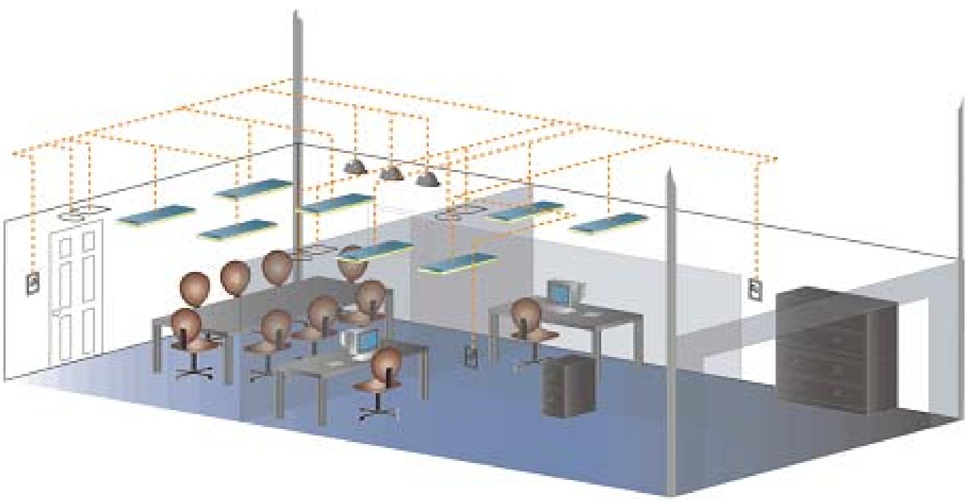
LIGHTING RESEARCH PROGRAM

Project 5.4 DALI Demonstration Report

FINAL REPORT



Prepared For:

California Energy Commission

Public Interest Energy Research Program

Consultant Report

Arnold Schwarzenegger, *Governor*

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CALIFORNIA ENERGY COMMISSION

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DALI Demonstration Report

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DALI Demonstration Report

Introduction

The DALI Lighting Control Device Standard Development (Project 5.4) is a two year cooperative effort with the National Electrical Manufacturers Association (NEMA), The Watt Stopper (TWS), and the California Energy Commission Public Interest Energy Research (PIER) Program under the Lighting Research Program. The goals are to help bring together a NEMA-facilitated working group of major manufacturers to develop an open standard for lighting controls, conduct roundtables to gain input from designer and end-user groups, and provide a demonstration of the enhanced protocol.

One key task under the PIER Lighting Research Program Project 5.4 is to demonstrate the installation of a lighting control system that uses the draft DALI control standard. Successful completion of this task will be measured by the delivery of a demonstration site with product, and by reviewing the site demonstration summary report. Meeting this goal helps to achieve the project objectives by illustrating that the contents of the standard can result in products that work.

The original scope of work specified a working demonstration in California, which evolved into The Watt Stopper office in Santa Clara. This was expanded to also include The Watt Stopper's panel site in Rhode Island. Both installations incorporated ballasts and controls from different suppliers. The RI site hosted a meeting on September 28, 2004 of the NEMA Joint Sections on DALI. A copy of the minutes of that meeting is attached. Rick Miller reviewed the Santa Clara site installation, and Commission representatives and various PIER LRP members visited the California site on November 30, 2004.

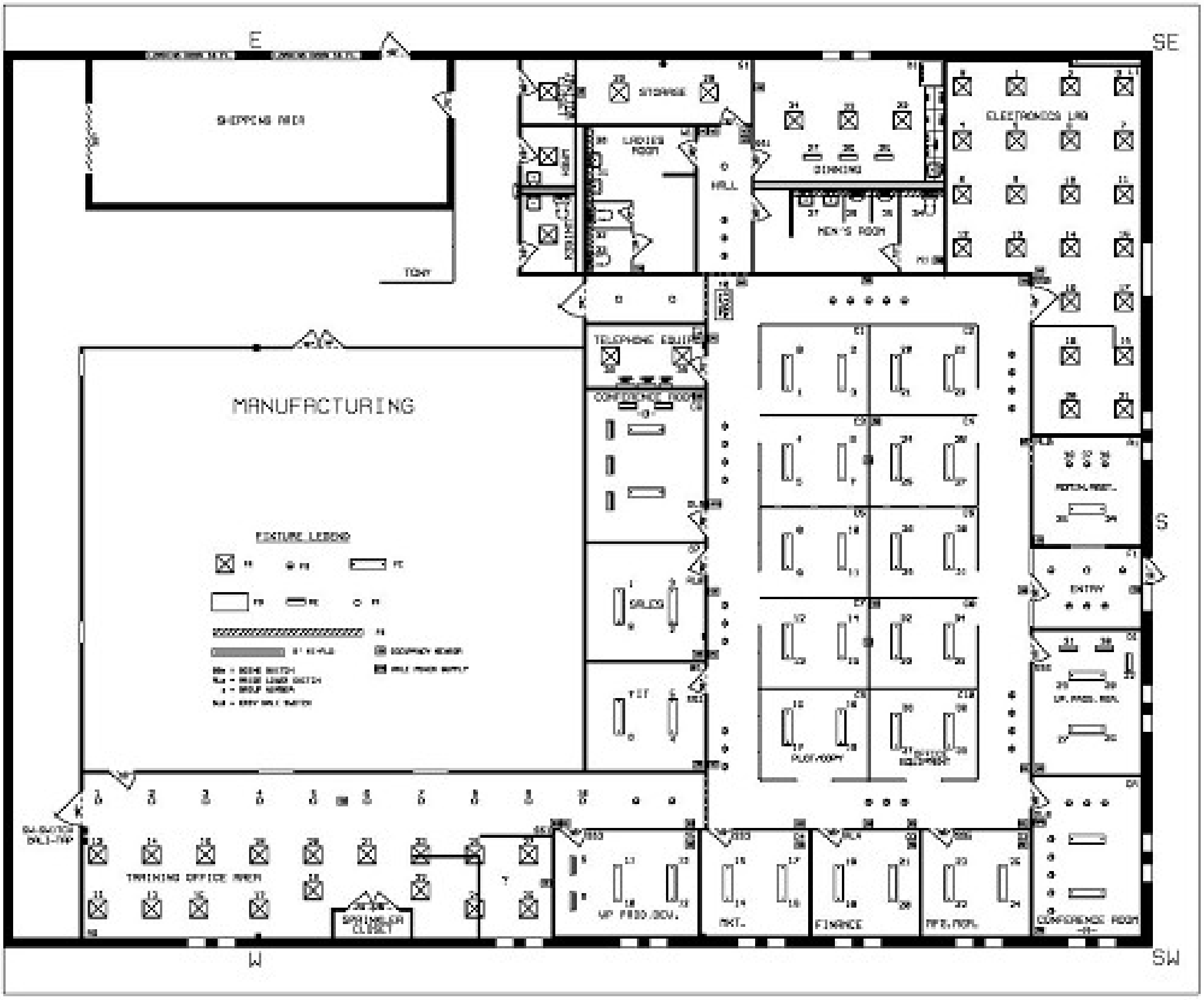
The two site DALI installations demonstrated the following key concepts:

- Control devices using the standard 2-byte message structure communicated successfully with ballast from different ballast manufacturers. Control devices also received and transmitted 3-byte messages, which added communications to the control devices without impacting the ballasts.
- Impressive energy and demand savings were shown with 28 percent in general office areas with aisles, 41 percent savings in open offices excluding aisles, and 62 percent in the laboratory. Private offices showed a power reduction of approximately 40 percent.
- Occupants indicated they were satisfied with the scene settings with the DALI systems. To gain the most from the DALI installation, individual users should be part of the decision process when pre-setting light levels and selecting scenes.

Overall, NEMA and PIER LRP representatives suggest the need for more test sites demonstrating DALI installations in various applications, which document costs, energy savings, and occupant satisfaction. It was also recognized that DALI has the potential to support sustainable design and LEED (Leadership in Energy and Environmental Design) efforts for design teams and building owners.

Rhode Island Demonstration Site

1.0.0 Floor plan



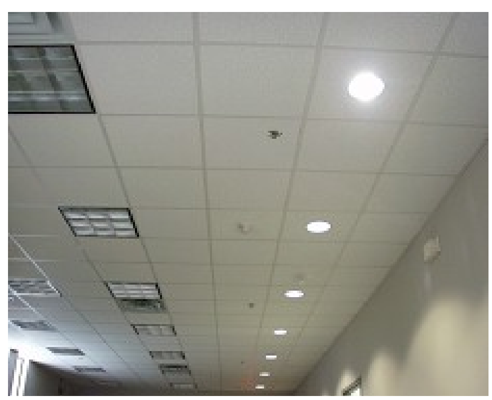
The open office cubicles used direct/indirect fixtures. Control intent: Allow occupants to select the direct lighting levels for each fixture while the indirect remained at 100%. Vacant offices set to mirror occupied. Two occupancy sensors control total area.

Aisles used standard electronic ballasts in wallwash fixtures. (They were not dimmed.) The wallwash provided adequate lighting for circulation while also providing vertical brightness. Control intent: Four occupancy sensors control all on/off.

1.2.2 Training room

The training area includes 2x2 fixtures and down-lights. Control intent: Provide a minimum of two scenes, one for discussions, the other for Power Point presentations. (The solution is to use a four-scene control switch for all of the fixtures in the room.)

When not being used for training, the Control Intent: breakout the down-lights to create an aisle. Provide auto-on/off with occupancy sensors.



1.2.3 Electronics lab

Room includes electronics prototype assembly and test, a separate CAD area, and a reference manual library.

The technician normally works at either the CAD station or at the prototype development bench. In both cases, the lab lighting can be set low and the CAD overhead fixtures off. Higher light levels are needed occasionally for assembly and reading.

Control Intent: Provide a Scene Switch with scenes matched to activities and automatically reset to low energy scene.

Scene	Lab Bench	CAD Station
Normal	Low	Off
Assembly	Med	Off
References	High	Off
Cleaning	High	High

Occupancy sensor returns lighting to Normal when occupancy is detected.

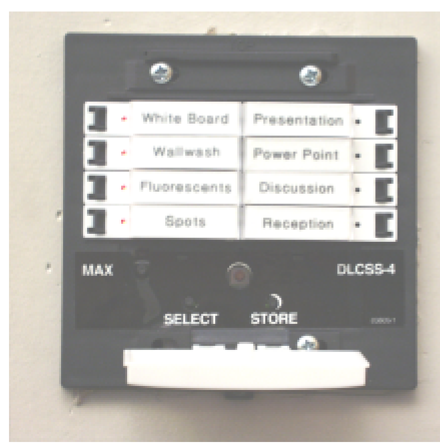
1.2.4 Private office

Each small office had two direct/indirect fixtures. Control Intent: allow the occupant to select a preferred level for each fixture to create a Normal work scene. (Suggest one fixture low.) Define up to 4 scenes.

Provide automatic off via sensor with automatic return to Normal (Occupant may have a 100% scene, but the controls return to Normal, saving energy.)

1.2.5 Conference

The conference rooms have four lighting groups…wallwash, art, fixture 1, fixture 2. Control Intent: provide four lighting scenes: Discussion, Power Point, Presentation, Reception. Allow the occupant to create a temporary scene. Provide automatic shutoff.



