Introduction

BACnet is a commonly used protocol used for communicating between industrial devices.

In the RAPIX Lighting Control System, a Zone Controller can act as a BACnet server.

A full description of BACnet is beyond the scope of this document. Refer to the official BACnet website at https://www.ashrae.org/.

This document describes of controlling and monitoring a RAPIX Lighting Control System using BACnet.

RAPIX Support for BACnet

System Architecture

The RAPIX Zone Controllers form a mesh to allow them to exchange information about zones and scenes, so they can all maintain a model of the whole system. A BACnet client only needs to connect to a single Zone Controller to get the state of most aspects of the system.
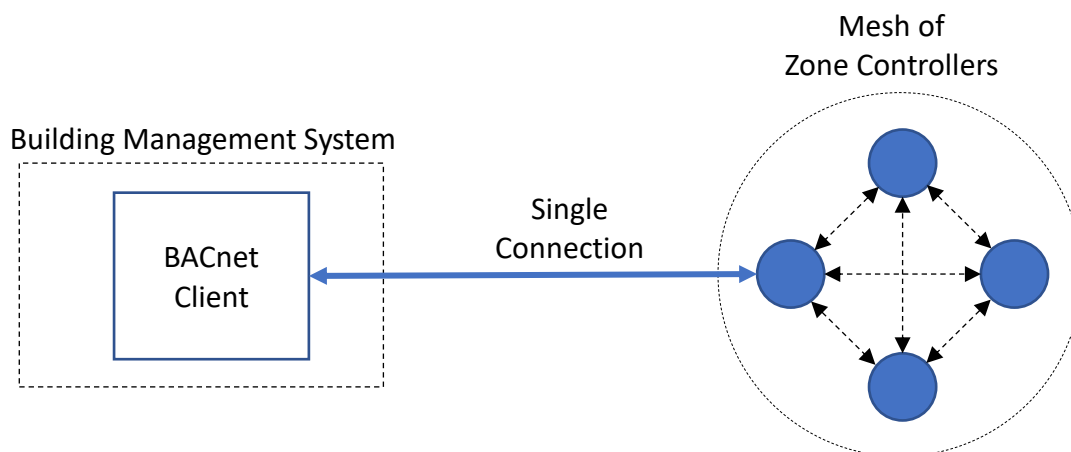
If the BACnet client needs to get details of individual DALI devices, it will be necessary to connect to each Zone Controller in the system.
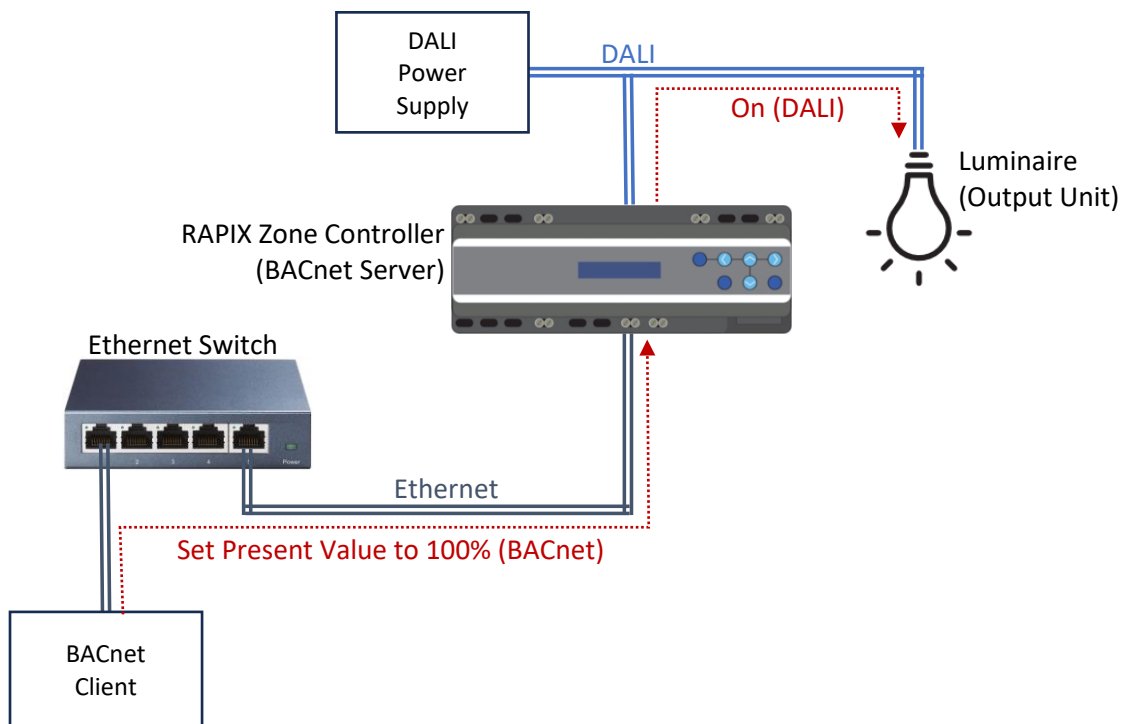
RAPIX supports BACnet connections via UDP/IP only.

