BREAKING THROUGH: INTEROPERABILITY

axis

Feb 1, 2022

"LED lighting products can also be made to work better within lighting systems through clearly defined and consistent communication and controls interfaces and through improved integration with sensor technology."

A.K.A.

INTEROPERABILITY

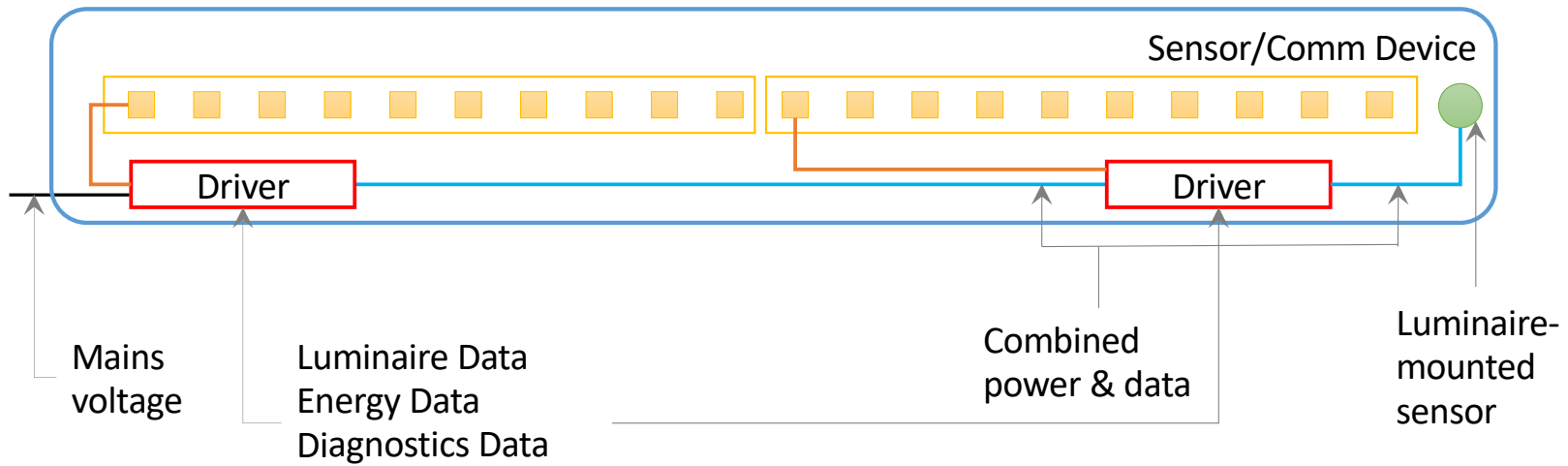| Question	Answer
❑ What is interoperability?	✓ Different parts of a system work together, often in a plug and play type way
❑ What is interchangeability?	✓ Parts can be exchanged/ replaced and still work
❑ What is a system?	✓ Hardware + firmware + software
❑ What makes a system "IOT?"	✓ Device Data + communication + analytics > dashboard
❑ What is "plug and play?"	✓ Components/devices work together without custom programming

THE CHALLENGING EMERGENCE OF IOT LIGHTING
JOURNEY FROM SINGLE MANUFACTURER SOLUTIONS TO INTEROPERABLE SYSTEMS

Proprietary IOT Luminaire

Sensor/Comm Device

Driver

Driver

Mains voltage

Luminaire Data
Energy Data
Diagnostics Data

Combined power & data

Luminaire-mounted sensor

"IOT Lighting is not new."