NOTE: the conference rooms were controlled by ezDALI, which does not require a PC. See section 2.7.0.

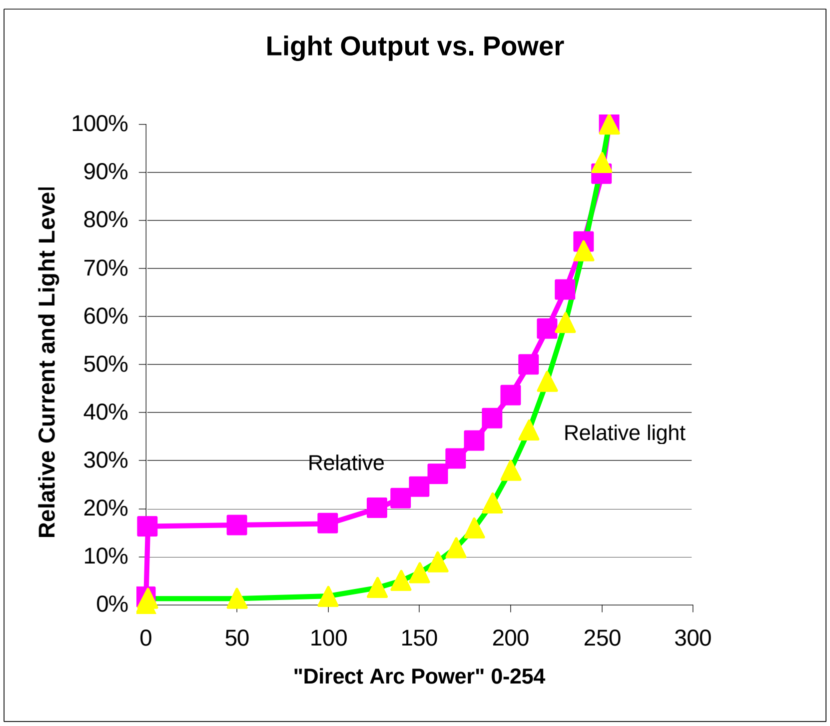
1.3.0 Other demo equipment

In addition to changing out the ballasts and controls in these spaces, portable demonstrators were developed to support the testing program and facilitate presentations.

1.3.1 Light rack

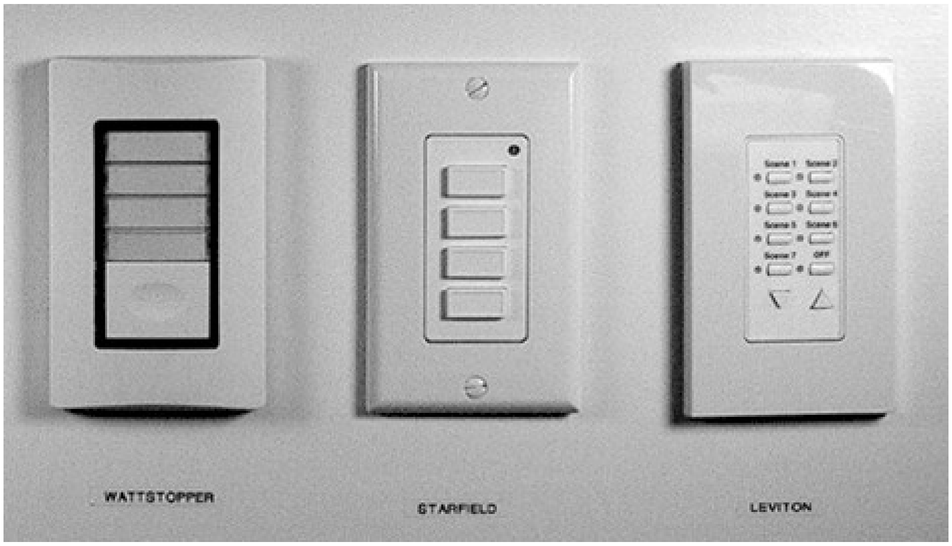
The light rack consists of 16 - 4foot light fixtures. Each side of the light rack has one of four manufacturer's ballast -- Advance, Sylvania, Tridonic, and Universal. Each side has a plug to either add or remove it from any tests in process. The data line also can be added or removed from the tests.

The light rack was also used to develop the relative light and power curves shown below, which show the correlation between light and power. For the first 30% dimming, the relationship is close to 1:1. For the last 30% in light output, power drops approximately 14%. The large drop off is the shutdown of cathode heat.



1.3.2 Multi vendor switches and dimmers and scene switches

To test for compatibility, scene switches and dimmers from multiple manufacturers (see graphic below) were added to one of the four site data buses and exercised repeatedly to create an error.

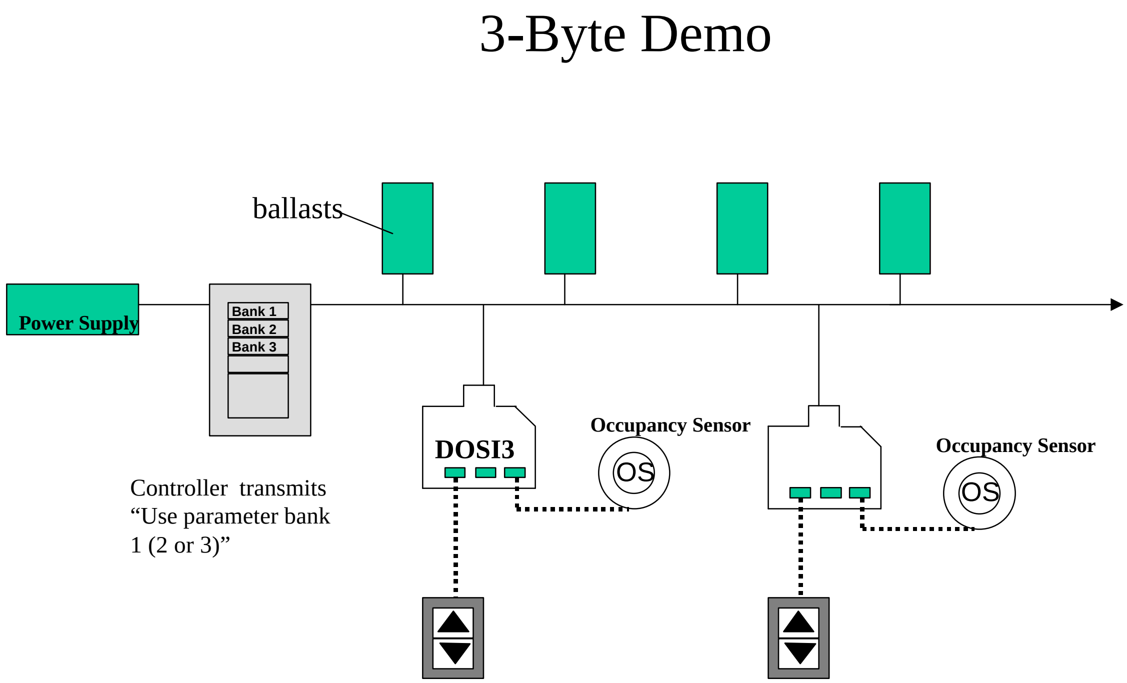


1.3.3 Two portable 3-byte

Two portable demos were created to provide proof of concept for the 3-byte protocol and parameter banks. Each demo had two DALI occupancy sensor interfaces (DOSI) which had been modified to accept 3-byte commands and support parameter banks. The DOSI-3 provides both an occupancy sensor interface and a raise/lower dimmer function.

The push-button switch in each office simulates the function of an occupancy sensor. Hence, the occupancy sensor closes sending a 24VDC signal to the DOSI, the DOSI would transmit scene 14 (warn) for 5 seconds and then go to scene 15 (off). These are the default parameters.

A controller was also developed to send a message on the data bus for the DOSI-3s to use parameter bank 1,2, or 3. (The DOSI-3 supports commands for all devices to use a particular bank or, for specific devices, to use a parameter bank.)



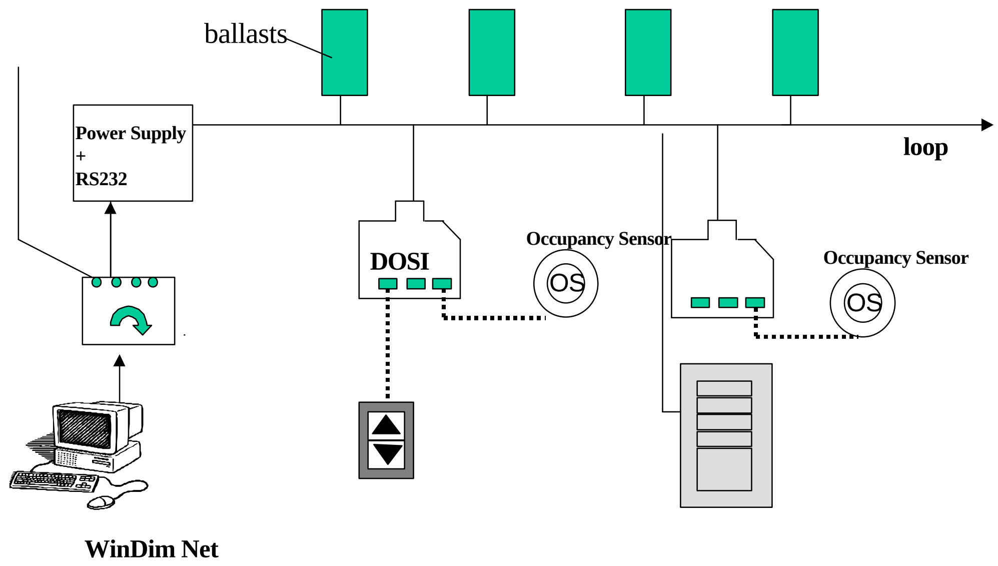
1.4.0 Controls

1.4.1 System

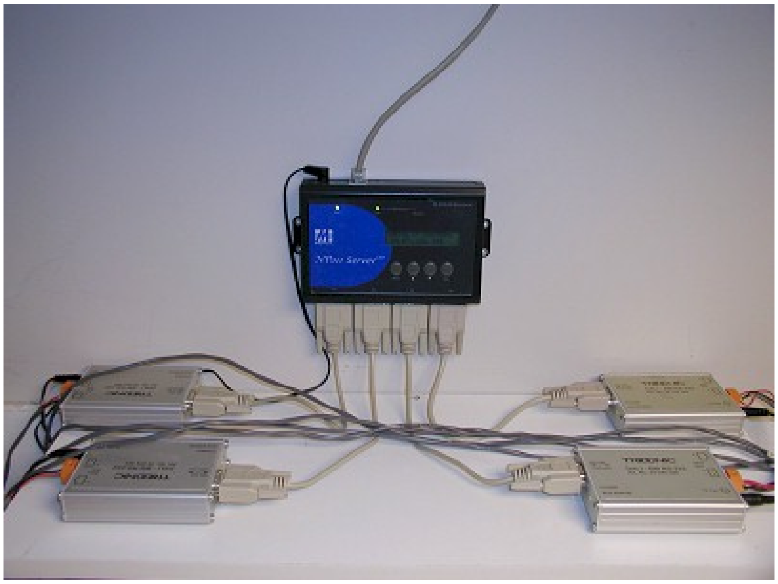
The Warwick system has a total of 144 ballasts on four loops, plus the ability to add 16 more by plugging in the light rack. Each loop has a Tridonic Bus Master that supplies loop power and an RS232 communications port for the PC, which runs WinDim Net.

