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DALI Technology Assessment

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Technology Assessment

Executive Summary...Technology

DALI is a protocol...”a signed document containing a record of the points on which agreement has been reached”. DALI is an IEC standard focused on fluorescent dimming. The standard includes electrical specifications, communications timing and message structures, dimming response curves, commands and possible responses. DALI is not a product. Rather, it defines the language and behavior that makes it possible for lighting control products from multiple manufacturers to co-exist and even cooperate. DALI supports a number of features. It also allows a high degree of freedom in the design of products.

This assessment is focused on how well DALI supports the following performance objectives:

1. Reduce lighting energy consumption and demand
2. Provide a means for shedding lighting in response to a signal from the utility without negatively impacting occupant productivity
3. Enable the effective and economical use of daylight
4. Work in existing buildings and new construction
5. Provide simple design, installation, commissioning and maintenance.
6. Maintain/increase occupant satisfaction

The performance against each objective is summarized below. In addition, we have included a summary of the commercial and reliability questions affecting DALI.

Reduce Energy and Demand

Excellent

DALI provides the capability to control the intensity of each fixture (to “tune” the lighting). This proved to be an extremely effective tool in the demonstration installations in both Rhode Island and California, allowing a power reduction of 25-60 percent. In these spaces, occupants selected their preferred normal light level. The occupancy sensor would always return to this level, but the occupant retained the ability to adjust the lighting if necessary.

Key Point...Maximum energy savings requires the ability to independently dim each fixture. This is a DALI strength. The ability to respond to the diverse needs of occupant is just as important as the energy savings.

DALI Load Shed

Excellent

DALI has the ability to query the light level of each ballast in the system. With this data, it is then simple to reduce the level of each by a desired percentage and to set the new level as a maximum. For example, if a 50 percent reduction is required and the current light level for a particular ballast is 82 percent, the maximum level would be set to 41 percent. Occupants would still have control from 0 to 41 percent.

DALI and Daylighting

Incomplete Solution

The ability of DALI to assign individual ballasts to control groups provides a very powerful tool for implementing daylight controls. Fixtures close to windows or skylights can be included in the control group, even if they are on different circuits.

The biggest challenge occurs when trying to combine occupant control and daylighting control of the same group of fixtures. If the occupant sets the fixture to a high level, the daylight sensor will sense that the light levels are higher than its own setting and will dim the lighting accordingly. In effect, the daylight sensor takes priority. To be effective, the controls must integrate the occupant's desire.

Retrofit DALI

Fair

The current DALI system runs the power wiring and data wires in the same conduit to each fixture. This is economical for new construction, but difficult to retrofit. Running the data wires outside the conduit as Class 2 low voltage simplifies the retrofit, but raises questions about compliance with the National Electric Code unless this is addressed within the fixture raceway.

Simple to design, install, commission, and maintain

Depends

The complexity associated with DALI is a reflection of the size and flexibility demanded of early showplace installations. DALI design and installation is simpler than dimming systems that require large central control panels. Furthermore, DALI can provide simple dimming of one or more zones more economically than analog systems.

That being said, it should be noted that dimming is more complex than on/off control. Problem-free fluorescent dimming, which is also energy efficient, requires separate heating of the cathodes as the lamp is dimmed to maintain a stable arc. The cathodes must not be shorted and the tombstones must maintain good contact with the lamp. These same requirements apply to program start lamps.

Once the decision is made to incorporate dimming, the next key decision is whether to provide control down to the individual ballast. This requires addressing, and addressing requires diligent design, installation, commissioning, and documentation. Maintaining

the ballasts also becomes more complex since control data is stored in the ballasts. The evolution of DALI support tools has made the process much more manageable. If, however, the user wants to control all of the ballasts on a control bus (up to 64 ballasts) as a group, then DALI is simpler than conventional 0-10v dimming. DALI provides stable, consistent dimming down to 1 percent without the interference issues, which force the 0-10 volt control signal to be run outside the power conduit.

Similarly, if the controller is aligned with a single room, the addressing function can be made transparent to the designer and facility manager. Ballasts may be “logic linked” to form functional lighting groups and these groups adjusted to create lighting scenes or presets. Again, simpler than conventional 0-10v systems.

Key Point: Two step decision process.

Decision 1...On/Off control or dimming?

Decision 2...Zone control or individual ballast control?

DALI wins when comparing apples to apples

Occupant Satisfaction

Given the ability to change their light levels, most occupants in our demonstration sites choose to operate their lighting at reduced levels. The ability to control the levels of each fixture to create a scene increased the savings.

Key Point: DALI has the potential to reduce energy consumption while increasing occupant satisfaction.