Driver examples:
- Signify SR
- Osram Dexal
- Lutron Vive
- Acuity nLight Air

THE CHALLENGING EMERGENCE OF IOT LIGHTING
JOURNEY FROM SINGLE MANUFACTURER SOLUTIONS TO INTEROPERABLE SYSTEMS

Initial IOT Lighting options have been primarily comprehensive offerings by manufacturers, including hardware, firmware, sensor, gateway, analytics, and software with dashboards.
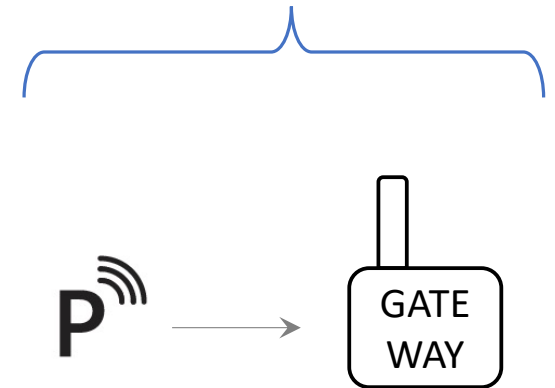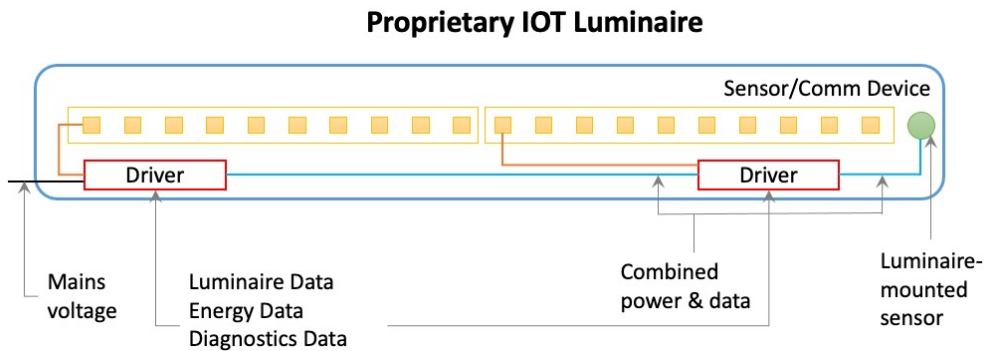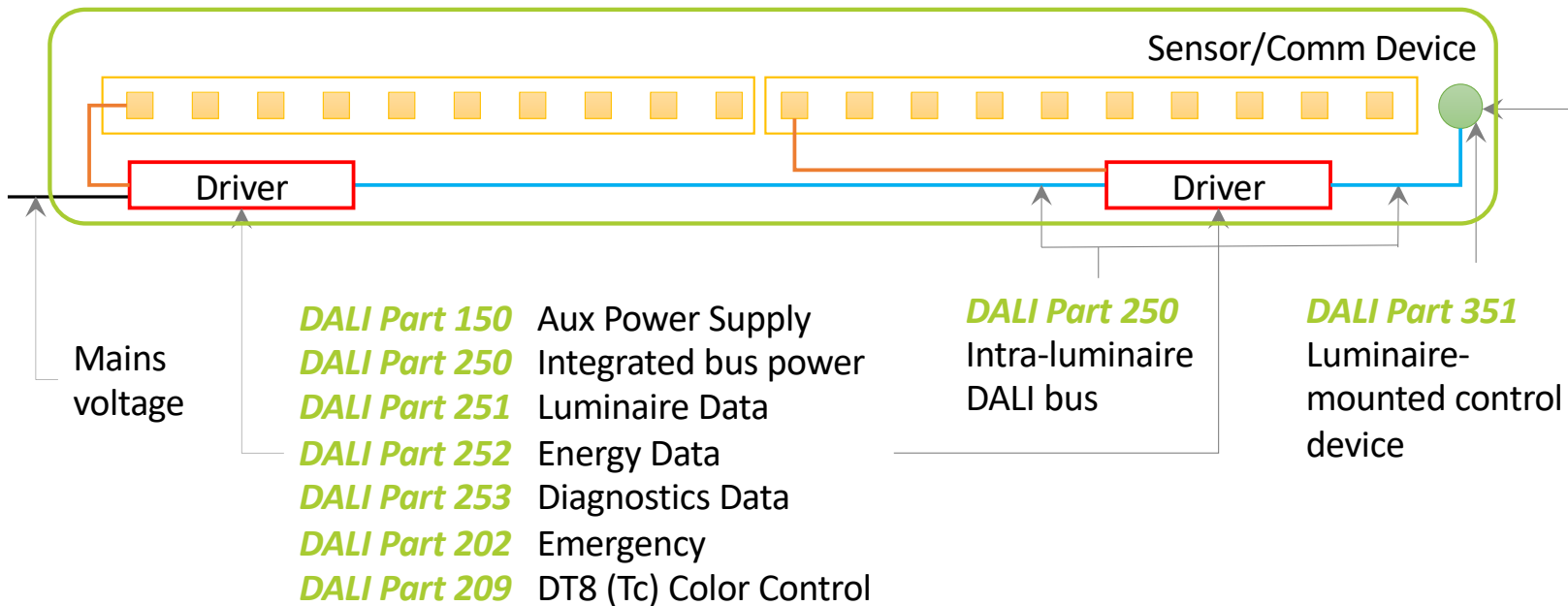
To the cloud

