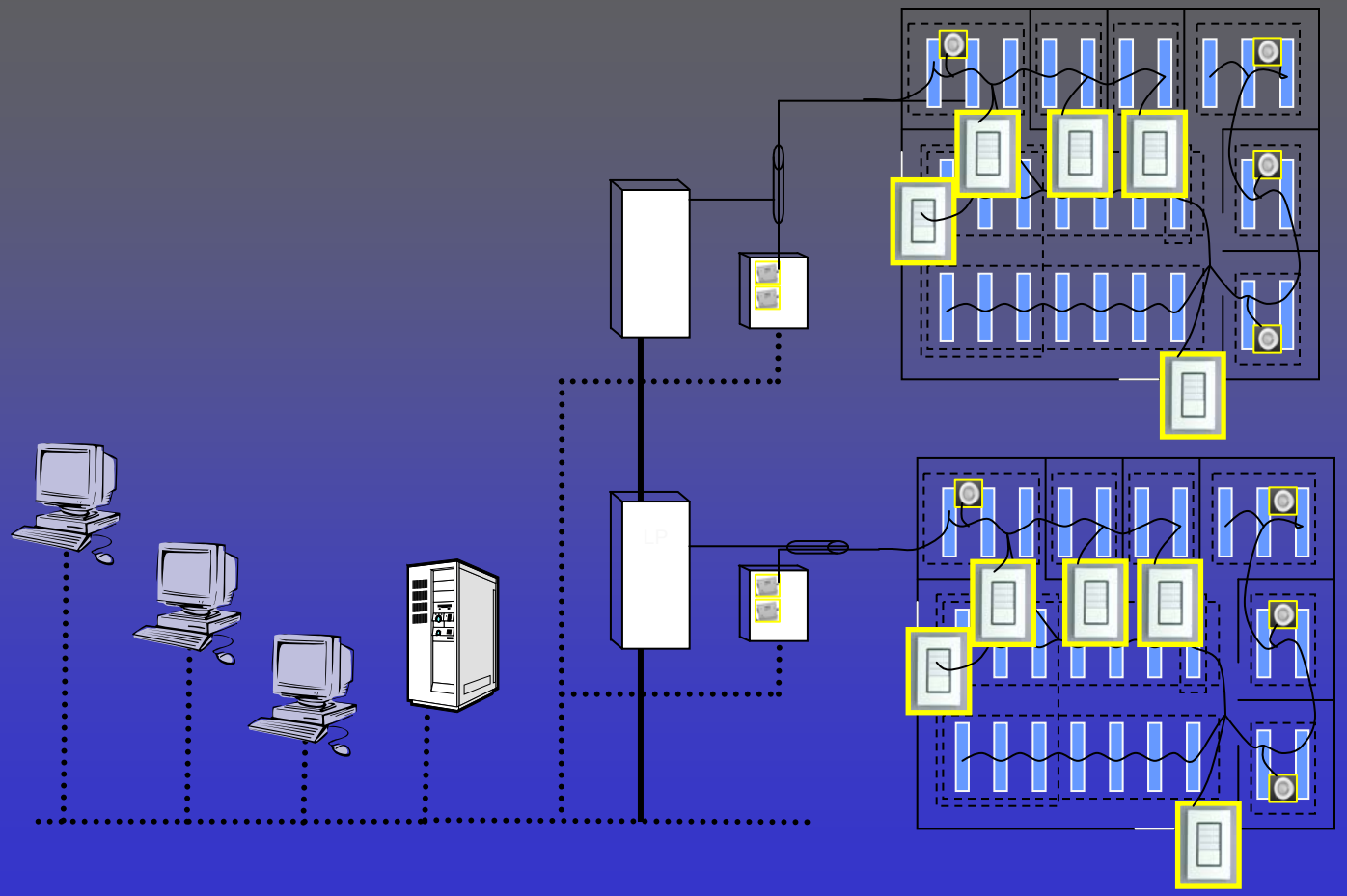


STEP 4:

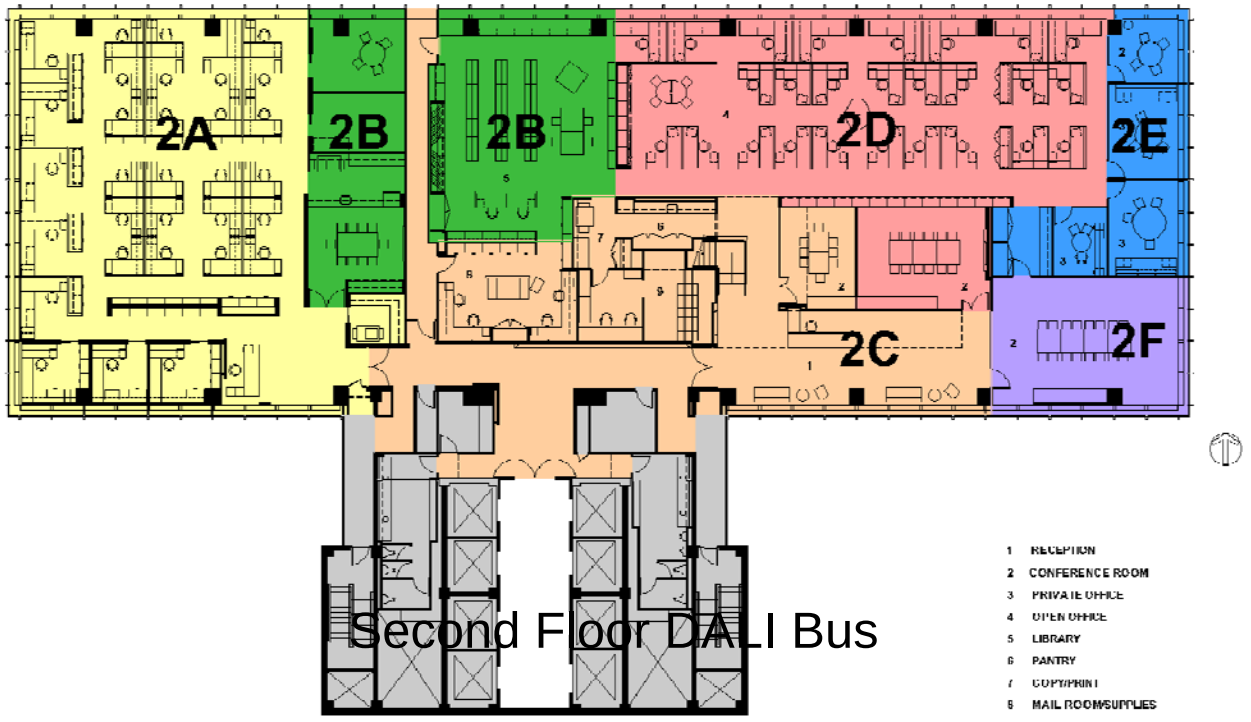
Address DALI ballasts. Determine fixture groupings and map control devices to fixtures. Each ballast can be assigned to multiple groups (16 max).