Executive Summary...Commercial

Intellectual property

a. History

The first digital dimming ballast were introduced into the European market in 1991. By 1996, there was growing interest in developing a standard for digital dimming ballast. Three major manufacturers, Phillips, Helvar, and Osram, formed a cooperative group called DALI. Tridonic joined the group a year or so later. There were diverging opinions within the group as to the structure and scope of the standard. A standard emerged focused on the ballast..

b. Patents

In the process of developing a standard, it became apparent that individual patents would have to be abandoned to obtain buy-in of all the players. Specifically, Phillips had two patents and Tridonic had three. In every case, the owners of the patents agreed to provide open access with no royalties to anyone developing controls that would work with DALI ballasts.

c. Open protocol

Today, DALI is a completely open protocol that covers the operation of digital addressable dimming ballast. While the standard provides a list of commands that are intended to be used by the controls manufacturers, the controls themselves were not included in the standard. A number of U.S. manufacturers have developed controls using the command sets available in DALI. In those cases, where commands did not exist, the same manufacturers have introduced their own commands. This places a sense of urgency on developing a controls oriented standard to create a total system covering both the ballast and the controls.

Reliability

d. Proven technology

DALI is a proven technology. Digital's dimming is more popular in Europe than it is in United States.

In Europe, there are 130 million magnetic ballasts and 40 million electronic ballasts sold annually. 10 percent of the 40 million electronic ballasts are dimmable. Of that group of ballast, approximate half are digital. DALI accounts for approximately 50 percent of the digital dimming ballasts...1 million ballast per year.

In the United States, there are approximately 60 million electronic ballasts and 60 million magnetic ballast sold annually. Of the electronic ballasts, only 2 percent (1.2 million) are dimmable, and less than five percent of the dimmable electronic ballasts are DALI. In total, DALI represents less than 1/10 of one percent of the electronic ballasts...60,000 ballast per year. With Advance, Tridonic, Osram, and Universal now in the U.S. market, we expect the same surge in sales that the European market experienced when DALI ballasts became available from multiple suppliers.

e. Failure Rates

DALI ballasts have proven to be reliable in both the United States and Europe. According to the leading manufacturer of DALI ballasts, the failure rate, including failures from wiring errors and from installing the wrong product, have been less than one percent.

Part of the reason for the confidence in ballast performance derives from the fact that the DALI ballast is built on the same electronics foundation as the program start ballast. Additional testing as has been outlined in the DALI ballast standard ensures that each DALI ballast will respond identically.

DALI Controls Manufacturers

The following are the current list of DALI controls manufacturers.

- Leviton
- Lutron
- Siemens

- Starfield
- Tridonic
- Watt Stopper

DALI System Overview

The overview in Sections 1 and 2 below is taken from the NEMA DALI Controls Standard 243. It is reproduced here for convenience.

1.0.0 Overview

The basic DALI system is described in Section 1.

1.1.0 Basic DALI Loop

The two-wire data bus is referred to as a “loop.” A loop connects up to 64 lighting devices (i.e., ballasts, transformers, relays, and others). The data bus is powered by at least one Loop Power Supply. Messages are sent by momentarily shorting and releasing the loop conductors to create a digital signal. See Figure 1-1. The data bus is not polarity sensitive and offers free topology.

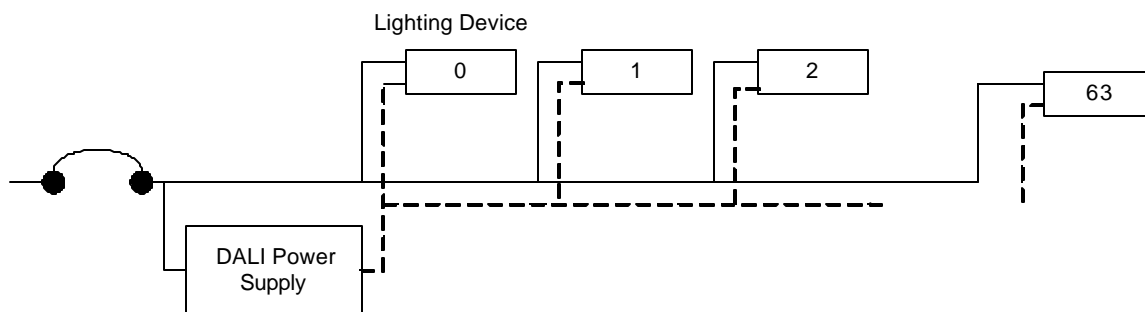


Figure 1-1. Basic DALI Loop

1.2.0 Basic Loop with Dimming Controller

As shown in Figure 1-1, all of the ballasts would be ON full. A control module could be added to dim all of the ballasts on the loop by sending a control command (Figure 1-2). (A command to all of the ballasts on a loop is called a “broadcast” command). There are 254 dimming steps to provide for a smooth response. The DALI bus wires and the power wires are run in the same conduit reducing installation costs. The digital signals are more immune to interference than conventional 0-10 volt dimming signals. The ballasts do not need to be addressed when the broadcast mode is used.

