# Best Practices for Optimal Dimming Performance with DALI®

DALI® is a low-voltage digital control protocol that has been available for several decades. Some of its benefits include the ability to individually control DALI® fixtures over a shared wire, get feedback from fixtures, and provide advanced features and sequences of operation. Its simple two-wire control wire topology provides simplicity and ease of installation for contractors.

However, the wiring flexibility provided by DALI® comes at a cost:

1. DALI® communications are very slow. Standard DALI® communications occur at 1200 bits/second, or 0.0012 Mbit/second. A standard DALI® command is comprised of multiple bits and additional overhead defined by the protocol.
2. DALI® commands are sent serially and a single DALI® command can only be sent to an individual fixture or group of fixtures at a time.
3. Many user-programmed operations (such as changing the light level) require multiple DALI® commands.

This combination of slow communications, multiple commands, and the ability to only send one command at a time means that special precautions must be taken to achieve high-performance dimming and control in a system that uses DALI®. Without proper precautions, control of multiple fixtures may lead to a phenomenon called “popcorning”, where multiple fixtures that should be synchronized together (such as “all turn off”) instead react one-by-one, and multiple seconds may occur between the change of the first fixture and the last. These DALI® performance limitations are inherent in the protocol, and are present regardless of the manufacturer of the control system.

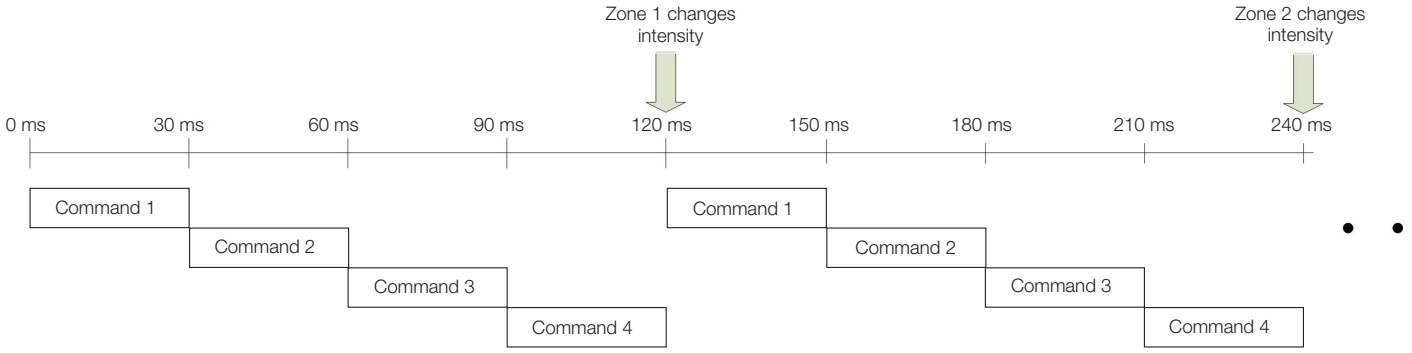
This application note provides further detail to the potential performance issues when controlling multiple DALI® fixtures, especially in instances when color tuning is involved, and provides design recommendations to optimize dimming performance in those scenarios. It also explains Lutron's exclusive dynamic DALI® grouping functionality, available with the Lutron Energi Savr Node DALI® Universal and HomeWorks Universal DALI® Power Modules, which helps automate the optimization of DALI® performance in many situations.

## Control Scenarios

Listed below are the two common control scenarios used with DALI®. This section gives insight into the technicalities involved with these control scenarios, which in turn helps better understand the limitations of DALI® communication.