Network System Configuration



Example Project - Loops



Example Project - Groups

Second Floor Control Groups

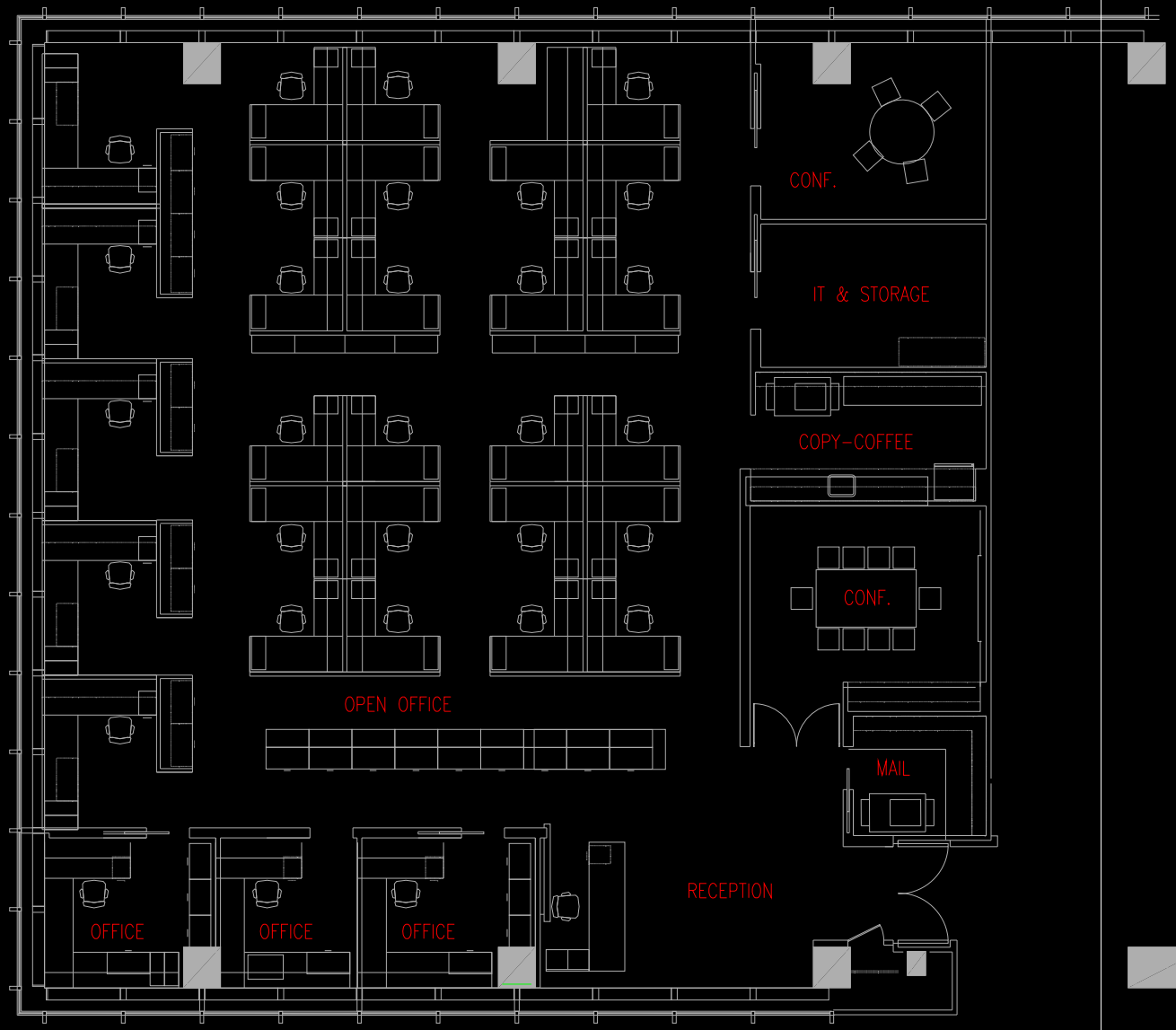
A Few Notes on Retrofitting

- Wiring to ballasts is not necessarily easy as a retrofit
  - Leads into ballast need to be precise
  - Lamp replacements can cause shorts and blow out ballasts
  - There is a higher level of electrical work and interface than normally associated in straight retrofit work
  - Select Contractors based on knowledge and experience with complicated systems.

A Few Notes on Retrofitting

- If there are existing Line Voltage Occupancy Sensors….
  - When the power to the ballast is OFF due to no occupancy, the ballast is not recognized; it cannot be programmed.
  - Whenever anyone leaves the space and the lights turn OFF (via power), when the lamps turn back on, they will go to a pre-programmed level (default is FULL ON); NOT the last setting set by the users.