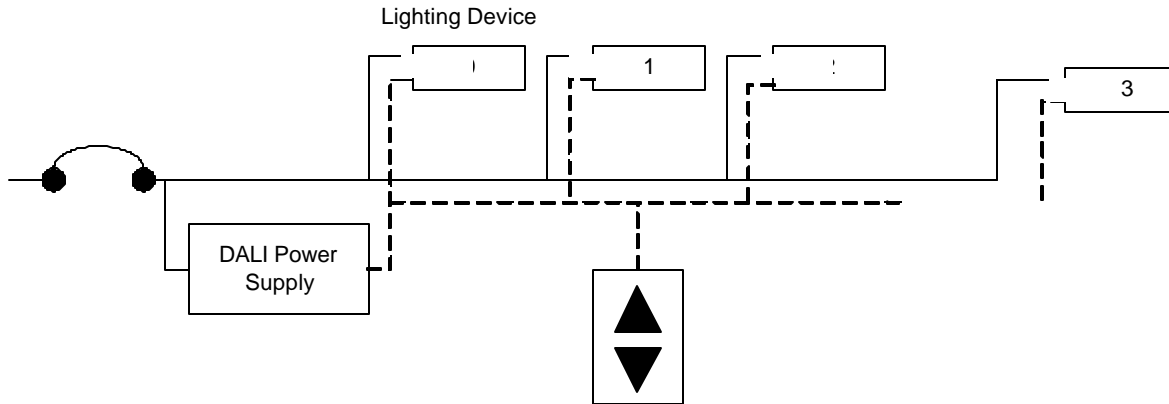


Figure 1-2. Basic DALI Loop with Dimming Controller

1.3.0 Controlling Selected Ballasts (rooms and zones)

Other control devices could be added to the above configuration, as shown in Figure 1-3. To control specific ballasts or groups of ballasts, however, the control module must be logically linked to those ballasts. This may be done by assigning the targeted ballasts to groups and then having the control module configured to talk to that specific group. Doing so requires addressing the ballasts and a programming tool.

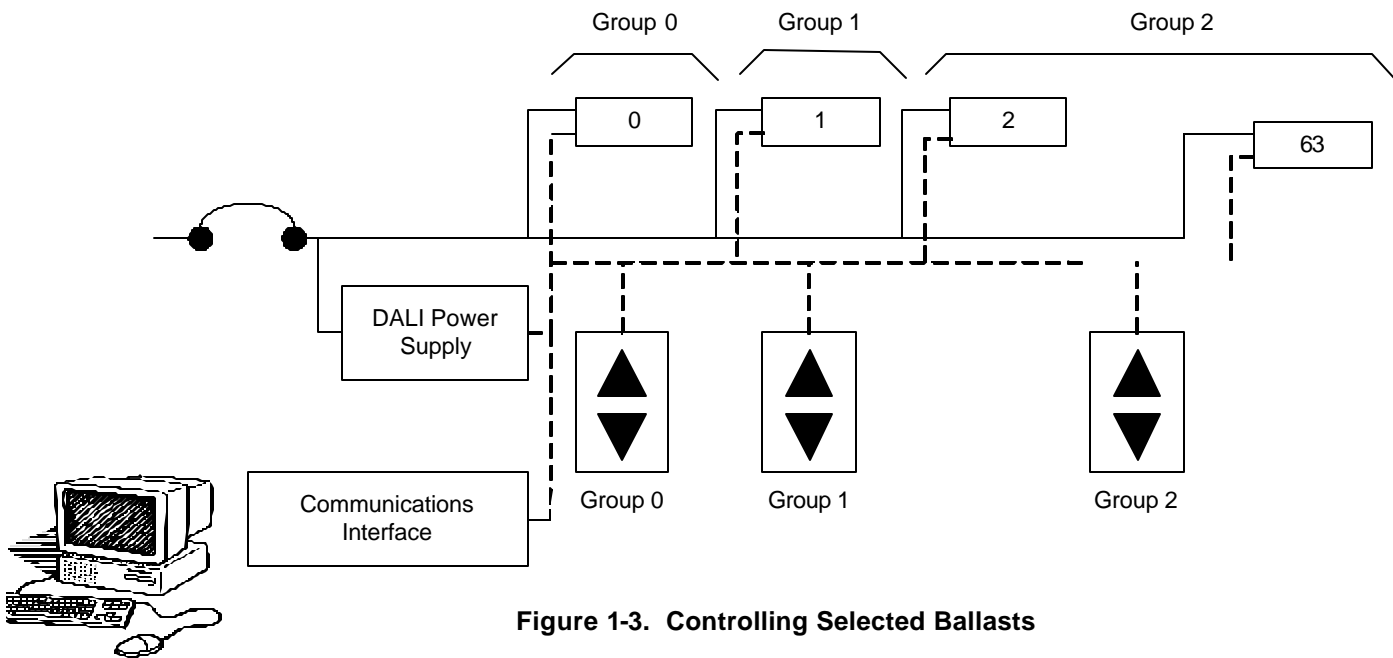


Figure 1-3. Controlling Selected Ballasts

1.4.0 Features

- 1.4.1 digital, addressable control down to the individual ballast
- 1.4.2 two-way communications
- 1.4.3 up to 16 groups
- 1.4.4 up to 16 scenes
- 1.4.5 logarithmic dimming curve

- 1.4.6 programmable fade rates
- 1.4.7 lamp failure data
- 1.4.8 250 ma max current on data bus
- 1.4.9 1000' data buss, end to end...3000 ft total (18/2)

2.0.0 Command Types

DALI has three commands to provide the control resolution desired. In all command types, control is achieved through DALI commands sent on a DALI loop to ballast or other DALI devices connected on that DALI loop.