Control and Monitoring

A BACnet client can be used to control and monitor various aspects of the RAPIX system:

- Zones
- Scenes
- Flags
- Operating Properties
- DALI Devices

An example of a BACnet Client controlling a luminaire via BACnet and RAPIX is shown below.

BACnet Client controlling a luminaire via BACnet and RAPIX

BACnet Objects

The BACnet object types used by RAPIX are listed below.

RAPIX Item	BACnet Object Type	Object Present Value
Zone Controller	Device	Not Applicable
Zone	Analog Value	Zone Target Level (scaled)
Operating Property	Analog Value	Operating Property Value
DALI Device	Analog Value	Device target DALI level (output units only)
Scene	Binary Value	Scene State (1 = set)
Flag	Binary Value	Flag State (1 = set)

BACnet Objects for Controlling and Monitoring RAPIX

Configuring the BACnet settings using RAPIX Integrator

To configure the BACnet settings for the RAPIX Lighting Control System:

- Run the RAPIX Integrator Software.
- Select the **Site** tab.
- Select the **BACnet** check box.

BACnet Settings.

The BACnet settings are described in the tables below and are discussed in detail elsewhere in this document.

| Setting	Purpose	Default Value
Zone Controller	The Zone Controller that will be the BACnet server. Avoid using the Zone Controller with the lowest IP Address, if possible, as it will be the "master" and will be the busiest of the Zone Controllers.	-
Port	BACnet Port.	47808
DALI Unit Objects	Select which DALI units to create BACnet objects for. Only select this option if needed, as it adds a lot of burden on the RAPIX system and the BACnet client.	None
Zone Level Range	The range that the BACnet clients will use for the Zone Level	254

BACnet Settings

Item	Object Type	Default Instance Number	Default Object Id
Zone Controller 1	Device (8)	1	33554433 (0x02000001)
Zone 1	Analog Value (2)	1	8388609 (0x00800001)
Op Prop 0	Analog Value (2)	1000	8389608 (0x008003E8)
ZC 1, Line 1, Device 0	Analog Value (2)	2000	8390608 (0x008007D0)
Scene 1	Binary Value (5)	1	20971521 (0x01400001)
Flag Group 0, Flag 0	Binary Value (5)	1000	20972520 (0x014003E8)

BACnet Instance Number Settings

Object Ids

BACnet object ids must be selected to ensure that they are unique within the BACnet system.

The range of Ids that will be used are shown to the right of the instance number selection controls. The object ids are a 32-bit-field as shown below:

Byte 3	Byte 2	Byte 1	Byte 0

10-bit Object Type   22-bit Instance Number
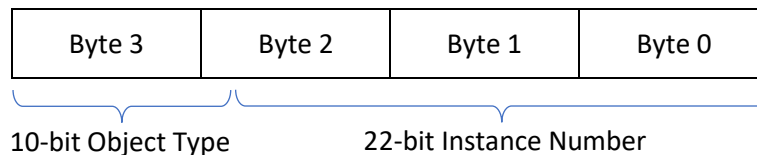
Run-time Execution

After the BACnet configuration has been set using RAPIX Integrator software, it is saved to the Zone Controllers.

After the configuration has been transferred, the Zone Controller(s) will open the BACnet port to allow use via BACnet.

After that transfer, there is no need for RAPIX Integrator to remain running.