Lighting Plan for a Typical Office Building Application


CONF.
IT & STORAGE
COPY-COFFEE
CONF.
OPEN OFFICE
MAIL
RECEPTION
OFFICE
OFFICE
OFFICE

1 – FLOOR PLAN

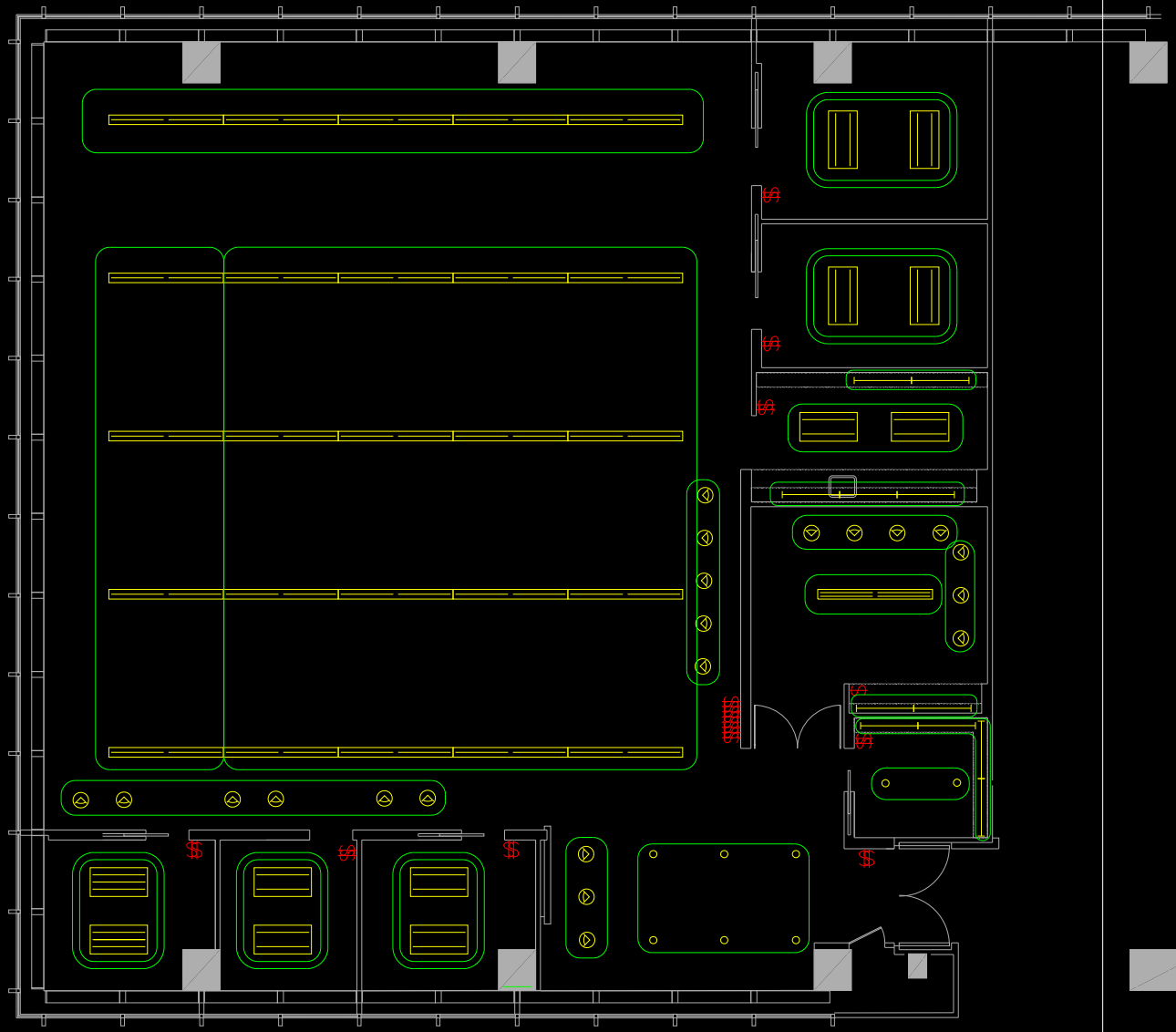
LEGEND

- 8' PENDANT, 1 LAMP XSECTION
- 8' PENDANT, 2 LAMP XSECTION
- 2x4 RECESSED, 3 LAMP
- 2x4 RECESSED, 2 LAMP
- 4' OPEN STRIP, 1 LAMP
- CF WALLWASH
- CF DOWNLIGHT