2.1.0 DALI Broadcast Command

All ballasts connected to a loop respond to a command sent at the Broadcast Command Level. All ballasts on a DALI loop shall respond at the same time and in the same way to a broadcast command. No commissioning is required for a ballast to respond to a broadcast command.

Note—Broadcast commands are often used in startups or where there is a need to set all ballasts to the same digital light level.

2.2.0 DALI Group Command

Ballast may belong to one or several of 16 groups (0-15). Commissioning is required to place in the ballast memory those groups to which the ballast will respond. To be able to assign groups to the ballasts, the units need to be addressed. Commands to ballasts on a DALI loop may be sent to a specific group of ballasts by sending a Group Command. All ballasts belonging to this group shall respond at the same time and in the same way to this command.

Note—Group Commands are often used to control specific areas of a room, e.g., front wall washers, or to control multiple rooms on a DALI loop where each room is assigned a different group.

2.3.0 DALI Individual Address Command

Ballasts may be assigned a unique individual address. There are 64 possible addresses (0-63). No two ballasts may have the same address on a DALI loop. Commissioning is required to place in the ballast an Individual Address Command. When an Individual Address Command is sent, only the ballast with that address responds.

Note—Individual Address Commands are often used to provide personal control to individual luminaires in an open plan office environment.

2.4.0 Go to Scene Command

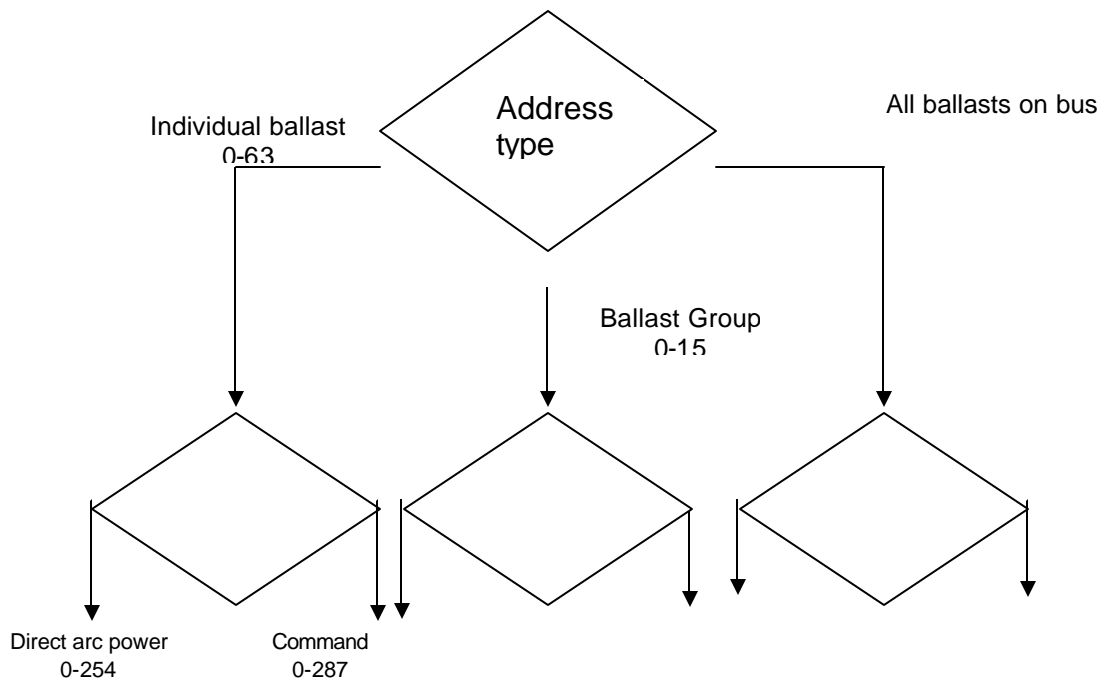
Ballasts may have stored Scenes (digital light levels) in memory. There are 16 possible scenes (0-15), and each scene stores a digital light level (0-254). Commissioning is required to store a Go to Scene level in a ballast. Scenes may be recalled from the three command levels (Broadcast, DALI Group, and Individual Address Commands).

Note—Stored Go to Scene Commands are often used in conference rooms to recall different task settings like audio-visual presentations or group meetings.

2.5.0 System Operation/Commands

The DALI control devices in the configuration described above transmit commands to the ballast on the data bus using a 2-byte message structure.

The first byte defines the type of address targeted for the command...an individual ballast short address 0-63, a group address 0-15, or all ballast on the bus. It also determines whether the message following will be to go directly to an arc power level or to implement a specific command



There are totaled the 288 commands in the existing DALI standard. Of the 288 total 190 are defined and 98 are reserved. (The implication is that there are no commands available for intelligent control devices. This prompted the development of the three-bite message structure for control devices)

2.5.1 Command summary

The full listing of commands is in section E4 of the IEC 60629. These include:

- Indirect arc power commands
- Configuration commands
- Arc power parameter settings
- System parameter settings
- Query parameter settings

3.0.0 Assessment

The following assessment looks at DALI from several perspectives.