A four channel multiplexer switches the RS232 between bus masters. Each space has a DOSI that works with an occupancy sensor to provide the automatic off function. Most of the rooms also have either a raise/lower switch or scene switch for the occupant.

System Configuration



1.4.2 Multiplexer and four Bus Masters



1.4.3 Occupancy sensor interface (DOSI)

The DOSI plugs into to a standard J-box where it connects to the 2-wire DALI data bus and to line-voltage power.
A four-position DIP switch on the back of the unit allows it to be linked to any one of 16 groups of ballasts on the data bus. The occupancy sensor and an optional raise/lower switch plug into the DOSI. Any
standard momentary SPDT switch may be used to provide the raise/lower function. Multiple occupancy sensors can be powered by a single DOSI.
The group of ballasts controlled by a DOSI is programmable,allowing the space to be reconfigured or modified without changing the fixture wiring. The ballast groupings and lighting scenes are programmed into the ballasts using the PC with commissioning software.
The lighting scenes (levels), activated when the sensor detects a change in occupancy, can be programmed to match the use of the space. For even greater occupant sensitivity, the sensor turns the lighting to a user-defined low level (Scene 14) for five minutes prior to going to the programmed Off mode (Scene 15).
Multiple raise/lower switches can be wired to the DOSI to provide dimming control from several locations. Pressing and releasing the UP side of the switch turns the lights to normal (Scene 0). Pressing and holding UP will first turn the lights to Scene 0 and, after two seconds, begin ramping the lights up. Releasing the switch “freezes” the lighting at that level. Pressing and holding the DOWN side ramps the lights down but does not turn them off. Pressing and releasing DOWN turns the lights to Scene 15, typically programmed as Off.

Figure 2 – Class 1 Wiring

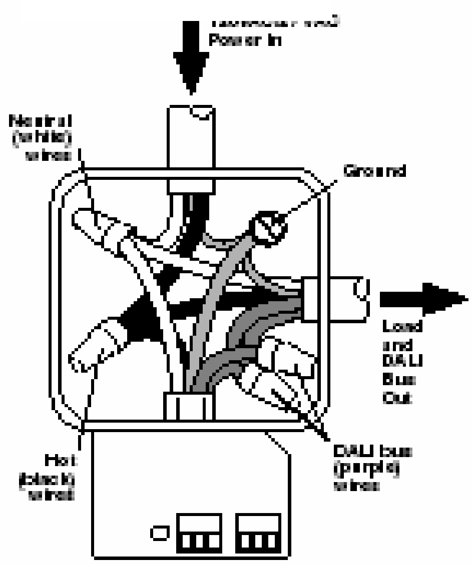
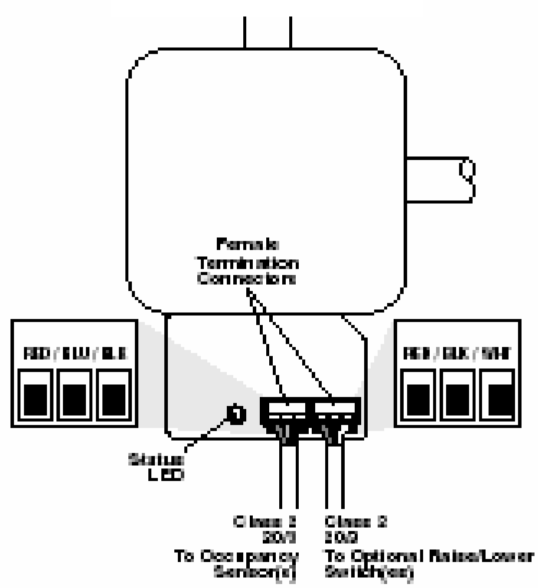


Figure 3 – Class 2 Wiring



1.4.4 Scene switch

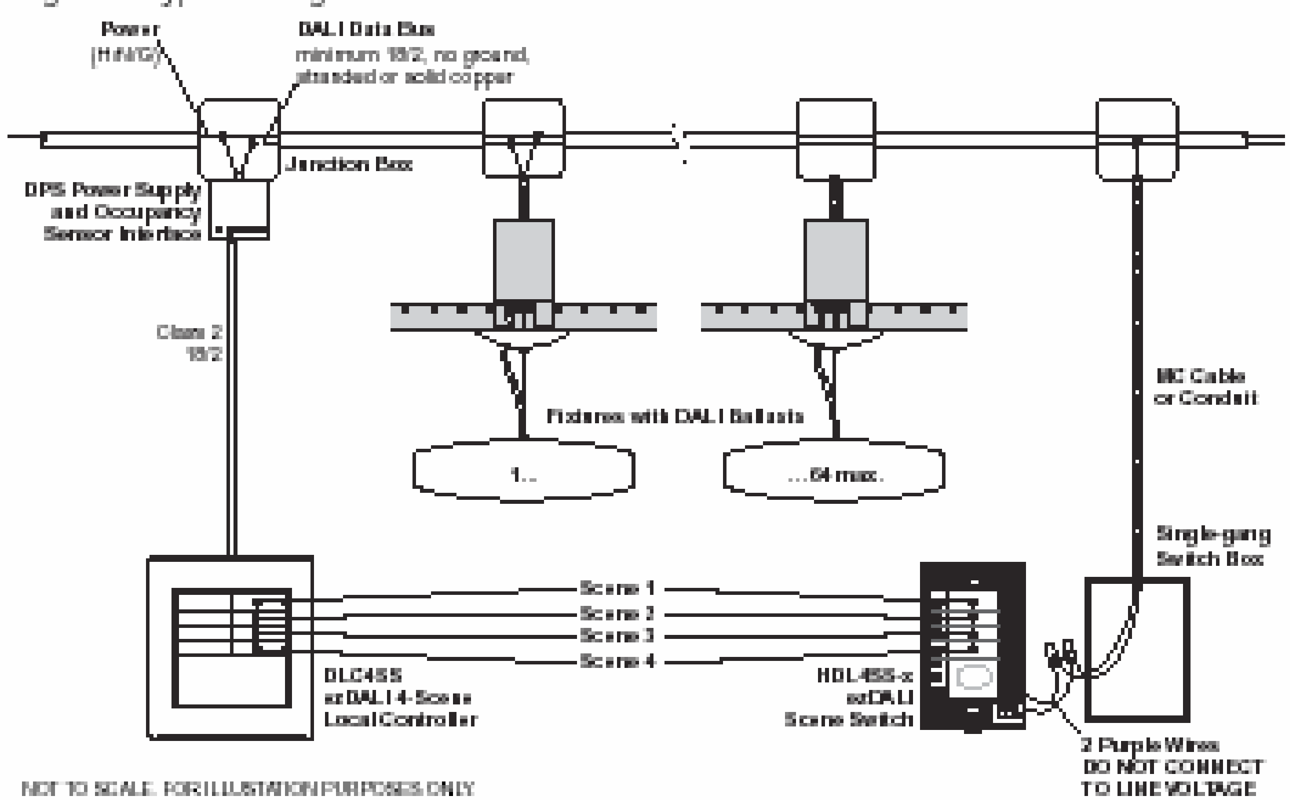
The four Scene buttons on the Scene Switch allow the occupant to recall up to four lighting presets or scenes. For example, the lighting levels of the fixtures within the room could be adjusted to create lighting environments suited to “Normal Work,” “Computer Lighting,” “Meetings”, and “Special Lighting.”

Pressing a Scene button initiates a command over the data bus to turn the controlled group of ballasts to that scene.

The large Master button on the switch provides an Off/Restore function. Once the occupant has selected the desired scene, pressing and releasing the Master button will turn off the scene. Pressing and releasing it again will restore the scene. Pressing and holding the Master button will ramp the lights up, allowing a temporary adjustment to the current scene. Releasing, then pressing and holding the Master button again,will ramp the lighting down.

The ballast groupings, scenes, and fade rates are programmed into the ballasts through the PC with commissioning software.

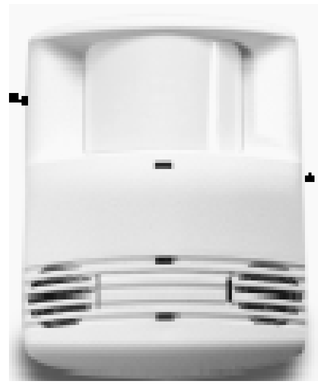
Figure 1 - Typical Wiring



1.4.3 Occupancy sensors

The DOSI is compatible with any 24VDC sensor. Furthermore, it can power multiple sensors when covering a large area.

Dual technology sensors were used in large offices, the training room and conference rooms.



Ultrasonic sensors were used in the open office, lab, and lunchroom

Passive infrared sensors were used in the aisles and small offices

1.5.0 3-Byte modified controls

1.5.1 DOSI3

The DOSI3 is a modified DOSI with firmware capable of sending and receiving both 2-byte and 3-byte messages. The operation of the DOSI3 is morphed by changes in its parameter bank in use. In the example below, the operation of the DOSI3 changes when the building goes into after-hours mode. During normal hours, the DOSI3 uses Parameter Bank 1 and turns the lights to low when unoccupied. At closing time, a controller transmits a message for the DOSI-3 to use Parameter Bank 2. Now, rather than turn the lights to low when unoccupied, the DOSI turns them off.

Similarly, if the building is requested to go into a shed mode, the controller would transmit a message for the DOSI to use Parameter Bank 3 and use a special reduced lighting scene (13) instead of scene 0.

	Bank 1 Normal occupancy	Bank 2 After hours	Bank 3 Demand Shed
Sensitivity	Medium	Medium	Medium
Time delay	20 min	10 min	10 min
ON Scene	0 (normal work)	0	13 (Shed level)
OFF Scene	14 (Low level)	15 (OFF)	15 (OFF)

1.5.2 3-byte parameter controller

The three-byte parameter controller is a Group DALI Switch with the software modified to send the 3-byte commands to the DOSI3 to change parameter banks.

The commands that are sent follow:
Button 1 – Use parameter bank 1 01h 82h 01h 50 ms del. 02h 82h 01h
Button 2 – Use parameter bank 2 01h 82h 02h 50 ms del. 02h 82h 02h
Button 3 – Use Parameter bank 3 01h 82h 03h 50 ms del. 02h 82h 03h
Where 1st byte is address number, 2nd byte is the command, 3rd byte is the parameter bank number.

1.6.0 Installation issues

1.6.1 Shunted tombstones

The Warwick facility converted from ESI Superdim AddressPro to Tridonic DALI. The ESI ballasts were wired in series with the tombstones on one end shunted. Wiring for DALI required rewiring of the fixtures with special attention paid to the tombstones to remove shunts.

Properly wired fixtures responded nicely with no barber-poling or other signs of instability.

1.6.2 Failed devices

The contractor reported 4 defective ballasts, no defective switches or dimmers, and several software corrections required for the conference rooms.

1.6.3 Wiring errors

There were numerous wiring errors, particularly in the original wiring where bus home runs to the electrical closet were missing.

1.6.4 Addressing

Incorrect numbering of controls proved to be the largest source of failures.

1.7.0 Commissioning

1.7.1 Four step process

We cut the commissioning process from 2 days to approximately one hour using the four-step process (after wiring errors had been corrected).