2 – LIGHTING PLAN

LEGEND

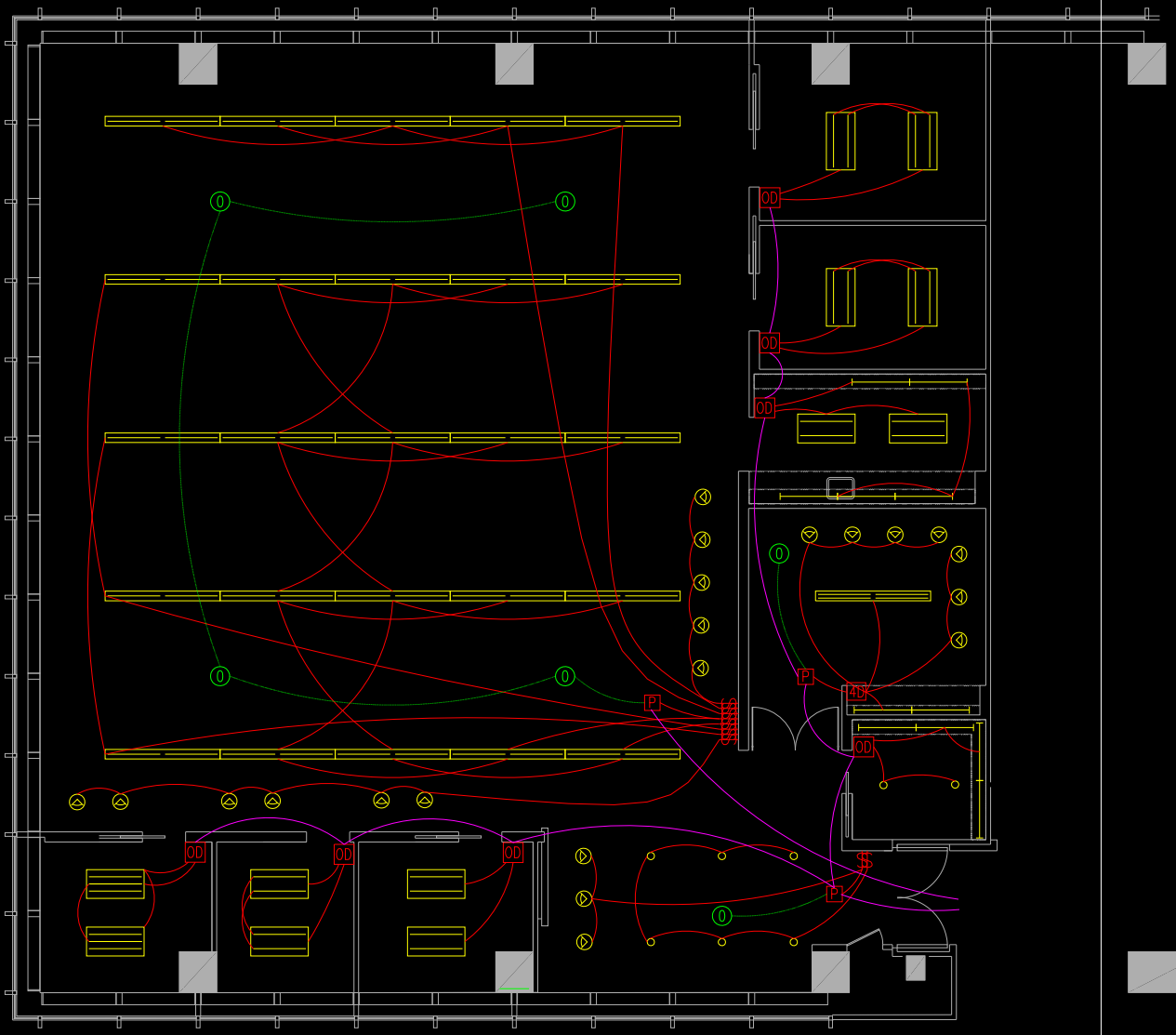
- 8' PENDANT, 1 LAMP XSECTION
- 8' PENDANT, 2 LAMP XSECTION
- 2x4 RECESSED, 3 LAMP
- 2x4 RECESSED, 2 LAMP
- 4' OPEN STRIP, 1 LAMP
- CF WALLWASH
- CF DOWNLIGHT
- LIGHTING CONTROL GROUP



3 – CONTROL GROUP PLAN

LEGEND

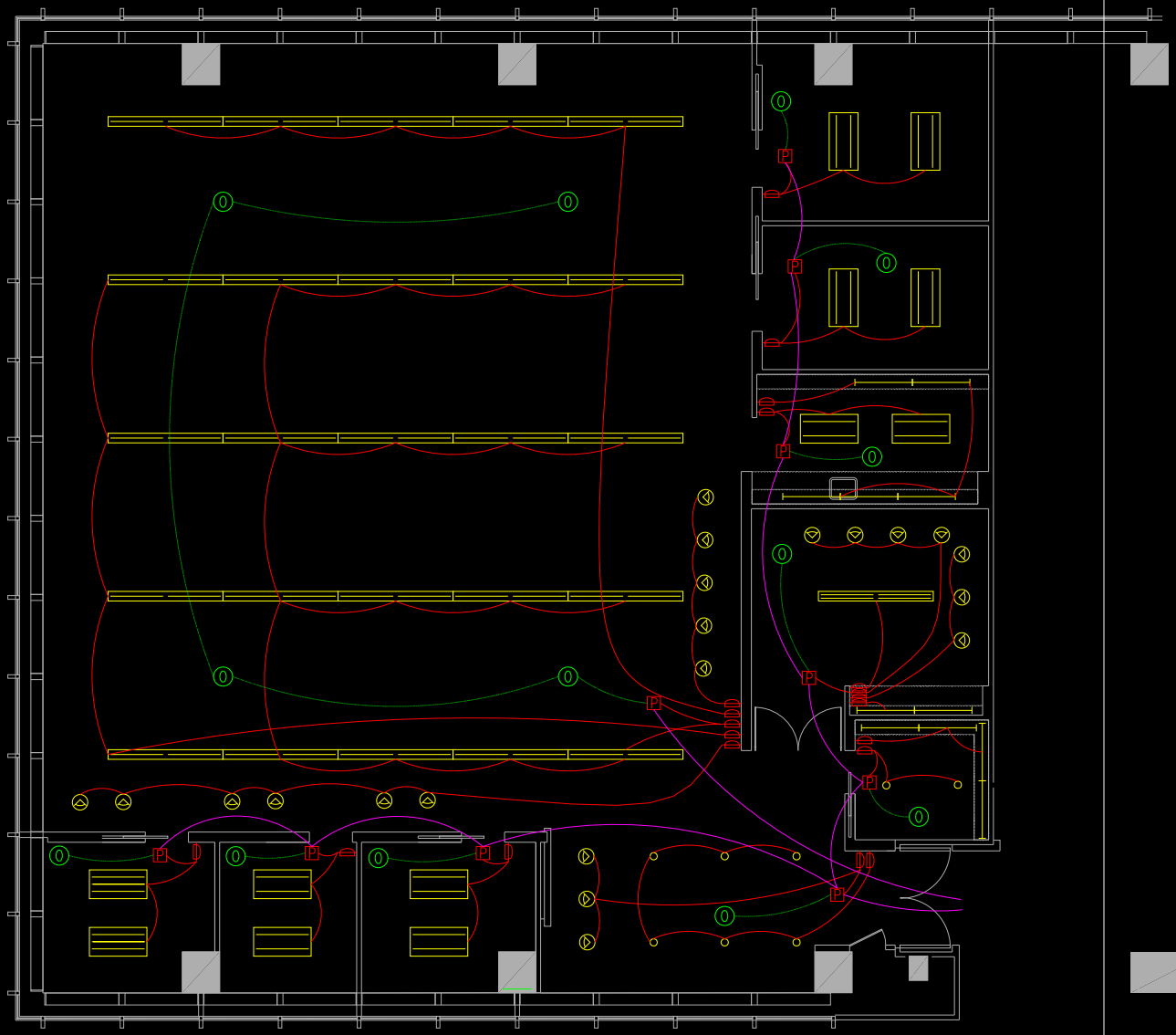
- 8' PENDANT, 1 LAMP XSECTION
- 8' PENDANT, 2 LAMP XSECTION
- 2x4 RECESSED, 3 LAMP
- 2x4 RECESSED, 2 LAMP
- 4' OPEN STRIP, 1 LAMP
- CF WALLWASH
- CF DOWNLIGHT
- LIGHTING CONTROL GROUP
- LINE VOLTAGE BRANCH CIRCUIT
- LINE VOLTAGE WIRING
- $ LINE VOLTAGE SWITCH
- OD OCCUPANCY SEN – DUAL SW
- LINE VOLTAGE DIMMER
- 4D 4 CHANNEL DIMMER
- P TRANSFORMER – RELAY
- A AUX DIGITAL LINE VOLTAGE DIMMER
- LOW VOLTAGE WIRING
- O LO VO OCCUPANCY SENSOR