DALI Units

The creation and maintenance of BACnet objects for all DALI units adds an additional burden on the system that should only be enabled if required. The BACnet objects for the DALI units are made available by their local Zone Controller.

If the **DALI Unit Objects** option is disabled, only the selected Zone Controller will have its BACnet interface open.

Polling

It is recommended that Change of Value (CoV) notification is used in preference to polling the Present Values.

The number of BACnet objects and properties being read, and the rate of the polling should be minimised to reduce the processing load on a RAPIX Zone Controller.

The RAPIX Zone Controller display can be used to show the CPU usage.

Reduce the polling rate if the RAPIX Zone Controller CPU load increases by more than 20%.

Custom Properties

The full list of properties is in the PICS section of this document.

Zone Levels

The RAPIX Lighting Control System provides several options for how the Zone level scaling can be done to suit the requirements of the BACnet clients. All messages that are used to control or monitor Zones will use a level scaled according to the selected option.

BACnet Scale	Purpose	Scaling
0 – 1	On/off control	0 = off 1 = on
0 – 100	Percentage control	0 = off 1 – 100 = 1% – 100%
0 – 254	DALI Level control	0 = off 1 – 254 = DALI Level 1 to 254
0 – 255	8-bit control	0 = off 1 – 255 = 0.4% to 100%
0 – 65535	16-bit control	0 = off 1 – 65535 = 0.4% to 100%

Zone Level Scaling

Zone Fade Times

When a RAPIX Zone is set to a new level, a fade time can be used. This is the time taken for the level to transition from the current level to the new level. Fade times of 0 (instant) and 0.7 to 65535 seconds (18 hours) can be selected.

Zone Colours

The Zone Colour can be controlled and monitored if the Zone contains DALI Type 8 devices (i.e. colour control). RGB, RGBW and Colour Temperature are supported.

For RGB colour, the value is a 24-but number, with bits as follows:

RRRRRRRRGGGGGGGGBBBBBBBB

The maximum value for any colour component is 254 (as per DALI standard).

So, for example, pure green would be 65024 (binary 000000001111111000000000)

For RGBW colour, the value is a 24-but number, with bits as follows:

RRRRRRRRGGGGGGGGBBBBBBBBWWWWWWWW

So, for example, all channels on (white) would be 4278124286 (binary 11111110111111101111111011111110)

Zone Error Status

RAPIX Zone Controllers can report the error status of Zones. The error status value is a bitfield as shown in the table below.

Bit-field Value	Name	Meaning
0x00	OK	Everything in the Zone is OK
0x01	LEVEL UNKNOWN	The level of some or all devices in the zone is unknown. **This is not necessarily an error.**
0x02	LAMP FAILURE	One or more devices has a lamp failure. Specifically, the DALI Query Status message reported "Lamp Failure".
0x04	DEVICE_FAILURE	One or more devices has an internal failure. Specifically, the DALI Query Status message reported "Control Gear Failure".
0x08	DEVICE MISSING	One or more devices in the Zone are not responding (but the DALI Line is OK).
0x10	DALI LINE FAILURE	One or more DALI Lines (which are part of the Zone) have a communication failure.
0x20	ZONE CONTROLLER COMMS FAILURE	One or more Zone Controllers (which are part of the Zone) is not communicating.
0x40	EM FAILURE	One or more Emergency Devices has a failure. Specifically, the Device Type 1 Query Failure Status message reported one or more of: • Circuit Failure • Battery Duration failure or Battery Failure • Emergency Lamp Failure • Function/Duration Test max. delay exceeded • Function/Duration Test failed
0x80	DEVICE_CONFLICT	One or more addresses has multiple devices

* Note: 0x indicates a hexadecimal value

The simplest way to use the Error Status value is:

1. If the value is 0, all is OK
2. If the least significant bit is set, then the Zone Level is unknown / uncertain (this is not necessarily an error)
3. If any of the other bits are set, there is a failure

Examples:

Error Status = 17 = 0x11 = 0x10 + 0x01 (DALI Line Failure and Level Unknown)

Error Status = 70 = 0x46 = 0x40 + 0x04 + 0x02 (EM Failure, Device Failure and Lamp Failure)

Testing

YABE

A simple way to test the Zone Controller BACnet server on Windows is to use YABE as follows:
1. Install the YABE BACnet client from https://sourceforge.net/projects/yetanotherbacnetexplorer/
2. Either:
    a. delete the file C:\Program Files\Yabe\Proprietary-properties.csv (this allows you to see the proprietary property ids); or
    b. replace the file contents with the text below (this allows you to see the RAPIX names for the proprietary properties).
3. Run YABE
4. Open the options, and enable "Show Property ID Numbers".