Analytics

Subscriptions

Proprietary IOT Luminaire

Sensor/Comm Device

Driver

Driver

Mains voltage

Luminaire Data
Energy Data
Diagnostics Data

Combined power & data

Luminaire-mounted sensor

P

GATE WAY

axis

D4i + Zhaga Book 20 Certified Luminaire

Sensor/Comm Device

Driver

Driver

Mains voltage

DALI Part 150 Aux Power Supply
DALI Part 250 Integrated bus power
DALI Part 251 Luminaire Data
DALI Part 252 Energy Data
DALI Part 253 Diagnostics Data
DALI Part 202 Emergency
DALI Part 209 DT8 (Tc) Color Control

DALI Part 250
Intra-luminaire
DALI bus

DALI Part 351
Luminaire-
mounted control
device

Zhaga Book 20
Sensor interface with
mechanical interfaces,
electrical connectors,
references to D4i specs
for power and control,
and luminaire tests

+

NEMA LS 20000-2021
Physical interface only,
well-aligned with
Zhaga Book 20

DALI: The basics

DALI® Digital Addressable Lighting Interface

- DALI® is the industry-standard protocol (language) for bi-directional, digital communication between lighting-control devices.
  - Dedicated to lighting, with a rich feature set

- DALI is derived from the open, global standard IEC 62386.

DALI 2®

- DALI-2™ is the certification program based on the latest version of the DALI protocol.

- DALI-2 is driven by the DALI Alliance (DiiA)
  - Ensures interoperability through testing and certification with trademark use

- DALI, DALI-2, D4i and DALI+ trademarks controlled by the DALI Alliance (DiiA)

DALI® Alliance   Smart Buildings Show – October 2021   5

DALI® Alliance

Our new identity explains that we are the
global industry organization for DALI
We are also known as the
Digital Illumination Interface Alliance(DiiA)

Digital Illumination Interface Alliance

Source: https://www.dali-alliance.org/

ZHAGA Consortium

≡
SHARE

Smart standards. Smarter lighting.

We are a global lighting-industry organization that aims to standardize interfaces of components of LED luminaires, including LED light engines, LED modules, LED arrays, holders, electronic control gear (LED drivers), connectors and sensing/communication modules.

Source: https://zhagastandard.org/

axis

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

DALI Part 250	DALI Part 251	DALI Part 252	DALI Part 253	DALI Part 351	DALI Part 150	DALI Part 209, DT8 (Tc)	DALI Part 202
Integrated Bus Power Supply	*Luminaire Data*	*Energy Data*	*Diagnostics*	*Luminaire – mounted Control Devices*	*AUX Power Supply*	*Color Control*	*Emergency*
Uses the same DALI wire for power and data [inside the driver]	Luminaire identifiers, CCT, CRI, Light Output [inside the driver]	Real-time power and energy usage for control gear (driver and sensor) [inside the driver]	Operating data for control gear and light source, including failure conditions, run-time data. [inside the driver]	Integral sensor protocol for motion sensing, light levels. Multi-sensor data.	Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options.	Commands for CCT (Tc), xy color control, RGBW	Enables illumination and emergency lighting on same network. Includes self-contained.
2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.	Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.	Energy savings goals, accuracy of real time data, utility rebates, tax incentives	Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)	Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.	Realistic market acceptance and transition, cost, supply, retrofit/ existing buildings.	Critical for color constancy between luminaires, quality control and calibration in production.	Supports testing and results. Function test: battery, charging circuit, driver/ relay & source. Data for failures, charge levels, operating hours.