4 – LINE VOLTAGE SWITCHING PLAN

LEGEND

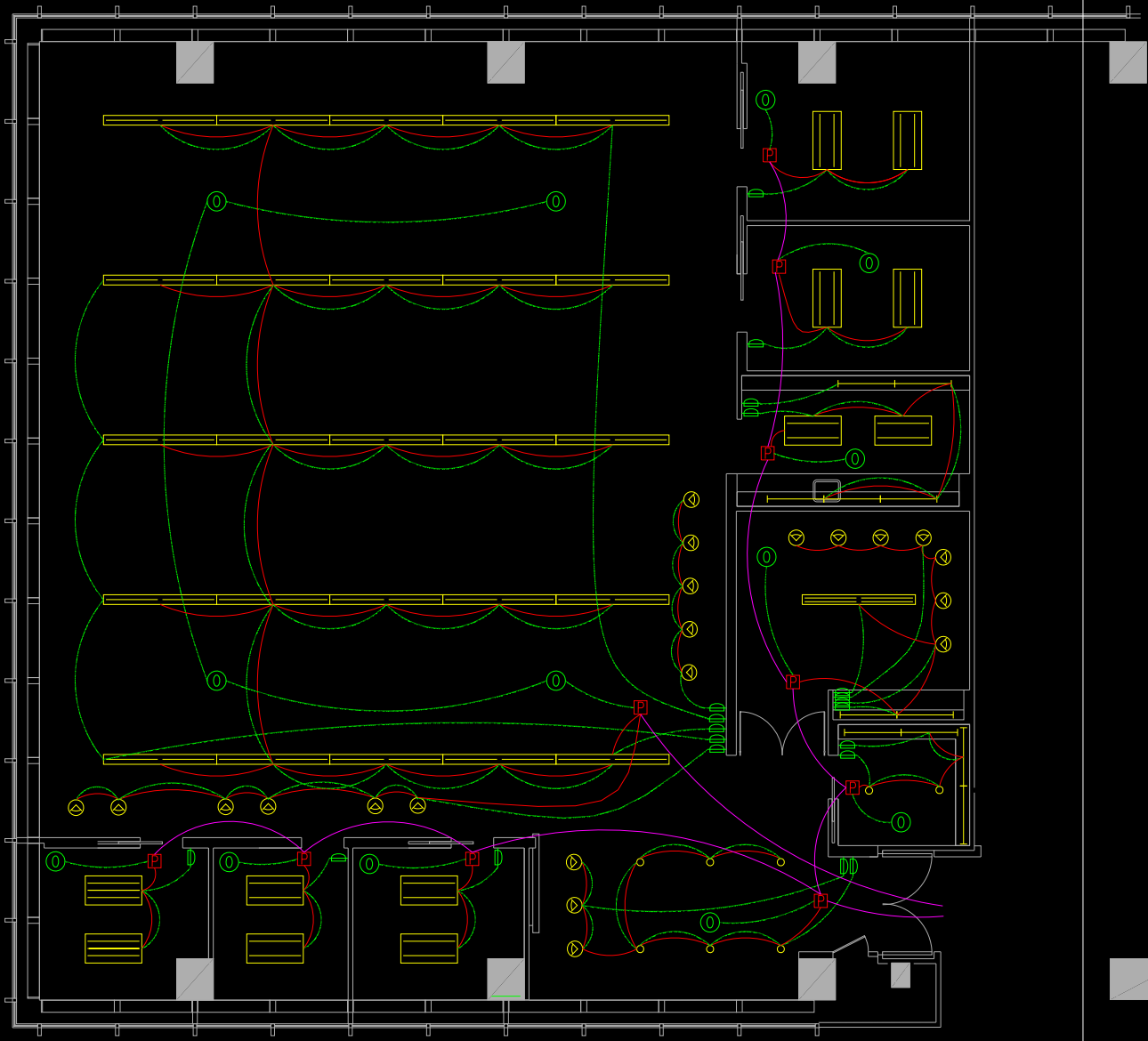
- 8' PENDANT, 1 LAMP XSECTION
- 8' PENDANT, 2 LAMP XSECTION
- 2x4 RECESSED, 3 LAMP
- 2x4 RECESSED, 2 LAMP
- 4' OPEN STRIP, 1 LAMP
- CF WALLWASH
- CF DOWNLIGHT
- LIGHTING CONTROL GROUP
- LINE VOLTAGE BRANCH CIRCUIT
- LINE VOLTAGE WIRING
- $ LINE VOLTAGE SWITCH
- OD OCCUPANCY SEN – DUAL SW
- LINE VOLTAGE DIMMER
- 4D 4 CHANNEL DIMMER
- P TRANSFORMER – RELAY
- A AUX DIGITAL LINE VOLTAGE DIMMER
- LOW VOLTAGE WIRING
- 0 LO VO OCCUPANCY SENSOR
- 0 – 10 VOLT DIMMER