The commissioning process for the ballasts has been reduced to four steps:

1 Broadcast a command to go to max/min level repetitively to identify any ballasts that are not responding properly.
2 Search for all addresses to confirm that the proper number of ballasts are responding.
3 Issue the max/min repetitive command to each ballast in order to verify that each is responding to its short addresses.
4 Swap the ballast addresses to make them align with the reflected ceiling plan documentation. Use a timed min/max to each ballast allowing us to “follow the blinking fixture across the floor.

1.7.2 Programming documentation

Training Center

Mux Control Port - 7

Ballast Number	Type	Group	Group	Scene 1	2	3	4	15	16
1	CF	1	12	76	29	68	48	5	0
2	CF	1	12	76	29	68	48	5	0
3	CF	1	12	76	29	68	48	5	0
4	CF	1	12	76	29	68	48	5	0
5	CF	1	12	76	29	68	48	5	0
6	CF	1	12	76	29	68	48	5	0
7	CF	1	12	76	29	68	48	5	0
8	CF	1	12	76	29	68	48	5	0
9	CF	1	12	76	29	68	48	5	0
10	CF	1	12	76	29	68	48	5	0
11	T8 Twin	1	-	68	1	48	25	5	0
12	T8 Twin	1	-	68	1	48	25	5	0
13	T8 Twin	1	-	68	1	49	25	5	0
14	T8 Twin	1	-	68	1	49	25	5	0
15	T8 Twin	1	-	68	30	49	25	5	0
16	T8 Twin	1	-	68	30	49	25	5	0
17	T8 Twin	1	-	68	30	49	25	5	0
18	T8 Twin	1	-	68	30	49	25	5	0
19	T8 Twin	1	-	68	30	49	25	5	0
20	T8 Twin	1	-	68	30	49	25	5	0
21	T8 Twin	1	-	68	30	49	25	5	0
22	T8 Twin	1	-	68	30	49	25	5	0
23	T8 Twin	1	-	68	30	49	25	5	0
24	T8 Twin	14	-	48	68	48	25	5	0
25	T8 Twin	14	-	25	70	48	25	5	0
26	T8 Twin	14	-	100	68	48	25	5	0
27	T8 Twin	14	-	100	65	48	25	5	0

All T8 Twin - Relay 8

All CF - Relay 9

Conference Rooms are ezDali - Relay 7
Ballast number change due to demos

						Scenes					
ballast	Location	Type	Group	Group	Group	1	2	3	4	15	16
0	Cube 1	T8 Single	1	2	15	78	-	-	-	0	0
1	Cube 1	T8 Twin	1	2	16	28	-	-	-	0	0
2	Cube 1	T8 Single	1	2	15	78	-		-	0	0
3	Cube 1	T8 Twin	1	2	16	0	-	-	-	0	0
4	Cube 3	T8 Single	1	3	15	78	-	-	-	0	0
5	Cube 3	T8 Twin	1	3	16	0	-	-	-	0	0
6	Cube 3	T8 Single	1	3	15	78	-	-	-	0	0
7	Cube 3	T8 Twin	1	3	16	0	-	-	-	0	0
8	Cube 5	T8 Single	1	4	15	78	-	-	-	0	0
9	Cube 5	T8 Twin	1	4	16	0	-	-	-	0	0
10	Cube 5	T8 Single	1	4	15	78	-	-	-	0	0
11	Cube 5	T8 Twin	1	4	16	48	-	-	-	0	0
12	Cube 7	T8 Single	1	5	15	78	-	-	-	0	0
13	Cube 7	T8 Twin	1	5	16	0	-	-	-	0	0
14	Cube 7	T8 Single	1	5	15	78	-	-	-	0	0
15	Cube 7	T8 Twin	1	5	16	48	-	-	-	0	0
16	Cube 9	T8 Single	1	6	15	78	-	-	-	0	0
17	Cube 9	T8 Twin	1	6	16	29	-	-	-	0	0
18	Cube 9	T8 Single	1	6	15	78	-	-	-	0	0
19	Cube 9	T8 Twin	1	6	16	29	-	-	-	0	0
20	Cube 2	T8 Single	1	7	15	78	-	-	-	0	0
21	Cube 2	T8 Twin	1	7	16	28	-	-	-	0	0
22	Cube 2	T8 Single	1	7	15	78	-	-	-	0	0
23	Cube 2	T8 Twin	1	7	16	0	-	-	-	0	0
24	Cube 4	T8 Single	1	8	15	78	-	-	-	0	0
25	Cube 4	T8 Twin	1	8	16	0	-	-	-	0	0
26	Cube 4	T8 Single	1	8	15	78	-	-	-	0	0
27	Cube 4	T8 Twin	1	8	16	0	-	-	-	0	0
28	Cube 6	T8 Single	1	9	15	78	-	-	-	0	0
29	Cube 6	T8 Twin	1	9	16	78	-	-	-	0	0
30	Cube 6	T8 Single	1	9	15	78	-	-	-	0	0
31	Cube 6	T8 Twin	1	9	16	78	-	-	-	0	0
32	Cube 8	T8 Single	1	10	15	78	-	-	-	0	0
33	Cube 8	T8 Twin	1	10	16	78	-	-	-	0	0
34	Cube 8	T8 Single	1	10	15	78	-	-	-	0	0
35	Cube 8	T8 Twin	1	10	16	78	-	-	-	0	0
36	Cube 10	T8 Single	1	11	15	78	-	-	-	0	0
37	Cube 10	T8 Twin	1	11	16	78	-	-	-	0	0
38	Cube 10	T8 Single	1	11	15	78	-	-	-	0	0
39	Cube 10	T8 Twin	1	11	16	78	-	-	-	0	0

Cube 1 - Spare	Cube 4 - Brad Stevens	Cube 7 - Spare	Cube 10 - Printers
Cube 2 - Ashu Vighne	Cube 5 - Bob Decelles	Cube 8 - Spare	Odd Cubes - Relay
Cube 3 - Spare	Cube 6 - Dan Ferriola	Cube 9 - Plotter/Files	Even Cubes - Relay

Perimeter Mux Control Port - 5

Ballast #	Location	Type	Group	Group	Scenes 1	2	3	4	15	16
0	O7	T8 Twin	1	-	49	-	-	-	10	0
1	O7	T8 Single	1	-	100	-	-	-	10	0
2	O7	T8 Twin	1	-	100	-	-	-	10	0
3	O7	T8 Single	1	-	48	-	-	-	10	0
4	O6	T8 Twin	2	-	20	100	0	100	10	0
5	O6	T8 Single	2	-	20	100	49	100	10	0
6	O6	T8 Twin	2	-	20	0	100	100	10	0
7	O6	T8 Single	2	-	20	0	100	0	10	0
8	O5	Biax	3	-	29	49	74	29	10	0
9	O5	Biax	3	-	29	49	74	29	10	0
10	O5	T8 Twin	3	-	100	100	100	50	10	0
11	O5	T8 Single	3	-	100	100	100	50	10	0
12	O5	T8 Twin	3	-	0	49	49	0	10	0
13	O5	T8 Single	3	-	100	100	100	50	10	0
14	O4	T8 Twin	4	-	100	29	10	49	10	0
15	O4	T8 Single	4	-	100	29	10	49	10	0
16	O4	T8 Twin	4	-	100	29	10	49	10	0
17	O4	T8 Single	4	-	100	29	10	49	10	0
18	O3	T8 Twin	5	-	49	-	-	-	10	0
19	O3	T8 Single	5	-	100	-	-	-	10	0
20	O3	T8 Twin	5	-	29	-	-	-	10	0
21	O3	T8 Single	5	-	100	-	-	-	10	0
22	O2	T8 Twin	6	-	100	75	49	25	10	0
23	O2	T8 Single	6	-	100	75	49	25	10	0
24	O2	T8 Twin	6	-	100	75	49	25	10	0
25	O2	T8 Single	6	-	100	75	49	25	10	0
26	O1	T8 Twin	7	-	29	100	0	0	10	0
27	O1	T8 Single	7	-	100	100	100	48	10	0
28	O1	T8 Twin	7	-	29	100	29	0	10	0
29	O1	T8 Single	7	-	100	100	100	49	10	0
30	O1	Biax	7	-	48	100	48	0	10	0
31	O1	Biax	7	-	48	100	48	0	10	0
32	O1	Biax	7	-	48	100	48	0	10	0
33				-						
34	AA1	T8 Twin	8	-	48	-	-	-	10	0
35	AA1	T8 Single	8	-	48	-	-	-	10	0
36	AA1	CF	8	-	48	-	-	-	10	0
37	AA1	CF	8	-	48	100	0	100	10	0
38	AA1	CF	8	-	48	-	-	-	10	0

O7- Don Munroe
O6- Walt Sulyma
O5- Bob Beatty
O4- Dorene Maniccia

O3- Jennifer Whitten
O2- Bill King
O1- Dave Peterson
AA1 - Bunny Voorhaar

All Perimeter - Relay 2

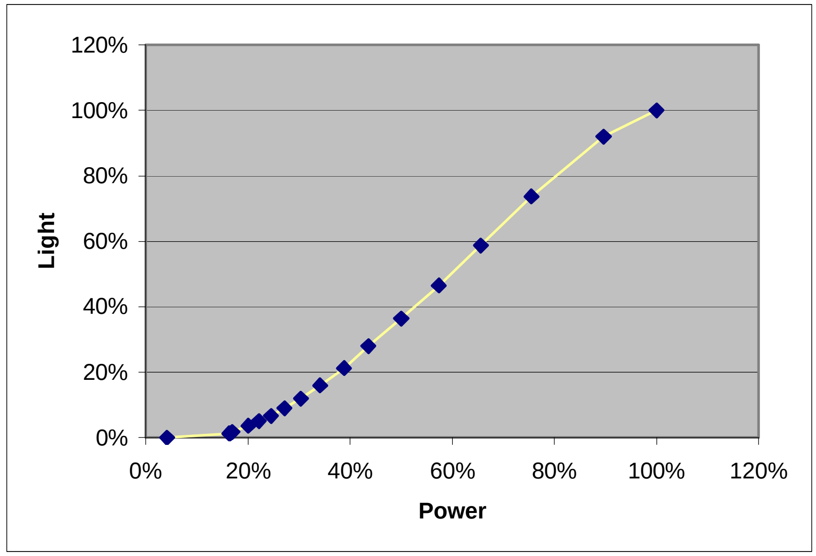
					Scenes					
Ballast #	Location	Type	Group	Group	1	2	3	4	15	16
0	Lab	T8 Twin	1	-	29	29	100	100	10	0
1	Lab	T8 Twin	1	-	29	29	100	100	10	0
2	Lab	T8 Twin	1	-	29	29	100	100	10	0
3	Lab	T8 Twin	1	-	29	29	100	100	10	0
4	Lab	T8 Twin	1	-	29	29	100	100	10	0
5	Lab	T8 Twin	1	-	29	29	100	100	10	0
6	Lab	T8 Twin	1	-	29	29	100	100	10	0
7	Lab	T8 Twin	1	-	29	29	100	100	10	0
8	Lab	T8 Twin	1	-	29	29	100	100	10	0
9	Lab	T8 Twin	1	-	29	29	100	100	10	0
10	Lab	T8 Twin	1	-	29	100	100	100	10	0
11	Lab	T8 Twin	1	-	29	29	100	100	10	0
12	Lab	T8 Twin	1	-	29	29	100	100	10	0
13	Lab	T8 Twin	1	-	29	29	100	100	10	0
14	Lab	T8 Twin	1	-	29	100	100	100	10	0
15	Lab	T8 Twin	1	-	29	100	100	100	10	0
16	Lab	T8 Twin	1	-	0	0	0	100	0	0
17	Lab	T8 Twin	1	-	0	0	0	100	0	0
18	Lab	T8 Twin	1	-	0	0	0	100	0	0
19	Lab	T8 Twin	1	-	0	0	0	100	0	0
20	Lab	T8 Twin	1	-	0	0	0	100	0	0
21	Lab	T8 Twin	1	-	0	0	0	100	0	0
22	Dining	T8 Twin	2	-	20	48	100	0	10	0
23	Dining	T8 Twin	2	-	20	48	48	0	10	0
24	Dining	T8 Twin	2	-	20	48	100	0	10	0
25	Dining	Biax	2	-	49	49	100	29	10	0
26	Dining	Biax	2	-	49	49	100	29	10	0
27	Dining	Biax	2	-	49	49	100	29	10	0
28	Storage	T8 Twin	3	-	100	0	0	0	5	0
29	Storage	T8 Twin	3	-	100	0	0	0	5	0
30	Women's Rest	T8 Twin	4	-	100	-	-	-	5	0
31	Women's Rest	T8 Twin	4	-	100	-	-	-	10	0
32	Women's Rest	T8 Twin	4	-	100	-	-	-	10	0
33	Women's Rest	T8 Twin	4	-	100	-	-	-	10	0
34	Men's Rest	T8 Twin	5	-	48	-	-	-	10	0
35	Men's Rest	T8 Twin	5	-	48	-	-	-	10	0
36	Men's Rest	T8 Twin	5	-	48	-	-	-	10	0
37	Men's Rest	T8 Twin	5	-	48	-	-	-	10	0
38	Telephone	T8 Twin	10	-	100	100	-	-	5	0
39	Telephone	T8 Twin	10	-	100	100	-	-	5	0
40	Ceiling by MR	Relay Module	9	-	100	-	-	-	0	0