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

axis

DALI Part 250	DALI Part 251	DALI Part 252	DALI Part 253	DALI Part 351	DALI Part 150	DALI Part 209, DT8 (Tc)	DALI Part 202
Integrated Bus Power Supply	*Luminaire Data*	*Energy Data*	*Diagnostics*	*Luminaire – mounted Control Devices*	*AUX Power Supply*	*Color Control*	*Emergency*
Uses the same DALI wire for power and data [inside the driver]	Luminaire identifiers, CCT, CRI, Light Output [inside the driver]	Real-time power and energy usage for control gear (driver and sensor) [inside the driver]	Operating data for control gear and light source, including failure conditions, run-time data. [inside the driver]	Integral sensor protocol for motion sensing, light levels. Multi-sensor data.	Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options.	Commands for CCT (Tc), xy color control, RGBW	Enables illumination and emergency lighting on same network. Includes self-contained.
2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.	Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.	Energy savings goals, accuracy of real time data, utility rebates, tax incentives	Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)	Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.	Realistic market acceptance and transition, cost, supply, retrofit/ existing buildings.	Critical for color constancy between luminaires, quality control and calibration in production.	Supports testing and results. Function test: battery, charging circuit, driver/ relay & source. Data for failures, charge levels, operating hours.

axis

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

DALI Part 250	DALI Part 251	DALI Part 252	DALI Part 253	DALI Part 351	DALI Part 150	DALI Part 209, DT8 (Tc)	DALI Part 202
Integrated Bus Power Supply	*Luminaire Data*	*Energy Data*	*Diagnostics*	*Luminaire – mounted Control Devices*	*AUX Power Supply*	*Color Control*	*Emergency*
Uses the same DALI wire for power and data [inside the driver]	Luminaire identifiers, CCT, CRI, Light Output [inside the driver]	Real-time power and energy usage for control gear (driver and sensor) [inside the driver]	Operating data for control gear and light source, including failure conditions, run-time data. [inside the driver]	Integral sensor protocol for motion sensing, light levels. Multi-sensor data.	Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options.	Commands for CCT (Tc), xy color control, RGBW	Enables illumination and emergency lighting on same network. Includes self-contained.
2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.	Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.	Energy savings goals, accuracy of real time data, utility rebates, tax incentives	Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)	Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.	Realistic market acceptance and transition, cost, supply, retrofit/ existing buildings.	Critical for color constancy between luminaires, quality control and calibration in production.	Supports testing and results. Function test: battery, charging circuit, driver/ relay & source. Data for failures, charge levels, operating hours.

axis

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

DALI Part 250	DALI Part 251	DALI Part 252	DALI Part 253	DALI Part 351	DALI Part 150	DALI Part 209, DT8 (Tc)	DALI Part 202
Integrated Bus Power Supply	*Luminaire Data*	*Energy Data*	*Diagnostics*	*Luminaire – mounted Control Devices*	*AUX Power Supply*	*Color Control*	*Emergency*
Uses the same DALI wire for power and data [inside the driver]	Luminaire identifiers, CCT, CRI, Light Output [inside the driver]	Real-time power and energy usage for control gear (driver and sensor) [inside the driver]	Operating data for control gear and light source, including failure conditions, run-time data. [inside the driver]	Integral sensor protocol for motion sensing, light levels. Multi-sensor data.	Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options.	Commands for CCT (Tc), xy color control, RGBW	Enables illumination and emergency lighting on same network. Includes self-contained.
2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.	Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.	Energy savings goals, accuracy of real time data, utility rebates, tax incentives	Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)	Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.	Realistic market acceptance and transition, cost, supply, retrofit/ existing buildings.	Critical for color constancy between luminaires, quality control and calibration in production.	Supports testing and results. Function test: battery, charging circuit, driver/ relay & source. Data for failures, charge levels, operating hours.

axis

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

DALI Part 250	DALI Part 251	DALI Part 252	DALI Part 253	DALI Part 351	DALI Part 150	DALI Part 209, DT8 (Tc)	DALI Part 202
Integrated Bus Power Supply	*Luminaire Data*	*Energy Data*	*Diagnostics*	*Luminaire – mounted Control Devices*	*AUX Power Supply*	*Color Control*	*Emergency*
Uses the same DALI wire for power and data [inside the driver]	Luminaire identifiers, CCT, CRI, Light Output [inside the driver]	Real-time power and energy usage for control gear (driver and sensor) [inside the driver]	Operating data for control gear and light source, including failure conditions, run-time data. [inside the driver]	Integral sensor protocol for motion sensing, light levels. Multi-sensor data.	Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options.	Commands for CCT (Tc), xy color control, RGBW	Enables illumination and emergency lighting on same network. Includes self-contained.
2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.	Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.	Energy savings goals, accuracy of real time data, utility rebates, tax incentives	Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)	Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.	Realistic market acceptance and transition, cost, supply, retrofit/ existing buildings.	Critical for color constancy between luminaires, quality control and calibration in production.	Supports testing and results. Function test: battery, charging circuit, driver/relay & source. Data for failures, charge levels, operating hours.