5 – LINE VOLTAGE DIMMING PLAN

LEGEND

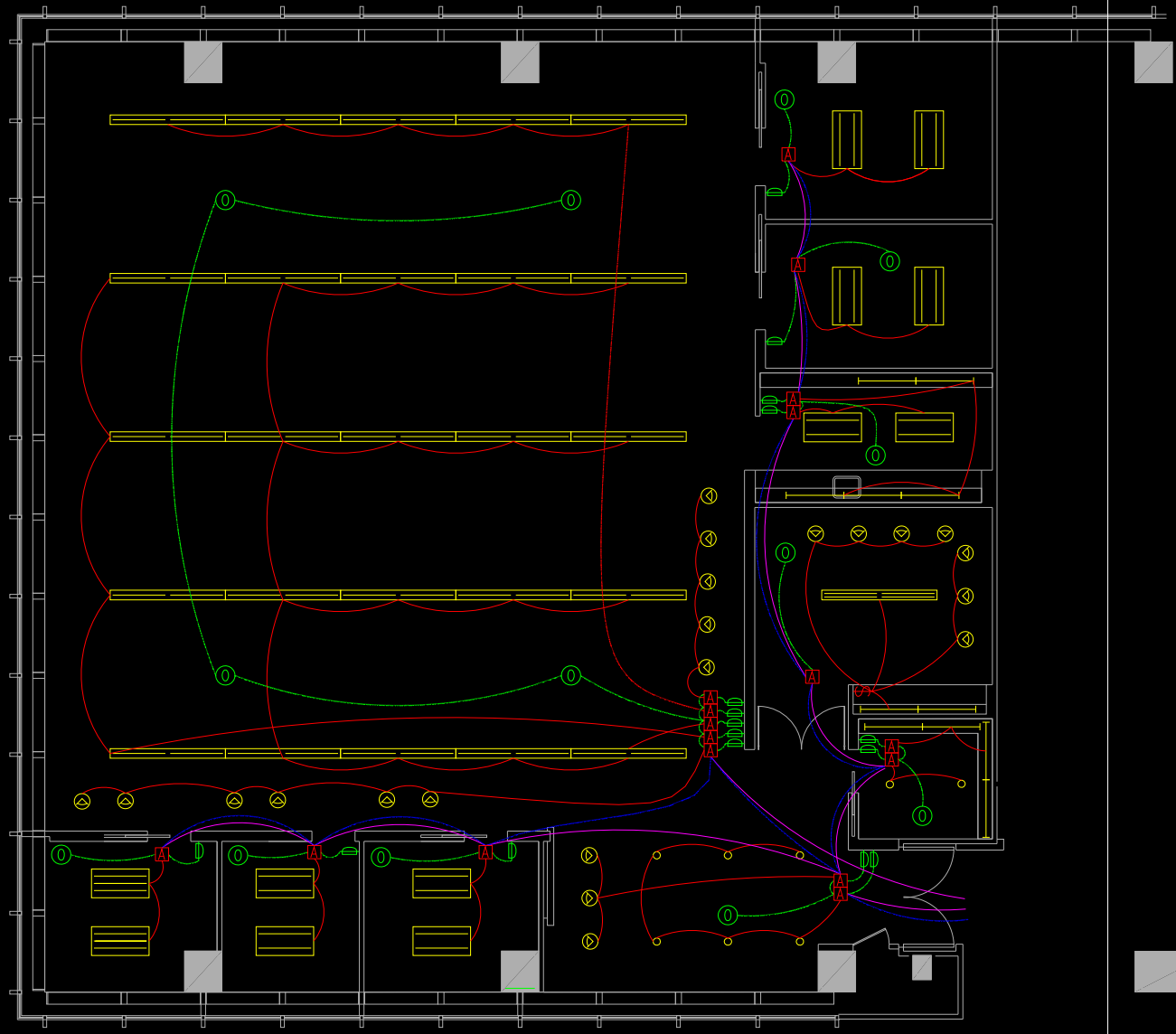
- 8' PENDANT, 1 LAMP XSECTION
- 8' PENDANT, 2 LAMP XSECTION
- 2x4 RECESSED, 3 LAMP
- 2x4 RECESSED, 2 LAMP
- 4' OPEN STRIP, 1 LAMP
- CF WALLWASH
- CF DOWNLIGHT
- LIGHTING CONTROL GROUP
- LINE VOLTAGE BRANCH CIRCUIT
- LINE VOLTAGE WIRING
- $ LINE VOLTAGE SWITCH
- OD OCCUPANCY SEN – DUAL SW
- LINE VOLTAGE DIMMER
- 4D 4 CHANNEL DIMMER
- P TRANSFORMER – RELAY
- A AUX DIGITAL LINE VOLTAGE DIMMER
- LOW VOLTAGE WIRING
- O LO VO OCCUPANCY SENSOR
- 0 – 10 VOLT DIMMER