Lab - Relay 3 All others - Relay 6 Relay Module controls aisle wall wash - Relay 1

1.8.0 Energy impact

1.8.1 Power vs. Light

The energy savings with DALI is a function of the ability to dim efficiently and to control each fixture independently. Three of the four ballast tested had practically identical power/light level curves.

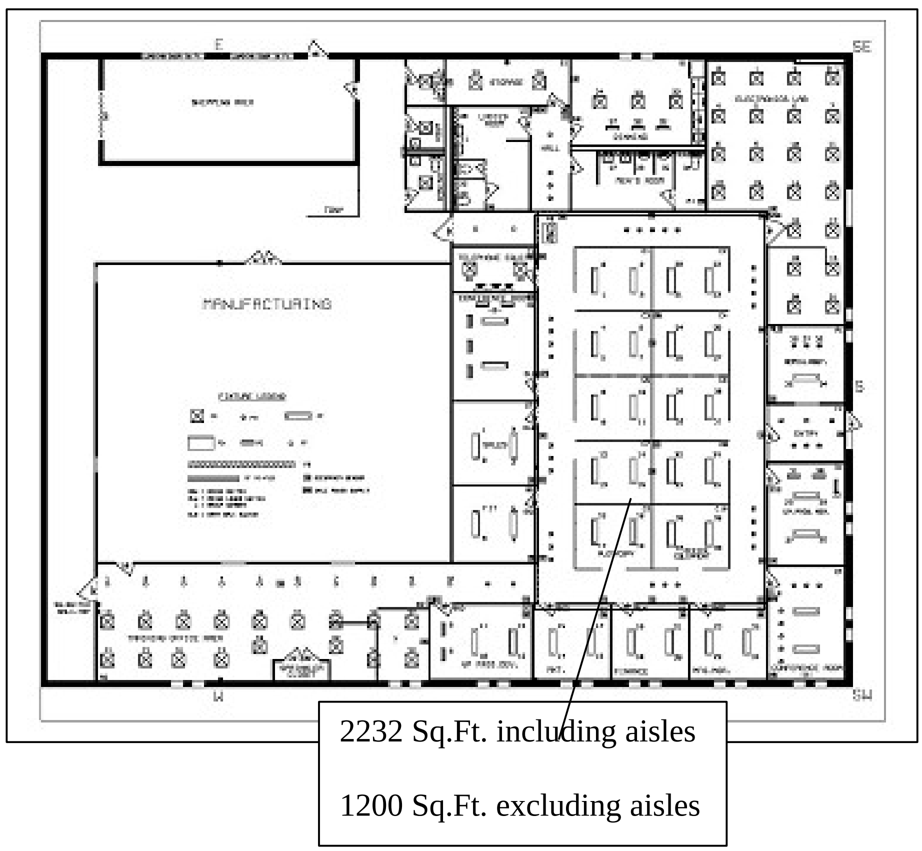


The ability to set the light level for each ballast had a major impact in the open offices, while the ability to set scenes for different functions had a strong impact in the lab, dining, and training rooms.

While the sample sizes here preclude quantitative analysis and projection, the data does support the idea of higher installed watts/sqft and then tuning the lighting to attain the wattage target while increasing occupant satisfaction.

1.8.2 Open office savings

- Including Aisles
  - @100%
    17.25mps x 116VAC
    + 936 watts for wallwash =
    2,937 watts
  - TUNED
    10.25mps x 116VAC
    + 936 watts for wallwash =
    2,125 watts
  - **Savings = 28%**
- Excluding Aisles
  - @100%
    2001 watts
  - TUNED
    1186 watts
  - **Savings = 41%**



1.8.3 Lab kW reduction

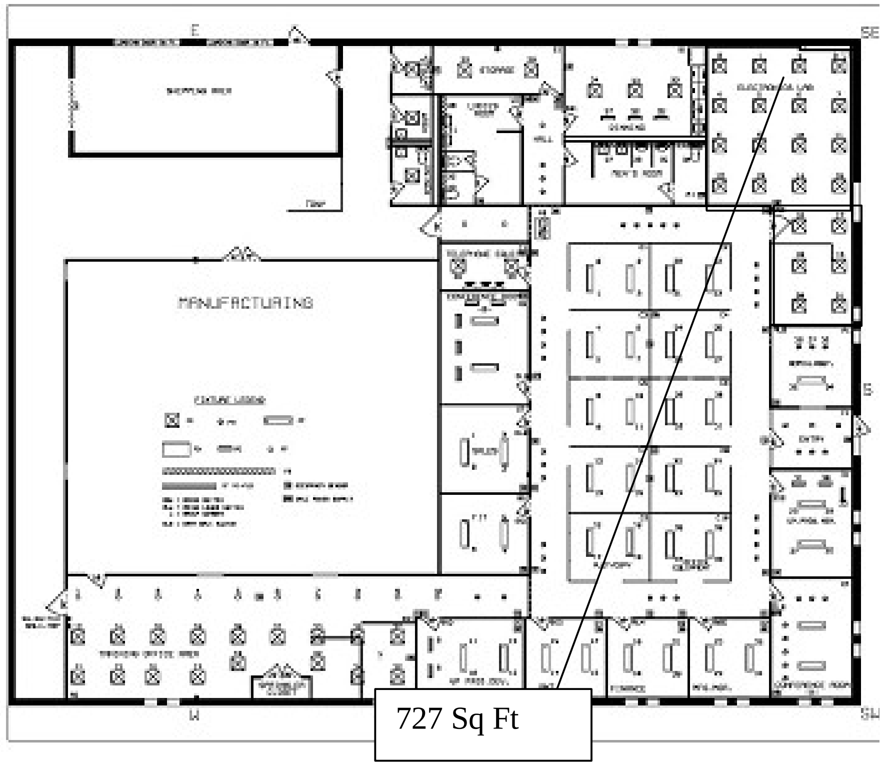
@100%

1740 watts

TUNED

667 watts

Savings = 62%



The savings above are based on actual readings of the current to the area. A close approximation may be had by using the light/power curve to convert each ballast to its program power level and then calculating the sum of the individual reduced wattages to the sum of the max wattage fir each.

For example, using the programming documentation sheet for the lab at scene 1, there are 16 fixtures at 29% light level and 6 at 0%. That would translate to 16 @ 45% power and 6 @ 2% power for a relative power level of 33%…a 67% savings, which compares o the 62% savings from direct measurement.

Area	Light Level % of Max	Power Level % of Max	Power Reduction
Men's Room	48%	60%	40%
Ladies room	100%	100%	0%
Dining	31%	44%	56%
Perimeter offices	63%	70%	30%
Training	23%		62%

1.9.0 Co-exist

One of our objectives was to determine the extent to which control devices from different suppliers might interfere with each other. We did not observe any instances where control devices or ballasts interfered with each other in normal operation.

1.9.1 Ballasts

Ballasts from the four manufacturers performed uniformly and no problems occurred when ballasts from different manufacturers were mixed. Similarly, there were no problems when ballast types, such as linear and compacts, were controlled as part of the same group.

1.9.2 Control devices

1.9.2.1 Switches and dimmers

Devices from three manufactures were installed on the same loop and then actuated together to try to create collisions. The only conditions that created a missed command were when a scene switch was actuated while a dimmer was ramping. The ramping function tied up the data bus creating the possibility of missed commands from other devices. It should be noted that the system recovered as soon as the ramping ceased.

1.9.3 Power supplies

Power supplies from two manufacturers were swapped with no impact on system performance.

1.10.0 3-byte demonstration

1.10.1 Task objective

To reiterate, the objective of the demonstration was to show that products developed around the new standard could work. This was done in several steps.

1.10.2 Step 1: Controls built to the current standard work

Controls used the standard’s 2-byte message structure to communicate with the ballast work. We met all of the control intent for each space and in the process showed impressive energy and demand savings while increasing occupant satisfaction.

1.10.3 Step 2: Show that 3-byte control messages do not impact the ballasts

The test program showed that the 3-byte control messages did in fact impact the ballasts. However, the ballast manufacturers were quick to correct the ballast software to eliminate the problem. Subsequent testing showed no interaction.

1.10.4 Step 3: Demonstrate that a 3-byte control device can duplicate the functions of the current devices and do more.

The DOSI-3 was developed to do just that. It sends 2-byte messages to the ballast to provide the automatic off occupancy sensor function while also providing an occupant dimmer the same as the DOSI devices installed throughout the test area. However, the DOSI-3 can also receive and transmit three byte messages. One of the key functions supported is the concept of parameter banks. (See section 1.3.3). The portable demo has 2 DOSI-3 and four ballasts. The DOSIs are addressed #1 and #2 so they can receive their specific programming data. To demonstrate, three parameter banks were programmed into each DOSI-3. The first two banks controlled the action of the sensor during normal hours versus after-hours as shown in section 1.3.3. The third bank changed the area being controlled by the DOSI, combining the two offices into one.