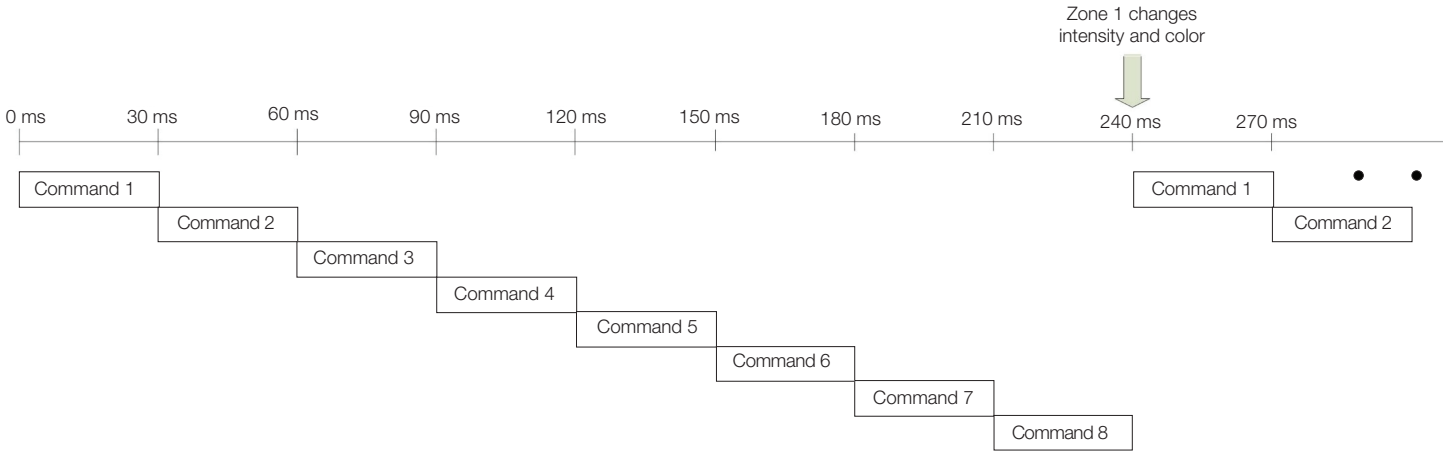
**1. Intensity Control Only**

It takes up to four (4) commands for a single group or light fixture to change light intensity. Each command takes 30 ms to send, taking a total time of up to 120 ms before the group or fixture starts to change its level. The time increases linearly as the number of groups or fixtures increases. For a hypothetical application with 64 individual light fixtures, each in its own zone, it can take up to 7.6 s (0.12 s x 64) for all the light fixtures to change intensity.




**2. Intensity with Color Control**

It takes up to eight (8) commands for a single group or light fixture to change light intensity and color. Each command takes 30 ms to send, taking a total time of 240 ms before the group or fixture starts to change its level and color. The time increases linearly as the number of groups or fixtures increases. For a hypothetical application with 64 individual light fixtures, each in its own zone, it can take up to 15 s (0.24 s x 64) for all the light fixtures to change intensity and color.

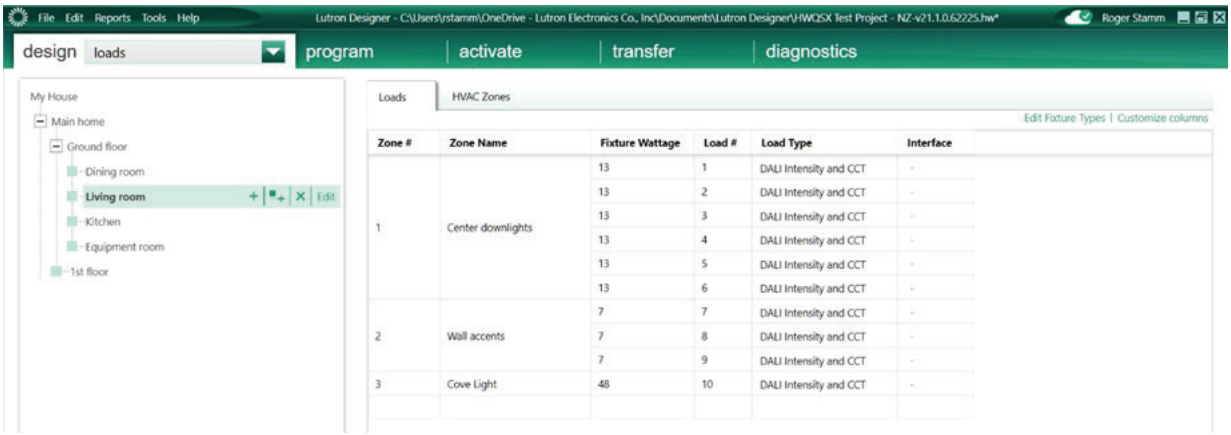


# Best Practices for Optimal Performance with DALI®

### 1. Use the DALI® group feature

The DALI® protocol allows you to assign multiple fixtures on the same DALI® bus to a group. The advantage of a DALI® group is that instead of having to send commands to individual fixtures, a single set of commands can be sent to the group, and each fixture in the group will change color or intensity levels at the same time.

The screenshot of the Lutron Designer software shows an example where there are ten (10) different DALI® fixtures in the living room. Six (6) fixtures have been put together in a zone/group called “Center downlights” and three (3) fixtures have been put together in a zone/group called “Wall accents”. This will minimize the number of commands that are used when controlling these zones/groups and therefore will reduce the popcorn effect.

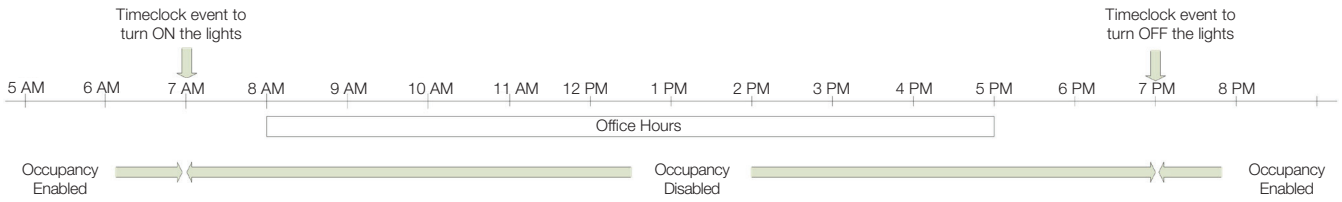



Group and zone have been used interchangeably in the above example. But for commercial spaces, DALI® Universal can have fixtures spanning across numerous zones. In such cases, to achieve the best dimming performance, DALI® Universal uses what Lutron calls dynamic DALI® grouping - the DALI® Universal will assign a DALI® group to the 16 largest zones in the space. When the zone that is assigned a DALI® group is commanded to change levels, all the loads within that zone will change levels simultaneously, as a group command can be used.