- The electrical requirements and installation. Key criteria...ease of wiring, signal robustness/noise immunity, failsafe
- Communications performance. Key criteria...response time, reliability
- Command availability and fit to function...Key criteria...are the commands available to support both energy and occupant control
- Energy savings effectiveness

3.1.0 Electrical

Communications to and from the ballast is defined in IEC-60929, Annex E. The low transmission rate (1200 Hz +/- 10 percent) coupled with a high voltage range (between 9.5 V and 22.5 V for high level and between -6.5 V and +6.5 V for the low level) provides high immunity to interference. These signal levels also provide reliable operation of control devices over their operating range.

3.1.1 Wiring...Good

The DALI data bus is typically run as 18/2, non-shielded in the same conduit as the power wiring. Contractors may also use Greenfield with two extra conductors. This works well in new construction.

Installation errors are reduced since the DALI bus is not polarity sensitive. However, it is possible to connect the DALI bus to the line voltage. While the ballasts are protected, control devices may not be. Furthermore, the specifier needs to be aware that any control device connected directly to the data bus must be installed as a Class 1 device.

3.1.2 Failsafe operation...Good

If the databus is shorted or open, all of the ballasts go to full on.

3.1.3 Multiple DALI Loops...Fair

Since there are a maximum of 64 ballasts per loop, a typical commercial building will have multiple loops. The DALI standard does not address the issue of communicating between loops. This is left to the systems integrator.

The fact that loops are limited and tend to align with power circuits simplifies installation and commissioning since the installation is broken into reasonable size zones.

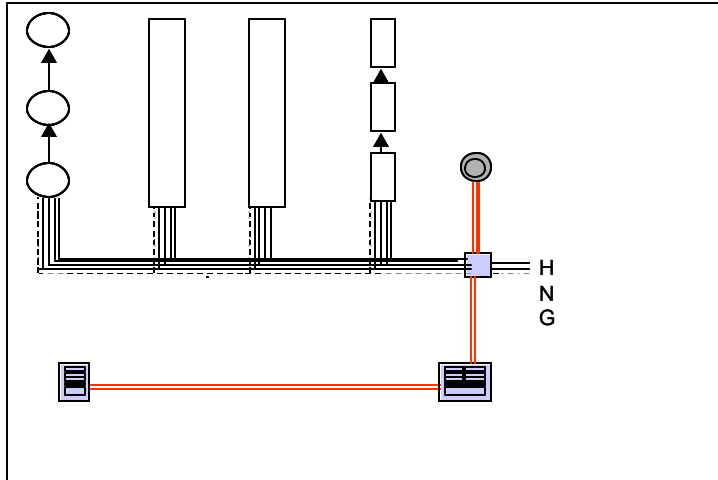
Communications from central controls or across loops is difficult due to the current state-of-the-art networking tools/software.

3.1.4 Wiring Connections...Good

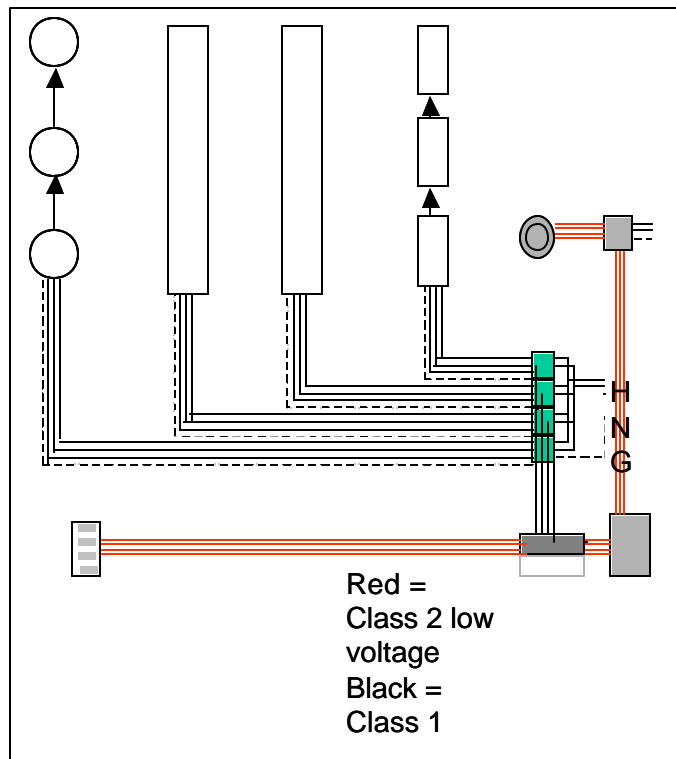
In areas employing multiple lighting groups, such as conference rooms and classrooms, DALI can reduce wiring complexity and connections as shown in the illustration below. For simple dimming, such as a 0-10 volt wall dimmer controlling a large zone, the wiring

complexity is similar, with DALI having the edge because the control wires can run in the same conduit as the power wires.