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

DALI Part 250	DALI Part 251	DALI Part 252	DALI Part 253	DALI Part 351	DALI Part 150	DALI Part 209, DT8 (Tc)	DALI Part 202
Integrated Bus Power Supply	*Luminaire Data*	*Energy Data*	*Diagnostics*	*Luminaire – mounted Control Devices*	*AUX Power Supply*	*Color Control*	*Emergency*
Uses the same DALI wire for power and data [inside the driver] 2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.	Luminaire identifiers, CCT, CRI, Light Output [inside the driver] Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.	Real-time power and energy usage for control gear (driver and sensor) [inside the driver] Energy savings goals, accuracy of real time data, utility rebates, tax incentives	Operating data for control gear and light source, including failure conditions, run-time data. [inside the driver] Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)	Integral sensor protocol for motion sensing, light levels. Multi-sensor data. Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.	Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options. Realistic market acceptance and transition, cost, supply, retrofit/ existing buildings.	Commands for CCT (Tc), xy color control, RGBW Critical for color constancy between luminaires, quality control and calibration in production.	Enables illumination and emergency lighting on same network. Includes self-contained. Supports testing and results. Function test: battery, charging circuit, driver/ relay & source. Data for failures, charge levels, operating hours.

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

axis

DALI Part 250	DALI Part 251	DALI Part 252	DALI Part 253	DALI Part 351	DALI Part 150	DALI Part 209, DT8 (Tc)	DALI Part 202
Integrated Bus Power Supply	*Luminaire Data*	*Energy Data*	*Diagnostics*	*Luminaire – mounted Control Devices*	*AUX Power Supply*	*Color Control*	*Emergency*
Uses the same DALI wire for power and data [inside the driver]	Luminaire identifiers, CCT, CRI, Light Output [inside the driver]	Real-time power and energy usage for control gear (driver and sensor) [inside the driver]	Operating data for control gear and light source, including failure conditions, run-time data. [inside the driver]	Integral sensor protocol for motion sensing, light levels. Multi-sensor data.	Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options.	Commands for CCT (Tc), xy color control, RGBW	Enables illumination and emergency lighting on same network. Includes self-contained.
2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.	Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.	Energy savings goals, accuracy of real time data, utility rebates, tax incentives	Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)	Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.	Realistic market acceptance and transition, cost, supply, retrofit/ existing buildings.	Critical for color constancy between luminaires, quality control and calibration in production.	Supports testing and results. Function test: battery, charging circuit, driver/ relay & source. Data for failures, charge levels, operating hours.

axis

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

DALI Part 250

Integrated Bus Power Supply

Uses the same DALI wire for power and data

[inside the driver]

2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.

DALI Part 251

Luminaire Data

Luminaire identifiers, CCT, CRI, Light Output

[inside the driver]

Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.

DALI Part 252

Energy Data

Real-time power and energy usage for control gear (driver and sensor)

[inside the driver]

Energy savings goals, accuracy of real time data, utility rebates, tax incentives

DALI Part 253

Diagnostics

Operating data for control gear and light source, including failure conditions, run-time data.

[inside the driver]

Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)

DALI Part 351

Luminaire – mounted Control Devices

Integral sensor protocol for motion sensing, light levels. Multi-sensor data.

Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.

DALI Part 150

AUX Power Supply

Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options.

Realistic market acceptance and transition, cost, supply, retrofit/existing buildings.

DALI Part 209, DT8 (Tc)

Color Control

Commands for CCT (Tc), xy color control, RGBW

Critical for color constancy between luminaires, quality control and calibration in production.
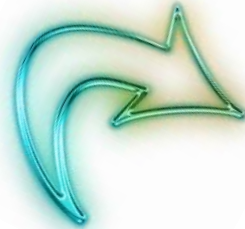
DALI Part 202

Emergency

Enables illumination and emergency lighting on same network. Includes self-contained.