6 – 0–10 VOLT DIMMING PLAN

LEGEND

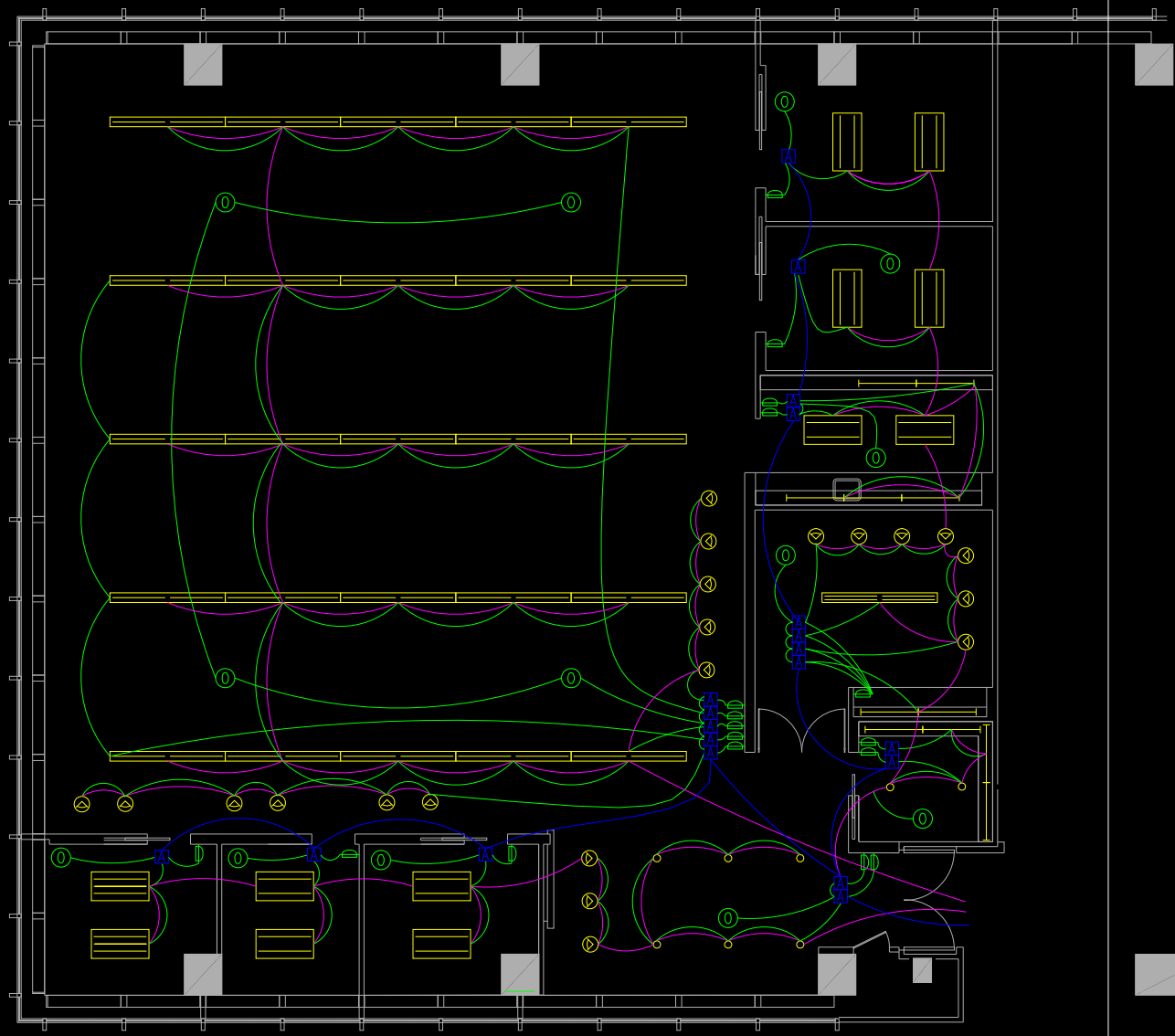
- 8' PENDANT, 1 LAMP XSECTION
- 8' PENDANT, 2 LAMP XSECTION
- 2x4 RECESSED, 3 LAMP
- 2x4 RECESSED, 2 LAMP
- 4' OPEN STRIP, 1 LAMP
- CF WALLWASH
- CF DOWNLIGHT
- LIGHTING CONTROL GROUP
- LINE VOLTAGE BRANCH CIRCUIT
- LINE VOLTAGE WIRING
- $ LINE VOLTAGE SWITCH
- OD OCCUPANCY SEN - DUAL SW
- LINE VOLTAGE DIMMER
- 4D 4 CHANNEL DIMMER
- P TRANSFORMER - RELAY
- A AUX DIGITAL LINE VOLTAGE DIMMER
- LOW VOLTAGE WIRING
- O LO VO OCCUPANCY SENSOR
- 0 - 10 VOLT DIMMER
- DIGITAL WIRING