DALI
Conference
Room



Conventional
Conference
Room



3.2.0 Communications

3.2.1 Message strategy...Excellent

All of the operating data is stored in the ballast...the groups to which that ballast will respond, the light levels for each scene, its maximum and minimum light levels, its fade rate, short address and power up level. This leads to several major benefits:

Fast response

When a command is sent from a control device to turn a group of ballasts to a level, all of the ballasts impacted receive the message at the same time and react immediately. The full command is transmitted in less than 0.016 seconds, well within the 0.250 second response that is required for occupant satisfaction.

Simple 3-way and 4-way switching

Any number of control devices can operate the same group of relays. This simplifies wiring for centralized switching and multiple position control found in large rooms such as classrooms, lecture halls, conference and training rooms.

Reduced Failure Impact

If a ballast should fail, only that one device is impacted. If a controller should fail, it can be replaced by another unit without requiring programming.

3.2.2 Priorities...Fair

DALI ballast protocol assumes the last message in wins. This assumption simplifies the operation of controls, but it is difficult to implement some functions, such as daylighting. (This is being addressed in the new controls standard.)

3.2.3 Collision management...Poor but being addressed

Since multiple control devices can talk to a ballast, the possibility exists that two devices could try to communicate at the same time. An effective collision management system for a control device must:

- Wait before trying to communicate over the bus to make sure another device is not using the data bus
- Allow the first device to finish and release the bus
- Re-transmit its message when the bus is free

The existing DALI standard does not provide collision detection and management. The new DALI Controls Standard does. The new standard does not, however, provide verification that a command has been received or specify the re-transmit.

3.2.4 Communications Weaknesses

3.2.5 Ballast replacement

If a ballast should fail, the operating data and short address must be programmed into the replacement ballast. This requires a programming tool and trained facility personnel. The problem is intensified by the lack of a permanent addressing for ballasts. Without a permanent address, care must be taken not to re-initialize all of the ballasts on a loop, which would then require complete reprogramming of all of the ballasts on the loop.

3.3.0 Command Adequacy

3.3.1 Schedule Functions

The DALI ballast commands do not fully address the automatic scheduling function. The common scenario for automatic shutoff includes a warning before automatic off. During this time, the occupant can enter an override. The override times out automatically. DALI accomplishes this function by first turning the lighting to minimum. After a warning period, the central PC sends a message for all of the lighting to step down and off. If the lighting was at the minimum level, the step down would turn it off. If the lights had been overridden on, the single step down would not turn the lights off. The sequence would be repeated every x-hours to catch the overrides. While this scenario works, it introduces a single point of failure. If the PC goes down, all schedules cease.

In addition, when catching the override, going to minimum turns all of the lights to minimum, not just those that were overridden. (Note: To avoid turning on lights that were off, the STEP DOWN command may be used rather than the RECALL MIN LEVEL) A more efficient approach would be to have an automatic shutoff command or a command "IF ON, GO TO MIN LEVEL"

3.3.2 Automatic Daylight Harvesting

DALI has a MAX LEVEL SET function that at first glance looks like a good fit to daylight harvesting. A sensor could set the max level based on the daylight coming through the window. Occupants could control their levels up to the maximum. The problem is that the lighting levels would not increase automatically as it became dark outside.

Another approach is to have a daylight controller initiate a DIM UP or DIM DOWN command to a group of ballasts. If the ballasts are off, these commands would be ignored. The weakness is in the inability of the occupant to override. For example, if the ambient lighting is set to 1 percent for a presentation, the daylight sensor will adjust the level upward to match its target. This solution would work for an open office configuration. For individual offices and classrooms where scene control is required, the ability to switch parameter banks (see NEMA 243) would allow the local scene controller to use an alternate set of scenes for daylight vs. dusk.

3.3.3 Fade rates

A ballast may have only one fade rate. This creates a problem when combining manual control and automatic control. For manual control, you need a fast response (<0.5 seconds) so that the occupant can see the change. For automatic inputs, such as a change from a daylit scene to a night scene, we would want a gradual change in levels to avoid disturbing the occupant.

