State-of-the art, energy-efficient lighting control systems with D4i-enabled luminaires

DALI Alliance seminar, Lightfair 2023
Speakers

Sree Venkit
• System Architect for Connected Lighting, Signify

Kevin Fitzmaurice, LC
• Principal Engineer, Lighting and Smart Services, Georgia Power

Michael Davidson
• System Architect, Synapse Wireless
What is “Connected Lighting”?

*Smart lighting fixtures will drive enhanced energy saving and make Lighting a key driver in the “Internet of Things”*

- Lighting is everywhere where people are
- Focus will gradually shift from energy savings to data insights leading to new uses:
  - Occupancy/space management
  - Building automation / control (HVAC, security, elevators)
  - Retail engagement
- Lighting provides an opportunity for human centric data collection
  - Luminaires become the collecting points for local information.....data nodes.......Luminaire OEMs uniquely positioned to be the carrier
Connected Luminaire Architecture:

Analog 0-10V:
- Complex with many components
- Limited standardization
- No data capability from LED driver
- Reduced reliability - AC mains connection to multiple components

0-10V Dim2OFF with Aux is in between, but still no data from LED driver.

Digital D4i:
- Simple with few components
- Standardized connection for power and digital data from LED driver
- High reliability – AC mains to the LED driver only
D4i – Overview

• D4i is a certification program for interoperable DALI devices that enable smart, connected luminaires
  – D4i is an extension of DALI-2 certification

• D4i components have a compulsory set of features
  – Based on power-supply and data specifications from DiiA

• All D4i LED drivers provide luminaire, energy & diagnostics data

• D4i enables intra-luminaire DALI
  – Other D4i implementations are also permitted

• D4i luminaires are smart and IoT-ready
  – D4i simplifies addition of sensors and communication devices (NLCs) to luminaires

• D4i enables plug-and-play interoperability when combined with a connector system
  – e.g. Zhaga Book 18 & 20 or NEMA/ANSI C136.41
## Benefit Summary – D4i Drivers vs 0-10V

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Driver Feature</th>
<th>Feature Description</th>
<th>0-10V</th>
<th>0-10V Dim2OFF w/Aux</th>
<th>D4i</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of maintenance and Asset Management</td>
<td>Asset management via DALI scenes</td>
<td>Use limited space in DALI scenes for unique vendor code and manual lookup tables to correlate to specific fixture</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asset management via MB1</td>
<td>Standardized method for storing vendor specific information in the driver; No lookup table required.</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Memory Banks with Diagnostics Data</td>
<td>Data such as voltages, surges, currents and thermals made available back through NLC for analysis</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Ensure/monitor energy savings</td>
<td>Memory Banks with Power/Energy metering Data</td>
<td>Measured power and energy data. Supports DLC NLC QPL listing and thus qualify for utility rebates.</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>High reliability</td>
<td>Integrated switching, and Low Voltage power supply</td>
<td>Eliminates mains protection and relay. No need for separate low voltage supply for the NLC.</td>
<td></td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>Easy integration</td>
<td>Built-in DALI Bus Power Supply</td>
<td>Simple two wire connection from the driver to the NLC node to supply power and data</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>System interoperability assurance</td>
<td>D4i Certification program</td>
<td>Testing assures DALI communication protocol robustness and D4i specified power and data availability to NLC.</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
## DiiA Specifications – Published

The following specifications can be downloaded from the DiiA website.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Name</th>
<th>Version</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply specifications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DALI Part 150</td>
<td>AUX Power Supply</td>
<td>v1.1, Oct 2019</td>
<td>✓</td>
</tr>
<tr>
<td>DALI Part 250</td>
<td>Integrated Bus Power Supply</td>
<td>v1.1, Oct 2019</td>
<td>✓</td>
</tr>
<tr>
<td>Data specifications for LED drivers &amp; other control gear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DALI Part 251</td>
<td>Luminaire Data</td>
<td>v1.1, Oct 2019</td>
<td>✓</td>
</tr>
<tr>
<td>DALI Part 252</td>
<td>Energy Data</td>
<td>v1.1, Oct 2019</td>
<td>✓</td>
</tr>
<tr>
<td>DALI Part 253</td>
<td>Diagnostics Data</td>
<td>v1.1, Oct 2019</td>
<td>✓</td>
</tr>
<tr>
<td>Specifications for control devices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DiiA Part 351</td>
<td>Luminaire-mounted Control Devices</td>
<td>v1.0, Oct 2019</td>
<td>✓</td>
</tr>
</tbody>
</table>
Specification of state-of-the-art lighting control system:

- Automatic control of light levels based on presence detection

- Co-ordinated control of lighting for zones and groups to optimize comfort and energy savings

- Ability to override light levels with schedules and other external factors such as weather, events etc.

- Ability to remotely monitor energy usage at a granular level on a continuous basis.

- Ability to adapt the LED driver, sensor and other control settings of the luminaire to optimize customer experience and energy savings.

- Ability to monitor the health of luminaires on a continuous basis to anticipate maintenance needs and, also entertain requests for extended warranty.