1.11.0 Vote to proceed

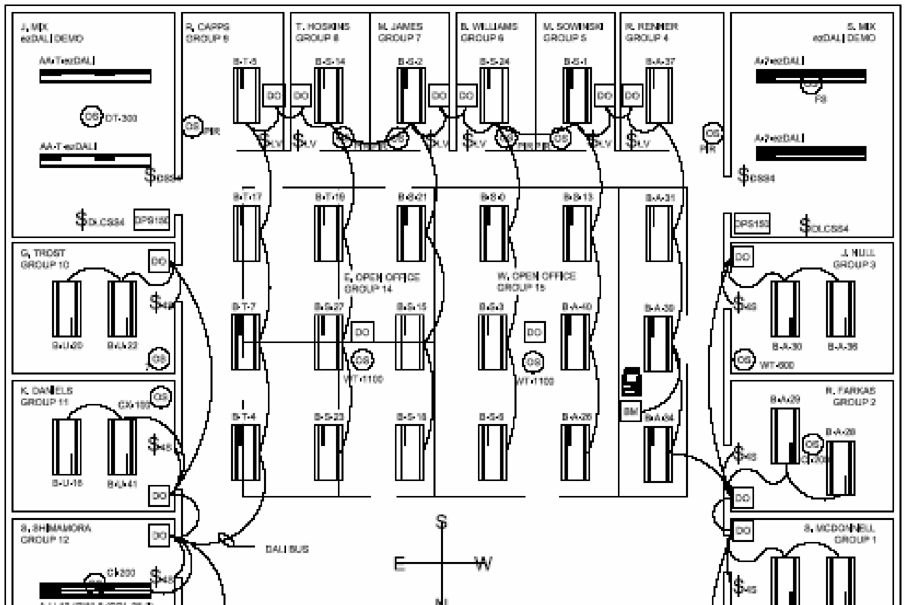
To support the 3-byte communications, control devices will have to be addressed from 0-63. The major benefit of adding communications to the control devices lies in the ability of the device to have different operating parameters to match the building mode. It also allows remote programming and diagnostics.

On September 28th, the NEMA Joint Sections on DALI voted to letter ballot the current draft standard, including the 3-byte protocol for controls.

2.0.0 California Demonstration Site

2.1.0 Floor plan

The drawing shown below illustrates the layout for all hardware that made up the DALI system (i.e. the controlled fixtures, ballasts, DALI override switches, 3-wire momentary Low Voltage override switches, DALI Occupancy Sensor Interfaces, the occupancy sensors, the DALI power supply, the PC running DALI setup software, and the DALI dataline).



Note:
Each Fixture has an identifier next to it in the format:
Letter1 - Letter2 - Number

Letter1 = Fixture Type (A, AA, or B)
Letter2 = Ballast Mfg (U=Universal, T=Tridonics, S=Sylvania, A=Advance)
Number = DALI Ballast Address(es), or if part of an ezDALI system

Fixtures with multiple ballasts include additional info for each ballast address to identify if the ballast controls Inner Lamps (I), Outer lamps closest to the Window (OW), or Outer lamps closest to the door (OD).

Also - Occupancy Sensor and Low Voltage Switch wire not shown.

DALI BALLAST INFO							
Fixt.	Shown As	Designation	QTY	Lamps Each	Lamps Total	Ballasts Each	Ballasts
A	▬	1x8x6	4	6	24	3	12
AA	▭	1x8x4	2	4	8	2	4
B	▭	2x4x2	36	2	72	1	36
Total			42		104		52
	Shown As	Designation	QTY	Comments			
	DO	DALI Occupancy Sensor Interface	16				
	$4S	DALI 4 Scene Switch	8	Set Initially to 100% / 75% / 50% / 25%			
	BM	DALI Bus Master	1	Various Types - See plan for specific units			
	OS	Occupancy Sensor	18	Located next to Computer			
	$LV	Low Voltage 3-Wire Switch	6				
	DPS150	ezDALI Power Supply	2				
	$DLCSS4	ezDALI Group / Scene Switch	2	Remote Mounted - used only for setup			
	$SS4	ezDALI Scene Switch	2				

The Watt Stopper
CEC DALI Project
Office Layout — Drawing: Typical
Scale: none — Date: 10/10/04 — Job Number: 4-0608A
Sheet: 1 of 4 — Rev: E
Drawn & Checked by: Charles Knuffke charles_knuffke@wattstopper.com
179 Haight St. San Francisco, CA 94102 (415) 981-3708

2.2.0 DALI databus

The DALI installation was a retrofit project using existing fixtures. The fixtures were originally wired on the power side using flexible whips connected to hard-piped junction boxes. In order to run the DALI databus, the decision was made to run the DALI conductors using Class 1 wiring methods. The DALI wires were connected from fixture to fixture in flex wire whips, which we fished through existing conduits where necessary.

Included with this report is a set of typical wiring diagrams for the following:

A) Enclosed High Wall Office with 1 or 2 fixtures
B) Small Office with Low Wall opening
C) Overall Network Wiring

It should be noted that the overall network wiring shows a connection between a DALI power supply and a Serial-Ethernet device. To simplify the system, this device was dropped, and the DALI power supply is connected directly to a PC running the DALI tool software.

2.3.0 Control Devices

The DALI software at this location is not capable of doing any automatic time-based control functions. In order to meet Title 24 requirements for shutting off all lighting automatically, occupancy sensors were installed in each room as well as the open areas. A mix of ultrasonic, infrared, and dual technology sensors were chosen. The sensors were all wired into a DALI Occupancy Sensor Interface (DOSI), which takes the 24V signal from the Occupancy sensor and converts it to a DALI command that tells a specific DALI group (0-15) to go to Scene 0. The group number transmitted is set via dipswitches on the interface unit.

When the occupancy sensor sees no activity for preset amount of time, it sends a 0V signal to the DOSI. At the 24V to 0V transition, the DOSI tells its group to go to Scene 14. After 5 minutes, if the sensor reports no activity, the DOSI sends out a message for its group to go to Scene 15. Scenes 14 and 15 are set up as a 10% lighting scene and a 0% lighting scene respectively.

After the initial transmission of the Scene 15 command, the DOSI re-transmits the Scene 15 command repeatedly at 30-minute intervals. This ensured that if someone changes the light level to some non-zero level via the PC, or if a brief power failure occurs at night, the lights would not stay at that level all night.

2.4.0 Multi-vendor ballasts

In an effort to prove the “open” nature of the DALI protocol, ballasts from 4 different manufacturers were used in this demonstration project. All products were donated by the respective manufacturers: Advance, Osram/Sylvania, Tridonics, and Universal.

After the initial startup of the system, it was determined that one manufacturer’s ballasts were not accepting their initial DALI address from the software. After identifying the cause of this issue, they immediately replaced the initial ballasts with newer version, and this corrected the issue with the addressing.

2.5.0 Multi-vendor dimmers and scene switches

In the Santa Clara installation, each individual private high-wall office was provided with a dataline scene switch. The switch connected directly to the DALI bus and was set to control a specific group via dipswitches on the back of the device (0-15). There were 4 small buttons on the face that corresponded to Scenes 0, 1, 2, and 3, and 1 larger button at the bottom that would trigger Scene 15. Scene 15 was set as Off for all ballasts, but preset Scenes 0-3 were set based on the individual occupant's preference.

In the 6 private offices that had a 5-foot wall in the front (On the West Side), instead of providing a dataline scene switch, a simple raise/lower switch was used. The switch itself was just a 3-wire momentary toggle device, and it was wired into a 3-pin jack on the DOSI to provide the special features. The switch/DOSI combo worked as such:

- Switch "tapped" up -> DOSI sends a single Group ON command.
- Switch held up -> DOSI sends multiple Group Ramp Up commands
- Switch held up -> DOSI sends multiple Group Ramp Down command.
- Switch "tapped" down -> DOSI sends a single Group OFF command.

2.6.0 3-Byte demo (See 1.10.4)

The decision to go to a 3-byte message structure for communicating with control devices had a major impact on system capability. In particular, it allowed a whole set of commands to be developed around the needs of control devices.

The messages follow a consistent format. The first byte defines "who" the message is intended for. The second byte defines "what" action is required. The third byte defines "how much". For example, the demo controller sends a message for "all occupancy sensor interfaces" to "use parameter bank" "#2".

The 3-byte message is heard by the ballasts and the control devices. However, the DALI ballast standard specifies that any message not conforming to the 2-byte structure is to be ignored by the ballasts. This makes it possible for the control messages to co-exist with ballast messages.

During the demo installation in Warwick, however, we observed ballasts reacting to 3-byte control commands. With further investigation, it became clear that some ballast simply truncated the 3rd byte thus creating a valid 2-byte command that the ballast would implement. Other ballasts used the 1st and 3rd bytes, again creating a message to which the ballast would respond.

Having caught this problem in Warwick, there was time for the ballasts manufacturers to correct the software for the ballasts going into Santa Clara. Subsequent testing at both sites confirmed that the modified software eliminated the problem.

2.7.0 ezDALI

The original plan for the office was to control the entire area using a single DALI bus. However, during the design, it was realized that it would require 18 different DALI groups to be able to control each area office area individually, which is 2 more than the 16 DALI groups allowed per bus. In conversations with the two principals in the Santa Clara office, they offered that instead of installing the normal network DALI system in their offices, they would be willing to test out a separate “modular” DALI system manufactured by Watt Stopper called ezDALI.

The ezDALI products were developed for sites that wanted to use DALI dimming ballasts in single room applications. Instead of requiring the controls to be set up via a software package, the ezDALI controls are set up solely by pressing buttons on the Group/Scene switch controller.

Each of the two individual ezDALI systems use standard DALI ballasts. A single device that functions as both the DALI power supply and Occupancy Sensor Interface is installed in each office. A Dataline Switch (called a controller in the ezDALI system) with 4 group buttons and 4 scene buttons acts as the occupant’s interface device to the system. The person setting up the system uses the controller to initially address all the ballasts on the ezDALI loop, and then follows the steps to assign each ballast to one of the 4 groups. Once the groups are set up, the buttons that control the groups can be used to turn a group On/Off or raise/lower its light level. Scenes, initially set by controlling the levels of the individual group buttons, can be assigned as a pre-set to any of the 4 scene buttons.

While the decision to add two ezDALI installations to the DALI test area was made after the initial program began, using ezDALI in the two offices allowed the rest of the office to be controlled by a single DALI bus. The ezDALI areas also offered two “control” groups to compare the complexity or simplicity of implementing occupant dimming zones in the network DALI system verses the more modular ezDALI approach.

2.8.0 Installation, Startup, and Commissioning

2.8.1 Installation

Installation of the entire DALI network took a team of 2, and occasionally 3, electrical technicians approximately one week.

Before beginning their installation, they were provided with a “scope of work” document alerting them to the work that they were specifically being asked to perform. This “scope of work” document is available for review. The hope was that by calling attention to all the steps required to install the DALI system, the team could review this together and pre-plan their activities.

Most of the time was spent running the new DALI wire in the space above the ceiling tiles. In the individual high-wall private offices, existing single pole toggle switches were removed, and the conduit and box reused for the new dataline scene switches. Since the 3-wire momentary switches for the individual low wall partition offices were Class 2 devices, holes and boxes were cut in the walls, but no conduit was needed.

2.8.2 Initial Startup

The initial startup of the system occurred immediately after the system installation. The purpose of the pre-start up was to verify that the PC’s DALI Tool software could communicate to the DALI ballasts and address them.