Supports testing and results. Function test: battery, charging circuit, driver/relay & source. Data for failures, charge levels, operating hours.

DALI SPECIFICATIONS ENABLING INTEROPERABILITY
NUMBER, TOPIC, DESCRIPTION, VALUE

axis

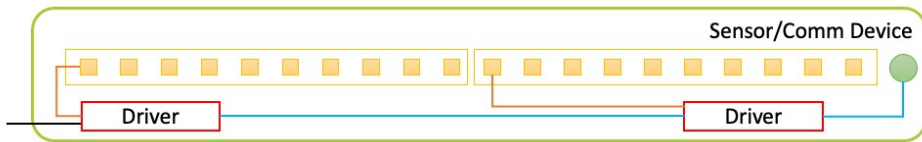| DALI Part 250	DALI Part 251	DALI Part 252	DALI Part 253	DALI Part 351	DALI Part 150	DALI Part 209, DT8 (Tc)	DALI Part 202
Integrated Bus Power Supply	*Luminaire Data*	*Energy Data*	*Diagnostics*	*Luminaire – mounted Control Devices*	*AUX Power Supply*	*Color Control*	*Emergency*
Uses the same DALI wire for power and data [inside the driver]	Luminaire identifiers, CCT, CRI, Light Output [inside the driver]	Real-time power and energy usage for control gear (driver and sensor) [inside the driver]	Operating data for control gear and light source, including failure conditions, run-time data. [inside the driver]	Integral sensor protocol for motion sensing, light levels. Multi-sensor data.	Allows communication with 0-10v drivers, and dim to off. Non-digital interface, but necessary for market transition, options.	Commands for CCT (Tc), xy color control, RGBW	Enables illumination and emergency lighting on same network. Includes self-contained.
2-wire system, reduces production and installation complexity, no worry about polarity, standardized. Individual addresses on same circuit.	Within a project, seeing these distinctions is important for lighting quality, maintenance, management of the system etc.	Energy savings goals, accuracy of real time data, utility rebates, tax incentives	Enables fault diagnostics, predictive maintenance and end of life management (e.g., lumen depreciation)	Enables granular control and data collection, Real Time Location Services when mapped, inter-changeability, upgradability.	Realistic market acceptance and transition, cost, supply, retrofit/ existing buildings.	Critical for color constancy between luminaires, quality control and calibration in production.	Supports testing and results. Function test: battery, charging circuit, driver/ relay & source. Data for failures, charge levels, operating hours.

LUMINAIRE AS THE HOME FOR INTEROPERABILITY
HEALTHY MANUFACTURER COMPETITION ABOVE AND BELOW IS GOOD FOR MARKET

IOT Analytics,
Software and Apps

D4i + Zhaga Book 20 Certified Luminaire

Sensor/Comm Device

Driver

Driver

Lighting Control
Systems

DALI Part 250	Intra-luminaire DALI bus/power
DALI Part 251	Luminaire Data
DALI Part 252	Energy Data
DALI Part 253	Diagnostics Data
DALI Part 150	Aux Power Supply
DALI Part 351	Luminaire-mounted control device
DALI Part 209	Color Control
DALI Part 202	Emergency
Zhaga Book 20	Physical and electronic (sensor, connector, D4i)
+	
NEMA LS 200000-2021	Physical interface only

![axis]

EVOLVING INTEROPERABILITY
EXAMPLES

AXIS STENCIL FLEX

- Suspended 120/277v framework with integral D4i drivers (certification in process)

- Can receive lighting inserts of all types (linear, decorative, track)

- Each insert can have it's own sensor/wireless module to deliver 1:1 control and data

- Inserts can be relocated within framework by electrician for workspace changes over time

- Choose one of several control systems that are compatible with DALI-2 integral power supply (Part 250, D4i on roadmap)

- Sensors within the inserts can be changed or maintained in the future per Zhaga Book 20