- Ability to provide the replacement parts information readily and quickly to replace failed parts and minimize disruption towards customers.
High level selection: Luminaire & lighting control system

Automatic control of light levels based on presence detection
- Luminaire should have the capability to integrate sensors

Co-ordinated control of lighting for zones and groups to optimize comfort and energy savings
- Ability to override light levels with schedules and other external factors such as weather, events etc
- Luminaire should have the capability to integrate a communication device
- Central Management System (CMS) capable of handling group level control and internet connectivity

RF communication node on top to get best signal range
Power supply (LED driver) for supplying power (and data) to the LED board, sensor and communication node
Sensor facing ground to be able to detect presence

Central Management System connected to the Cloud/Internet
Luminaire components & wiring:

- All components can interoperate on the DALI bus and communicate digital data (Basic DALI Parts 101, 102, 103)
LED driver & sensor on the luminaire

- Automatic control of light levels based on presence detection

- D4i certified LED driver provides compatible LV bus power supply to the sensor (Part 250)

- D4i certified sensor works with the bus power supply from the driver (Part 351)

- D4i certified sensor provides presence data on the DALI bus (Part 303)
LED driver & communication node on the luminaire

- D4i certified LED driver provides compatible power supply to the communication node (Part 150 - 24VDC, 3W).
- D4i certified communication node works with the 24V, 3W power supply from the driver (Part 351, Type A).
- D4i certified communication node acts as a master application controller to communicate with and control the LED driver and sensor (Part 351).

- Ability to adapt the LED driver, sensor and other control settings of the luminaire to optimize customer experience and energy savings.
LED Driver & Communication node on the luminaire

- D4i certified LED driver provides energy data to the communication node (Part 252)
- D4i certified LED driver provides diagnostic data (fault codes, temperature…) to the communication node (Part 253)
- D4i certified LED driver provides asset management (luminaire model# and associated details) to the communication node (Part 251)
Luminaire & CMS

CMS connected to the Cloud/Internet

- Automatic control of light levels based on presence detection
- Co-ordinated control of lighting for zones and groups to optimize comfort and energy savings
- Ability to override light levels with schedules and other external factors such as weather, events etc.
- Ability to remotely monitor energy usage at a granular level on a continuous basis.
- Ability to adapt the LED driver, sensor and other control settings of the luminaire to optimize customer experience and energy savings.
- Ability to monitor the health of luminaires on a continuous basis to anticipate maintenance needs and, also entertain requests for extended warranty.
- Ability to provide the replacement parts information readily and quickly to replace failed parts and minimize disruption towards customers.

- CMS communicates with the internet to obtain external data (e.g. weather, events) and send notifications (e.g. email)
- CMS communicates via the communication node to the sensor to read the presence signal and, also adapt sensor settings to optimize performance (Sensor Parts 303, 351)
- CMS communicates to the LED driver via the communication node to control driver settings and the light level (Driver Part 207)
- CMS communicates to the LED driver via the communication node to continuously monitor asset, energy and diagnostic data (Driver Parts 251, 252, 253)
Summary – Luminaire with all D4i components
Asset Management and Energy Reporting

Real Life Examples

Kevin Fitzmaurice – Principal of Smart Services – Georgia Power
LightFair 2023
# Asset Management and Energy Reporting

## Luminaire Asset Data retrieval from DALI Drivers

Data can be retrieved via lookup codes in older DALI version 1 drivers without Memory Bank 1 (MB1)

Data can be retrieved from MB1 using the ANSI C137.4 format in newer style DALI drivers (e.g., D4i, DALI-2, DALI with MB1)

### Examples of data:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>MFG Part Number</th>
<th>Input Wattage</th>
<th>Lumen Output</th>
<th>CCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRI</td>
<td>Distribution Type</td>
<td>Color</td>
<td>Input Voltage</td>
<td></td>
</tr>
</tbody>
</table>
### Luminaire Asset Data from DALI Drivers using Scene Data

#### Luminaire Asset Data from Lookup Tables

<table>
<thead>
<tr>
<th>SCENE 11</th>
<th>SCENE 12</th>
<th>SCENE 13</th>
<th>LOOKUP_CODE</th>
<th>MFG_PART_NUMBER</th>
<th>STYLE</th>
<th>WATTAGE</th>
<th>SOURCE</th>
<th>LUMENS</th>
<th>CCT</th>
<th>DIST_TYPE</th>
<th>COLOR</th>
<th>VOLTAGE</th>
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<tbody>
<tr>
<td>04</td>
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<td>0000</td>
<td>ERL10C7E140AGRAYLR005</td>
<td>Evolve</td>
<td>51</td>
<td>LED</td>
<td>5090</td>
<td>4000K</td>
<td>II</td>
<td>Gray</td>
<td>120-277</td>
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<td>04</td>
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<td>0001</td>
<td>ERL10E3E140AGRAYLR005</td>
<td>Evolve</td>
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<td>LED</td>
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<td>4000K</td>
<td>II</td>
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<td>0005</td>
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<td>Evolve</td>
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<td>LED</td>
<td>14085</td>
<td>4000K</td>
<td>III</td>
<td>Bronze</td>
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<td>4000K</td>
<td>III</td>
<td>Gray</td>
<td>120-277</td>
</tr>
</tbody>
</table>
Asset Management and Energy Reporting

Luminaire Asset Data from DALI Drivers with MB1

- Specification for DALI-2/D4i memory bank 1 extension (DALI part 251)
- Luminaire’s DALI driver shall support the programming and storage of applicable information
- OEM information shall be encoded by the luminaire manufacturer
- This requires the NLC and CMS partner to be able to access the data
- Table 5 is derived from DiiA Specification DALI Part 251 and sourced by permission from Digital Illumination Interface Alliance (DiiA)
The D4i LED driver can report operational data including:

- Active energy/power
- Apparent energy/power
- Load-side energy/power
Asset Management and Energy Reporting

Energy Reporting – DALI Part 252

Use Cases

- Adaptive lighting and scheduled dimming
- Input data for monitoring and control systems
- Submetering for cost allocation or billing

Benefits

- Energy Savings
- Compliance
- Sustainability
- Improved Operations