7 - DIGITAL LINE-VOLTAGE DIMMING PLAN

LEGEND

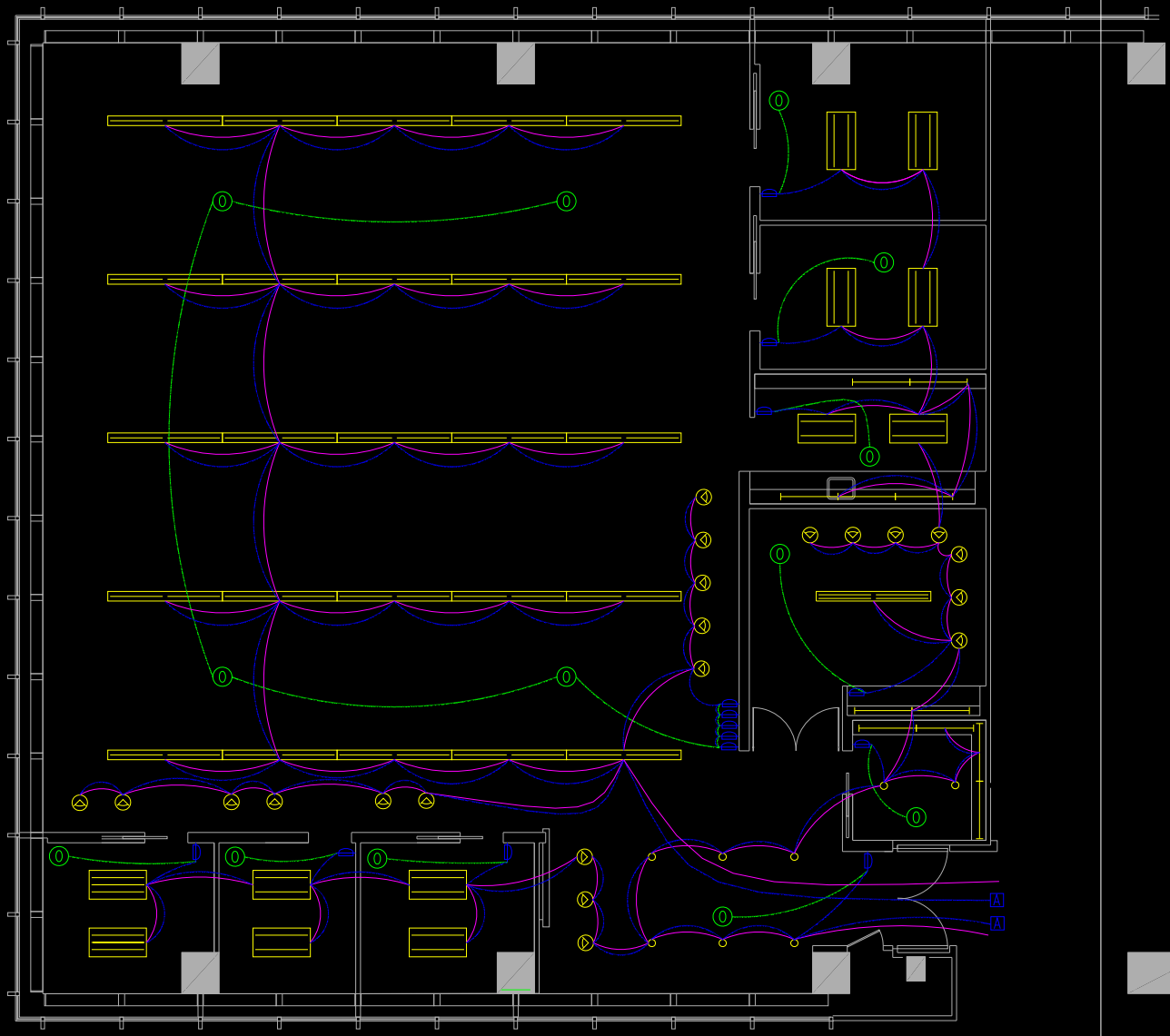
- 8' PENDANT, 1 LAMP XSECTION
- 8' PENDANT, 2 LAMP XSECTION
- 2x4 RECESSED, 3 LAMP
- 2x4 RECESSED, 2 LAMP
- 4' OPEN STRIP, 1 LAMP
- CF WALLWASH
- CF DOWNLIGHT
- LIGHTING CONTROL GROUP
- LINE VOLTAGE BRANCH CIRCUIT
- LINE VOLTAGE WIRING
- $ LINE VOLTAGE SWITCH
- OD OCCUPANCY SEN – DUAL SW
- LINE VOLTAGE DIMMER
- 4D 4 CHANNEL DIMMER
- P TRANSFORMER – RELAY
- A AUX DIGITAL LINE VOLTAGE DIMMER
- LOW VOLTAGE WIRING
- O LO VO OCCUPANCY SENSOR
- 0 – 10 VOLT DIMMER
- DIGITAL WIRING



8 – DIGITAL LOW VOLTAGE DIMMING PLAN

LEGEND

- 8' PENDANT, 1 LAMP XSECTION
- 8' PENDANT, 2 LAMP XSECTION
- 2x4 RECESSED, 3 LAMP
- 2x4 RECESSED, 2 LAMP
- 4' OPEN STRIP, 1 LAMP
- CF WALLWASH
- CF DOWNLIGHT
- LIGHTING CONTROL GROUP
- LINE VOLTAGE BRANCH CIRCUIT
- LINE VOLTAGE WIRING
- LINE VOLTAGE SWITCH
- OD — OCCUPANCY SEN – DUAL SW
- LINE VOLTAGE DIMMER
- 4D — 4 CHANNEL DIMMER
- P — TRANSFORMER – RELAY
- A — AUX DIGITAL LINE VOLTAGE DIMMER
- LOW VOLTAGE WIRING
- LO VO OCCUPANCY SENSOR
- 0 – 10 VOLT DIMMER
- DIGITAL WIRING
- DALI GROUP SCENE SELECTOR
- A — DALI POWER SUPPLY AND COMPUTER INTERFACE



9 – DALI DIMMING PLAN

Summary of DALI
(as it stands today)

Benefits of Networked Fluorescent Dimming

- Decrease energy usage
  - Set maximum dimming levels
  - Possible to provide peak load shedding
  - Overall energy management
- Improve occupant comfort

Benefits of DALI

- Simplify wiring installation
- Minimizes Components
- May Lower maintenance cost
- Increase space flexibility
- Status monitoring of individual components

Limitations of DALI

- Fade Time: <0.7 sec to 90 sec
- Requires computer to initialize and program
- Intended only for lighting
- **NOT ENOUGH DALI PRODUCTS**
- **SOFTWARE UPGRADES NECESSARY FOR EASE OF IMPLEMENTATION**
- **MONITORING IS NOT USEABLE WITHOUT EXTENSIVE PROGRAMMING EFFORT**

DALI still in Early Adopter Stage

- Initial costs are high
- Learning curve with technology
- Products are limited
- Software not user-friendly or intuitive
- Monitoring capabilities difficult
- Must have clients willing to support the system

Advice for Future Commissioners

- Make sure you've got time to check out system, and understand how checkout will impact occupants.
- Startup up of sites we have done have taken over 60 hours. Problems break down into:
  - 1/3 "New Technology issues" (software implementation)
  - 1/3 problem issues (wiring and ballast burnout)
  - 1/3 commissioning setpoints

Wish List (Components)

- Compact Fluorescent Ballast
- Incandescent Dimmer – 120 Volts
- Incandescent Dimmer – 12 Volts
- Metal Halide Ballast
- LED Driver
- Occupancy Sensor
- Photo Sensor
- Daylight Harvesting

Wish List (Software)

- Make it easier for typical building maintenance personnel
- Schedulers
- Peak Load Shaving
- Real Energy Monitoring Capability with reporting (recognize ballast type and calculate real values or have sensors in the ballast circuiting for actual power consumption).

Wish List (Interfaces)

- Line Voltage Occupancy Sensor Interface
- Audio/Visual Interface
- Motor Control for Blinds, Curtains, Projection Screens
- Gateways for BACnet®, DMX512, LONWORKS®, and TCP/IP
- Interface to 0-10V dimming system

Is it Time to Get a DALI?

You Decide…

Brian Liebel, PE, LC
AFTERIMAGE + s p a c e

Rick Miller, PE, LC
RNM Engineering