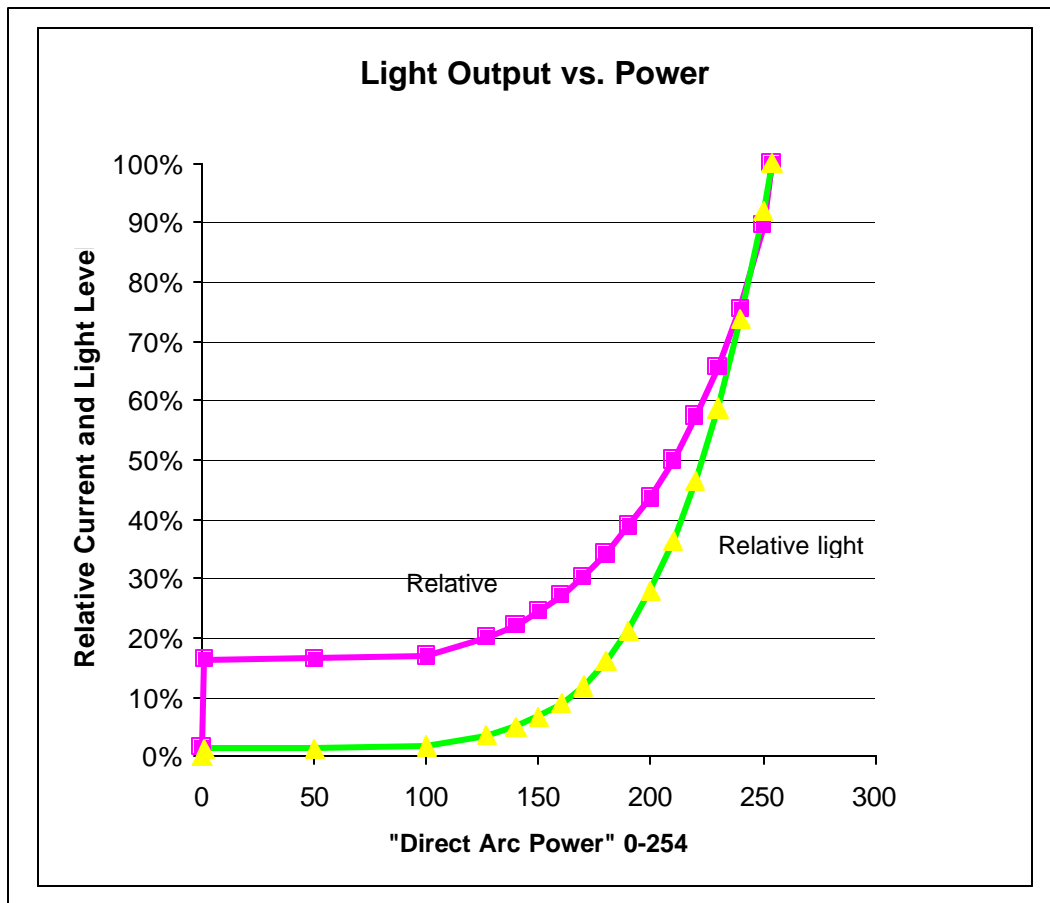
4.0.0 Energy Savings Effectiveness

The ability of DALI ballasts and controls to save energy depends on two factors:

- First, the degree to which the power curve tracks the light level.
- Second, the ability of the control algorithms to reduce the lighting demand.

4.1.0 Power vs. light

Direct measurement of light levels versus current shows that lighting and power track closely for the first 30 percent and are within 10 percent for the next 30 percent. Below 10 percent light levels, there is little additional savings unless the lights are turned off completely (power is removed from the cathodes).



4.2.0 Control Strategy Effectiveness

Strategy	Impact Potential	DALI Fit	Comments
Tuning	●	●	Measured watts/sq.ft reductions of 33 percent to 62 percent in Warwick
Occupancy	●	●	DALI provides option to return to occupant's last level or to "normal" (This is a control function.)
Daylight	●	○	Ability to select fixtures to be dimmed. Challenge = integrating occupant overrides
Schedule	○	○	Scheduling applies primarily to large spaces
Lumen Maintenance	○	○	Lumen depreciation decreasing in importance as lamps/ballasts improve
Demand Shed	●	●	DALI provides simple shed on a relative basis. (This is a control function)

High Medium Low
 ● ○ ○

4.3.0 Occupant Interaction

DALI provides multiple approaches to provide occupant control: simple raise/lower dimmers which control a whole room or group, slide dimmers, scene switches or via the occupant's PC. The basic operation of each of these control devices is detailed in Part 1 of the draft DALI controls standard

4.3.1 Group control

Simple raise/lower and slide dimmers control a group of ballasts. The Group Address (0-15) is stored in the ballasts and the same number is typically assigned to the dimmer.

From an operational perspective, all of the ballasts in a group are controlled together and all are typically at the same level. The effect is the same as a conventional dimmer.

4.3.2 Scene control

The simple dimming described above fails to take advantage of DALI's ability to control the level of each ballast within a group. DALI ballast store their level for up to 16 scenes. Scenes provide a simple way to recall one of several alternate lighting combinations. This is well understood for large conference rooms. DALI makes scene control economically viable for offices, small meeting rooms and classrooms.

4.3.3 Scene control as an energy tool

Scenes allow the option of setting one fixture low and another high. Assume the first fixture was set at 100 percent and the second at 50 percent for a combined power reduction of 25 percent. A second scene might reverse the high and low fixture. A third might have both low. Occupant's who need full lighting could temporarily override or ask for a full lighting scene. In any case, an occupancy sensor could be programmed to always come on automatically to a reduced energy scene.

5.0.0 Design

The design process for a DALI system is significantly more complex than conventional on/off systems.

5.1.0 Criteria

5.1.1 Ballast availability

DALI ballasts are available from Advance, Osram-Sylvania, Universal and Tridonic. Each continues to extend their line, but some types and wattages may not be available. The designer needs to confirm availability.