The first issue that came up was a shorted dataline, but that was easily identified and corrected. After running the first DALI tool test (a broadcast raise/lower), we identified 3 fixtures that did not respond. Those three fixtures had not been connected to the DALI bus, but about 20 minutes later that issue was corrected.

The final issue came about when we used the DALI tool to address the ballasts. Out of the 42 ballasts on the system, only 28 took an address. Checking the documentation, all 14 of the missing ballasts were identified as being from one manufacturer.

The portion of the DALI ballasts that did take DALI address worked fine, and all the 4-button scene switches in the offices with these ballasts were working (Conference Room to Grace's Office). Additionally, one of the ezDALI offices was started up, but there was an issue with one of the ballasts not going to full level every time.

2.8.3 Final Startup

The final startup took place about a week after the initial startup. During the week in between the two events, the manufacturer identified the issue that prevented their ballasts from taking an address, and shipped replacement ballasts to the site. The replacement ballasts were inserted, and a quick test done that verified that they would take their addresses during the DALI tool setup.

2.8.4 Commissioning

The Watt Stopper Product Line Manager and the Western Region Technical Manager spent approximately two full days to commission the system (Sunday, most of Monday, and a good part of Tuesday). The purpose of commissioning the system (verses a startup) was to make sure that the entire system was working properly, not just communicating on the data bus. This involved checking each individual space to make sure that the individual’s switch was set up and controlled the lights in the space, and testing the occupancy sensors to make sure they also interacted with the DALI system as designed.

During the commissioning, it was realized that the dipswitches on several of the devices were set using a different numbering scheme than originally planned. While the instructions on how to set the dipswitches on the DOSIs and Scene switches all used group numbers 0-15, the first screen of the DALI tool software listed the groups as numbers 1-16. This slight discrepancy caused the loss of several hours when commissioning the system. Re-setting the dipswitches on the Dataline Scene Switches was fairly easy since they were mounted on the exposed office walls. Resetting the dipswitches on the DOSI proved much more difficult as they were located above the ceiling, and it was rarely easy to get access to the units. It cannot be stressed enough that this issue of identifying groups and scenes as 0-15 verses 1-16 needs to be standardized in every DALI system, regardless of the manufacturer.

To set up the initial level for each area, one of the commissioning people went into each individual office and used a ramp up/ramp down function while asking the occupant to identify the light level they wanted when they came into the room (this level was assigned as Scene 0 in their ballasts). It was obvious that this very short interaction with the occupant was key to getting the occupants educated about the system and assuring them that both the sensors and Scene Switches were controlling their lights to their desired level.

One other product that required fine-tuning was the occupancy sensors. Some sensors needed to have their sensitivity or their mounting direction adjusted. Unfortunately, some ultrasonic sensors were mounted too close to air registers, and were false triggering ON constantly.

2.8.5 Sniffer

When working with any protocol that is transmitting and receiving messages over a dataline wire, it's beneficial to be able to "see" the messages as they are transmitted. A device that does this is called a "sniffer". During the commissioning of the DALI system, a sniffer was used to analyze the DALI messages. A sniffer allowed one person working on the system to quickly walk around a floor and press a button on each wall switch. That person could then go back to the computer and see a log listing each message transmitted, and be able to verify that the correct groups were sent. This takes much less time than having to pull each Scene switch out of the wall and check the dipswitch settings to see that the groups are correct.

The sniffer used at the Santa Clara project used a modified single 9-pin serial connector, and connected directly to the DALI bus. The 9-pin connector connected to a different PC running Tridonic's WinDim software. Once connected and set up, whenever a DALI command came across the dataline, the WinDim software displayed the command in hex format. As new commands were translated, they were listed below the previous command.

Since the DALI commands were in hex format, we developed the following reference table to allow each message's group and scene identifiers to be decoded:

Group Translations			Scene Translations	
Command	**Group**		**Command**	**Scene**
9F	15		1F	15
9D	14		1E	14
9B	13		1D	13
99	12		1C	12
97	11		1B	11
95	10		1A	10
93	9		19	9
91	8		18	8
8F	7		17	7
8D	6		16	6
8B	5		15	5
89	4		14	4
87	3		13	3
85	2		12	2
83	1		11	1
81	0		10	0

2.8.6 Failed devices

2.8.6.1 Shunted tombstones

All existing fixture tombstones were verified to be rapid start, or were changed to that configuration during the ballast retrofit.

2.8.6.2 Failed devices

Following items were found to be problematic, and were replaced. New devices took care of the problem.

1 DALI Ballasts. Both were in an office with ezDALI system.
1 DOSI Unit

Currently there is an issue with 1 fixture in one of the high-wall partition offices, but no one has yet examined that fixture to determine if a lamp or ballast issue.

2.9.0 Results

2.9.1 Occupant response

The DALI system is currently up and operational, and the people in the individual high-wall offices have offered varied responses. One person offered tacit acceptance of the system capability, but stated the desire for 100% light from the fixtures when the individual enters the room. Many others, including several who stare at the computer continuously during the day, were gleeful about the new system capability and most requested that their default light level be set from 50% down to several individuals who requested a default 25% level. 11 of 13 individual office occupants used a reduced lighting level.

One key point from the above is to get the most out of a DALI installation, individual users must be part of the decision process and the system must have a champion.

2.9.2 Unexpected

Sometime after the system had been set up and operating, an issue came up that all the fixtures were at 100% and none of the dataline Scene switches worked. A phone call to one of the commissioning technicians provide several possible issues, and it was determined that one of them was the cause – the DALI power supply had been plugged into an outlet strip. During the day, someone in the office removed the outlet strip, and the power supply was left unplugged. Without the DALI power supply providing system power, all ballasts immediate when to high, and none of the override switches could communicate to the ballast. The outlet strip has since been replaced and a sign letting all know not to unplug the lighting control power supply has been added to prevent a reoccurrence.

Another issue identified is an occupancy sensor mounted near an air vent incorrectly kept the lights from ever going Off. However, someone using the DALI software on the PC ended up sending out a Broadcast Off Command, which turned Off all the lights. The next day people entering the area controlled by the sensor complained that the sensor wasn’t seeing them enter the space and they couldn’t turning their lights ON (This was one of two spaces within the project that didn’t have an override switch). The issue wasn’t that the sensor didn’t see them – it was that the sensor had never gone into an unoccupied mode, and therefore couldn’t go to an occupied mode when someone entered the room. Once this situation was identified, it was immediately corrected by properly adjusting the sensor.

As far as reducing demand during the normal hours, the system resulted in considerable savings during the occupied hours. See next section below.

2.9.3 Energy impact

A table showing the addresses, Group and Level Settings for all Ballasts.

Add.	Room	Notes	Group (0-15)	S0	S1	S2	S3	S14	S15	Fixture	Ballast Mfg
33	J. Sy	Window	0	25%	100%	50%	15%	10%	0%	B	Advance
38	J. Sy	Door	0	25%	100%	50%	15%	10%	0%	B	Advance
32	S. McConnell	Door	1	25%	100%	50%	15%	10%	0%	B	Advance
35	S. McConnell	Window	1	25%	100%	50%	15%	10%	0%	B	Advance
28	R. Farkas	Window	2	100%	75%	50%	25%	10%	0%	B	Advance
29	R. Farkas	Door	2	100%	75%	50%	25%	10%	0%	B	Advance
30	J. Null	Door	3	25%	100%	75%	50%	10%	0%	B	Advance
36	J. Null	Window	3	25%	100%	75%	50%	10%	0%	B	Advance
37	R. Renner		4	100%	75%	50%	25%	10%	0%	B	Advance
1	M. Sowinski		5	50%				10%	0%	B	Sylvannia
24	B. Williams		6	50%				10%	0%	B	Sylvannia
2	M. James		7	50%				10%	0%	B	Sylvannia
14	T. Hoskins		8	50%				10%	0%	B	Sylvannia
5	R. Capps		9	50%				10%	0%	B	Tridonics
20	G. Trost	Window	10	25%	75%	50%	0%	10%	0%	B	Universal
22	G. Trost	Door	10	50%	100%	75%	25%	10%	0%	B	Universal
16	K. Daniels	Window	11	100%	66%	50%	25%	10%	0%	B	Universal
41	K. Daniels	Door	11	50%	65%	50%	25%	10%	0%	B	Universal
8	S. Shimamora	Outer Door	12	25%	66%	48%	25%	10%	0%	A	Universal
12	S. Shimamora	Outer Window	12	25%	68%	50%	25%	10%	0%	A	Universal
25	S. Shimamora	Inner	12	25%	68%	50%	25%	10%	0%	A	Universal
9	Conference	Outer Window	13	50%	100%	75%	25%	10%	0%	A	Universal
10	Conference	Outer Door	13	50%	100%	75%	25%	10%	0%	A	Universal
11	Conference	Inner	13	50%	100%	75%	25%	10%	0%	A	Universal
4	East Open Office	Aisle	14	100%				10%	0%	B	Tridonics
7	East Open Office	Aisle	14	100%				10%	0%	B	Tridonics
15	East Open Office		14	100%				10%	0%	B	Sylvannia
17	East Open Office	Aisle	14	100%				10%	0%	B	Tridonics
18	East Open Office		14	100%				10%	0%	B	Sylvannia
19	East Open Office		14	50%				10%	0%	B	Tridonics
21	East Open Office		14	50%				10%	0%	B	Sylvannia
23	East Open Office		14	50%				10%	0%	B	Sylvannia
27	East Open Office		14	50%				10%	0%	B	Sylvannia
0	West Open Office		15	50%				10%	0%	B	Sylvannia
3	West Open Office		15	100%				10%	0%	B	Sylvannia
6	West Open Office		15	100%				10%	0%	B	Sylvannia
13	West Open Office		15	50%				10%	0%	B	Sylvannia
26	West Open Office		15	50%				10%	0%	B	Advance
31	West Open Office	Aisle	15	100%				10%	0%	B	Advance
34	West Open Office	Aisle	15	100%				10%	0%	B	Advance
39	West Open Office	Aisle	15	100%				10%	0%	B	Advance
40	West Open Office		15	50%				10%	0%	B	Advance

2.9.3.1 Open offices

A total of 18 Open Office 2x4 fixtures were retrofitted with DALI ballasts. As the table above shows, the initial light level for these fixtures changed from 18 @ 100% to 10 @ 100% + 8 @ 50%. The net effect was a savings of 22%.

2.9.3.2 Private Offices

11 of 13 occupants choose lighting levels less than 100%. Leading to a power reduction of approximately 40%.

Appendix 1: Data Line Monitor

DALI Data Line Monitor

Purpose:
The purpose of the DALI Data Line monitor (DDLM) is to monitor all traffic on the data line and send it to a terminal or computer for processing. It also has the ability to inject messages on the DALI Data Line.

Equipment Required:
An Atmel STK500 Development board, an interface circuit, an Atmel ATMega163 (or equivalent) micro controller are required for the sniffer to work.

Setup Parameters:
To use the DALI Data Line monitor the following setting are required on the terminal or computer:

Terminal		Computer
Baud Rate:	19200	Same
Parity:	None	Same
Start Bits:	One	Same
Stop Bits:	One	Same
Flow Control:	None	Same
Caps Lock:	On	Same
Auto Line Feed:	No	No
Emulator:	Standard ASCII	VT52

Note: The reason for no flow control is that the DALI Data line communication frequency is 1200 baud and with the terminal running at 19200Baud monitoring the data line requires no control. On transmitting, it is assumed someone is typing the commands so there should not be an issue. If an automatic system is required DALI Data Line Timing requirements must be incorporated into the software, so as not to have problems with command sequences.