- **D4i enabled framework becomes the "home" for interoperability**

Empower

axis

EVOLVING INTEROPERABILITY
EXAMPLES

AUTANI INSIGHTS

- Offers a Gateway with IOT Analytics and Visualization
- Pulls from multiple different manufacturers sensors, even within the same application
- Sensors/devices can have different wireless protocols, e.g. Zigbee 3.0, Bluetooth, UWB
- Multi-function sensors
- Only open protocol options
- D4i readable, D4i certified sensor in 2022
- **Gateway with software acts as integrator, becomes the "home" for interoperability**
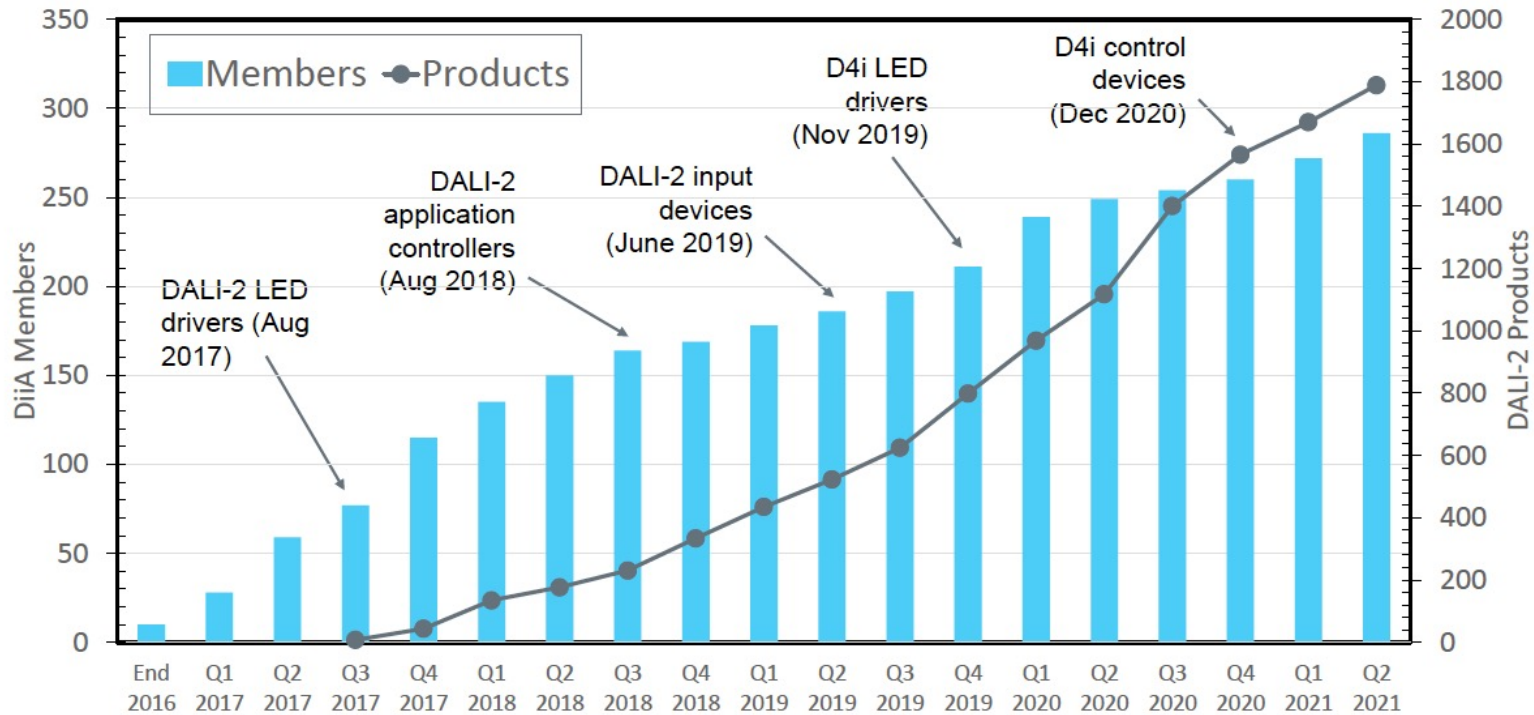
axis **STATUS QUO IN N.A. IS DISAPPOINTING**
INTEROPERABILITY IS WITHIN REACH

- Reality check: In North America, we have very little uptake of the (8) DALI Parts reviewed

- The small number of driver products are using bus power over DALI line (Part 250), primarily SR or Dexal

- Certifications so far are for European products

- Lack of awareness, customer demand, product supply, incentives

- Interoperability is technically available **NOW**

I meant what I said,
and I said what I meant.
An elephant's faithful,
one hundred percent!

Carpe Diem

SEIZE THE DAY

THANK YOU