5.1.2 Loop design

The design and documentation of a DALI bus or loop is similar to laying out a lighting circuit. In most cases, the loop will coincide with a lighting circuit. However, it is possible for a loop to cross between circuits, especially in 120 VAC installations. The designer must keep track of the following:

Number of ballasts

There are a maximum of 64 ballasts on a loop. To allow for future expansion, a maximum of 50 is realistic.

Number of groups

Each ballast may respond to no more than 16 group addresses. This may be a greater restriction than the number of ballasts. For example, 16 offices with two ballasts in each would maximize the loop even though there were only 32 ballasts.

Power supply

The loop can carry only 250ma. Each ballast sinks 2ma, so the 64 ballasts uses up half of the maximum. However, the power supply may be less than 250ma, so the designer must integrate the power supply specification into his design. The design of the loop must also take into account the current draw of control devices that reside on the loop.

Size and distance

Voltage drop associated with the loop resistance determines the maximum length, end-to-end of the loop. The total amount of wire in the loop is dictated by the capacitance.

To make it simple, the recommendation is to use 16/2 and limit the distance to 900 ft and the total wire to 3000 ft.

5.2.0 Manual controls

5.2.1 Dimmers

The designer must specify the number of groups to be controlled. Groups may overlap, but this is not recommended.

5.2.2 Scene Switches

Specify the number of scenes at a minimum. Some specifiers also document the lighting levels for each ballast and the name of each scene and how it will be labeled.

5.2.3 Class 1 wiring

If the loop has been run in the same conduit as the power wires, the scene switch and dimmer must be listed and installed as a Class 1 device.

5.3.0 Automatic controls

5.3.1 Occupancy sensors

This is the most common form of automatic control. DALI's "last command wins" works well when combining manual controls and occupancy. To be sure an automatic off is not missed, the sensor needs to repeat the off command every 30-60 minutes as long as the area is unoccupied.

5.3.2 Daylighting

(discussed above)

5.3.3 Scheduling

(discussed above)

5.3.4 Documentation

(please reference the Santa Clara demonstration documentation)

5.4.0 Reflected ceiling layout

The reflected ceiling layout captures the type and location of each fixture along with its address(es), the location and description of all dimmers and scene switches and the control group number for each area.

5.5.0 Excel Control Schedule

An Excel spreadsheet provides a convenient vehicle for recording the groupings and scenes for all of the ballasts on a loop

5.6.0 Sequence of operation

Given the flexibility of DALI, it is very possible for the specifier and owner to assume that the operation of the controls can be modified as required. It is much better to start with a desired sequence of operation for each space, recording how the lighting is expected to respond throughout the day to the combination of automatic and manual inputs.

6.0.0 Commissioning

The following describes commissioning issues.

6.1.0 Barrier

Commissioning of early DALI installations took months of on-site technician time. Improving the process and tools was reduced the on-site time to less than a day. Now, much of the data entry is done at the commissioning agent's office.

6.2.0 Responsibilities

Part of the improvement in commissioning time is in the expansion and clarification of the installing contractor's role. Now the contractor assumes responsibility for getting each ballast addressed per the reflected ceiling plan and communicating/functioning. He is also responsible for getting the controls addressed and properly transmitting.

6.3.0 Process

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

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

6.4.0 Local support

Owner's and specifiers demand local support and accountability. This area needs to be improved before DALI goes mainstream.

7.0.0 Troubleshooting

7.1.0 Wiring

Wiring problems can normally be identified and corrected using standard electrical contractor diagnostic tools. An open or shorted databus can be diagnosed with the line voltage power off.

7.2.0 Logic

The diagnostic challenge is much tougher when there is a logic problem. For example, an occupancy sensor may not work for a number of reasons:

- the sensor itself may be defective or miswired.
- the sensor group number may be set incorrectly so that you are not controlling the correct ballasts.
- the ballast may not be programmed to respond to that group or scene command.
- the scene commands may be programmed incorrectly.
- other control devices may be controlling the same group.

7.3.0 Sniffer

Because there are so many possible sources for error, it's critical that low cost diagnostic tools be available that can confirm that a control device is sending the appropriate message and monitor the databus for all of the control messages that are impacted that controller or ballast.. A "Sniffer" that does just that was developed as part of this contract and is available upon request. The Watt Stopper will provide the first 5 units at no charge.

7.4.0 Addressing

Addressing errors are the single largest problems encountered during start-up. This has been exasperated by numbering conflicts within the commissioning and operating software. In one set of software, Groups and Scenes are numbered 1-16 and in another 0-15. This is a continuing problem that must be corrected.

7.5.0 Maintenance

7.5.1 Lamps

Lamps can be replaced as necessary. However, the lamp sockets may contribute to lamp failures. For stable dimming, lampholders should meet IEC-60400 that specifies the force to remove the wire, contact forces and endurance of the mechanical connection, impedance and endurance of the electrical connection, and resistance to heat, stress and corrosion.

7.5.2 Ballasts

Replacing a defective ballast requires reprogramming of the replacement unit and setting its short address. For small installations, it is easy to reprogram the room. For large installations, a programming tool is required, or the ballast can be ordered with its short address preprogrammed.

7.5.3 Controls

Control devices can usually be replaced without requiring special tools or programming.