### 2. Use Timeclocks to turn ON and OFF the lights in a space when there is no occupancy

The turn ON and turn OFF events often have the worst popcorning effects, visually—and this effect is common in an open office setup wherein occupancy sensors are used to trigger turn ON and turn OFF events. One way to avoid this popcorning effect is to have the turn ON and OFF events happen outside of the office hours, when there are no occupants in the space to observe it. This can be achieved by setting up Timeclock events.

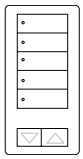
The screenshot below shows Timeclock events in the "Open Office" area being set to turn ON and turn OFF the lights at 7 AM and 7 PM respectively, outside of the typical office hours of 8 AM to 5 PM—and the second screenshot below shows occupancy sensor being enabled only outside of the 7 AM to 7 PM time period.



## Best Practices for Optimal Performance with DALI® *(continued)*

### 3. Use longer fade times

In a restaurant space, use a 5 minute fade to change the scene from lunch to dinner. This will make the asynchronous behavior of light fixtures less noticeable.

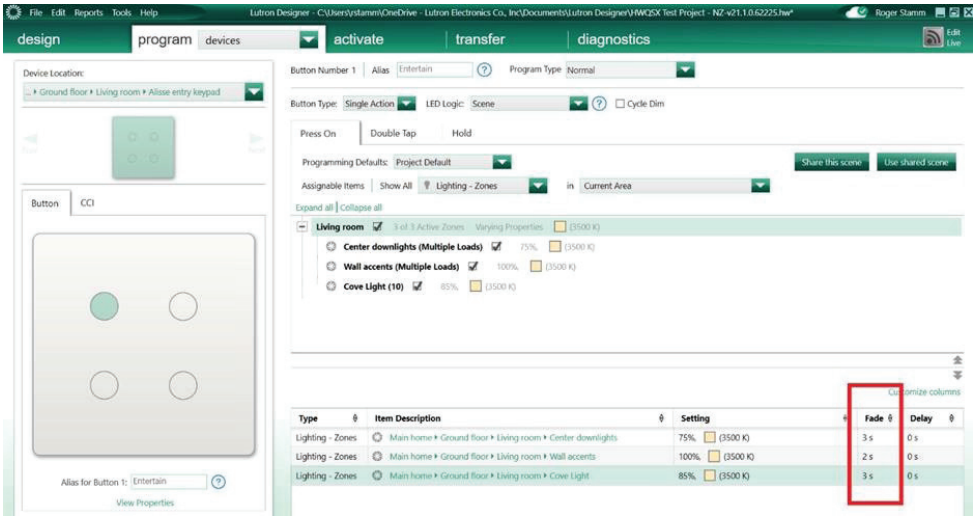
| Device | Fade Time | |
|---|---|---|
|  seeTouch QS wallstation | 3 seconds | X |
| | 5 minutes | √ |

### 4. Use the same fade times throughout the project

The Lutron Designer software allows great flexibility of choosing independent fade times for every control of a single lighting zone. However, every time the fade time is changed for a DALI® zone, more commands will need to be sent to change intensity or color and the popcorn effect will be worse. To minimize the popcorn effect from DALI® fixtures, it is best to use the same fade time everywhere in the project where the DALI® zones are controlled. This can be achieved by buttons on different keypads that control the same zone(s), occupancy sensors and time clock schedules.

The screenshot below shows an example of a button that has a 2 s fade time for the living room "Wall accent" lights and a 3 s fade time for the "Center downlights" and the "Cove light". By using the same fade times everywhere, these zones are controlled and will lessen the popcorn effect.

Note that it does not make the popcorn effect worse when different zones have different fade times. The popcorn effect is only made worse when different buttons, occupancy sensors or time clocks have different fade times for the same lighting zone(s).




Another scenario where different fade times may need to be utilized is during Turn ON and Turn OFF for light fixtures in a room. For example, when a room becomes occupied it may be desirable to have the lights Turn ON quickly and a common fade time is 2 s or 3 s. However, when a room becomes unoccupied it may be desirable to have the lights Turn OFF over 10 s allowing time to completely exit the room. In this case, programming the “ON” button with a 3 s fade time and the “OFF” button with a 10 s fade time would make the popcorn effect worse. An alternative solution would be to program the "OFF" button to have a 7 s delay followed by a 3 s fade time.

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