How to use:
Connect the DDLM to the DALI Data line and the spare serial port to a terminal or computer. Complete the above setup Parameters for the terminal or computer terminal emulation software.

Turn on the STK500 device.

Testing Receive
Press a switch button of a device connected to the DALI Data Line. You should see a scene broadcast.

Testing Transmit:
With the caps lock on type the following commands:

45 cr	1-byte message
FEFE cr	2-byte message

DF0123 cr 3-byte message

(cr = carriage return)

Messages are input as ASCII strings 0-9, A-F following the DALI IEC command specification. These characters are converted to binary form and put into a transmit buffer to be sent on the data line upon receipt of the carriage return.

In the receiver mode, the binary data is captured and after the 2 stop bits are received converted to 7 bit ASCII characters for analysis by the user. If there is an incorrect count of data bits, the message is terminated by an asterisk"*" to warn the user there has been a collision or 2 devices have tried to speak on the data line at the same time.

<u>Design Notes:</u>
The DALI Data line transmitter is driven from the crystal oscillator (1.8432Mhz) on the STK500 board to generate timer interrupts every 104 microseconds. Every half bit of the Manchester encoding is 4 interrupts. The unit counts the interrupts and changes state to follow the Manchester code every 4 and 8 interrupts. 8 interrupts = .832 milliseconds which is the frequency for 1200 Baud (really .8333milliseconds). The message format is shown below:

1 Byte message – 1 start bit, 8 data bits, 2 stop bits - 9.17ms
2 Byte message – 1 start bit, 16 data bits, 2 stop bits- 15.83ms
3 Byte Message – 1 start bit, 24 data bits, 2 stop bits - 22.49ms

For the receiver section the DDLM waits for the first transition of the data line, when this occurs a timer is reset and time is measured. Upon the next transition the time is checked to see if it is the first or second half of the message. If it is the first, the routine just exits, if it is the second half, the level of the signal is checked and the received message byte is updated accordingly.

Appendix 2: Notes from NEMA Warwick Demo

1300 North 17th Street, Rosslyn, VA 22209

MINUTES:	JOINT SECTIONS COMMITTEE ON DALI
PLACE OF MEETING:	THE WATT STOPPER SYSTEMS 20 COMMERCE DRIVE WARWICK, RI 02886
DATE AND TIME:	TUESDAY, SEPTEMBER 28, 2004 --8:30 A.M. TO 4:00 P.M. EDT

MEMBERS PRESENT:

Wally Creer	Universal Lighting Technologies
Robert Erhardt	Advance Transformer Co.
Pekka Hakkarainen	Lutron Electronics Co.
Al Lombardi	Leviton Manufacturing Co., Inc.
David Peterson	The Watt Stopper, Inc.
Mike Stein	Universal Lighting Technologies
Guido Walther	Tridonic, Inc.
Howard Wolfman	OSRAM SYLVANIA
Howard Yaphe	Lightolier Canlyte Division of Genlyte-Thomas

MEMBERS ABSENT:

Thomas Batko	Hubbell Incorporated
John Green	Holophane
Ray Griffin	Genlyte-Thomas Group
Donald Klusmann	Genlyte Controls
Kalyan Pisupati	Lightolier/Genlyte-Thomas Group
Drew Reid	Square D/Schneider Electric

OTHERS PRESENT:

Robert Beatty	The Watt Stopper, Inc.
Pete Baselici	The Watt Stopper, Inc.
Mike Williams	OSRAM SYLVANIA
Ron Runkles	NEMA Staff

PRESIDING OFFICER: Mr. David Peterson, Chairman

1. Approval of the Previous Minutes

With a quorum present, members approved the minutes of the July 8, 2004, meeting of the Joint Sections Committee.

Mr. Peterson reminded members that this meeting is to be conducted in accordance with the *Guidelines for Conducting NEMA Meetings*.

Members expressed appreciation to The Watt Stopper, Inc. for hosting this meeting at their facilities.

2. Committee Membership

A few members have not attended the past several meetings, making it difficult at times to achieve a quorum to move forward with our work. After a brief discussion the following motion was made, seconded, and approved. Motion: Members who have not attended recent meetings are to be contacted and notified that they will be moved to "information member" status unless they respond with an intent to participate within thirty days of notification.

It was reported that members of the IESNA Protocols Committee would like to become involved in our project to develop a DALI protocol for lighting control devices. Action Item. Mr. Wolfman will forward to NEMA Staff a list of those members of the IESNA Protocols Committee that are to be added to the list of JSC information members. As information members, they will receive copies of meeting notices, agendas, and minutes. They will also be sent drafts of the standards being developed by the JSC upon request.

3. California Energy Commission Activities

Mr. Peterson reported that the CEC Professional Advisory Committee met on September 15 and 16, 2004, and heard reports on about 18 different PIER projects. Mr. Peterson was among those that made a presentation to the CEC, which was on the development of our open DALI protocol standard for lighting control devices. He then reviewed with members of the JSC the Microsoft PowerPoint presentation he gave to CEC.

After reviewing the presentation, Messrs. Peterson, Baselici, and Beatty took members of our JSC on a tour of The Watt Stopper facilities, which is a demonstration site for the CEC PIER project on DALI lighting controls.

4. Relationships with Other Organizations

4.1 DALI-AG

It was reported that the DALI protocol for emergency lighting equipment is being finalized. At some point in time, it is expected that this protocol will be introduced into the IEC.

4.2 IEC/TC 34

Mr. Stein referred to his report in the July 8, 2004, minutes (see item 2, page 30). IEC seems willing to take the work being done by this JSC for lighting control devices and adopting it with some modifications. It was noted that the IEC has not submitted any comments on our draft standard to date.

5. Market Transformation

5.1 Verification of the Standard

Mr. Peterson opened the discussion of market transformation by proposing the development of a standardized set of control devices, which would work together employing basic elements of the DALI protocol that each manufacturer could build and improve upon. This approach would be one way to assure basic functionality of the various DALI control devices and increase market acceptance. This concept immediately led to a discussion of testing and verification that products made to the proposed standard would work.

With regard to testing and verification, it was noted that it would be extremely difficult to test for all commands being developed and all possible implementations. During the discussion, it was suggested that one possible approach to testing and verification is to sponsor a “Plug Fest” on a regular basis where product designers could come together with their products, connect them in various configurations, and analyze any resulting compatibility problems. Ultimately, the following motion arose from the discussion, which was seconded and approved.

<u>Motion</u>: A JSC Task Force is to develop a scope of effort, or business plan for a proof of concept, verification of the standard with workable products (all devices in proposed Section 7). This Task Force is to determine the resources needed to accomplish this project. Possible sources of funding include CEC, DOE, EPA, and NEMA member companies. A Task Force was appointed with the following members: Messrs. Beatty (chairperson), Yaphe, Hakkarainen, and Peterson.

The purpose of the motion is aimed at answering two primary questions once the standard is approved: (1) How do you encourage companies to provide dedicated software and hardware designers to develop product based on the standard and (2) how do you prove, or verify the standard?

5.2 Core Benefits of the DALI Protocol for Lighting Control Devices

JSC members reflected on the potential benefits, which include the following:

- Reduced wiring costs
- Clarification of misconceptions, such as “a system”
- Energy savings
- Flexibility in lighting various spaces
- Control of individual luminaires
- The seamless integration of product into a system, which in turn
    - Makes specifiers more comfortable—they have confidence that, because the products are made to an industry recognized standard, they will be available for a long time
    - Provides for greater flexibility

<u>Action Item</u>. During the course of the discussion on market transformation, NEMA Staff noted that an article was recently published in NEMA’s newsletter, *EI: Electroindustry*, entitled, “DALI Open Protocol for Lighting Control Devices Makes for Better Lighting.” NEMA Staff is to also submit this article to *LD + A, Lighting Design + Application*, for publication.

6. Review of Proposed NEMA 243, Part 1 and Part 2

Motion. A motion was made, seconded, and passed to letter ballot the current drafts of proposed NEMA 243, Part 1 and Part 2 individually to validate the work done to date. The letter ballot is only for members of the JSC and to last for sixty days. Assignments were made to re-work Part 1, Clause 5.9 and Section 7 by October 26, after which date NEMA Staff is to circulate the letter ballots. The purpose of these letter ballots is to encourage all members to seriously consider the work done to date.

With regard to assignments, Bob Beatty was assigned Part 1, Clause 5.9 and Pete Baselici, Pekka Hakkarainen, and Wally Creer are to review and re-work Part 1, Section 7. It was decided to change the “minimum” to “recommended” in the title of Section 7. Any members that so desire can flesh out Part 2, Sections 3, 6, 7, 8, and 9, but must do so by October 26.

7. Next Steps

NEMA Staff reviewed the action items, motions made, and the timeline in Figure 1 below.

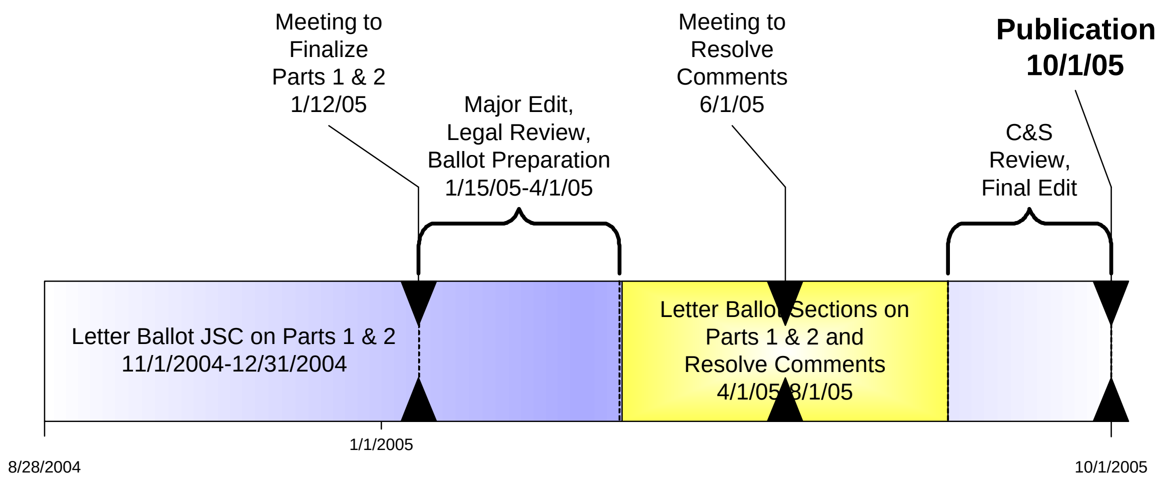


Figure 1. Timeline for the Remainder of the Work to be Done On Parts 1 and 2

8. Date and Place of the Next Meeting

The date of the next meeting was set as January 12, 2005. However, the location of the next meeting was left undecided. NEMA Staff will search for a meeting site in the southeastern U.S.

9. Adjournment

With no further business to discuss, Mr. Peterson adjourned the meeting at 4:00 p.m.

Ron Runkles
Program Manager
September 29, 2004

REVIEWED BY COUNSEL