The Show Property Id Numbers setting

5. Click on the Add Device button.
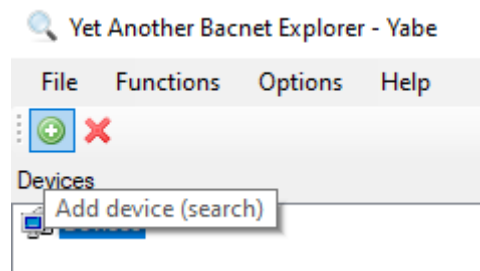
The Add Device Button

6. Enter the computer's IP Address and click on **Start.**
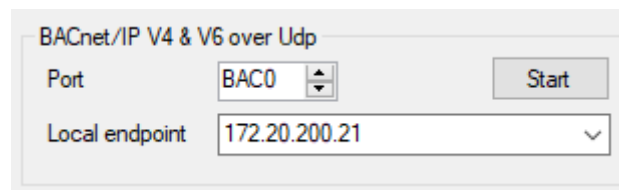
The computer's IP Address setting and the Start Button

7. The list of Zone Controllers will appear.
8. Click on a Zone Controller to see the list of objects.
9. Click on an object to see the list of properties.
10. The "Present Value" allows the select object to be viewed or controlled:
    a. Zone: Present Value is the Target Level.
    b. Op Prop: Present Value is the Operating Property value.
    c. DALI Output Unit: Present Value is the DALI target level.
    d. Scene: Present Value is 1 if the scene is set.
    e. Flag: Present Value is 1 if the flag is set.
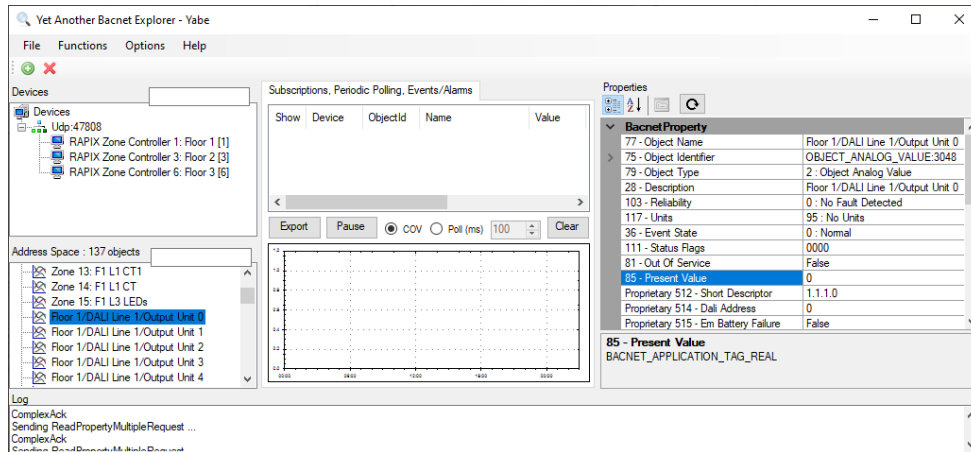
The YABE User Interface
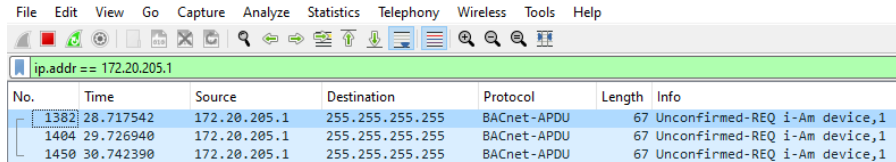
Proprietary-properties.csv:

```
Id,PropertyDescription
512,Short Descriptor
513,Occupancy
514,DALI Address
515,EM battery Failure
516,EM Lamp Failure
518,Comm Failure
519,GTIN
520,Serial Number
521,OEM GTIN
522,OEM Serial Number
524,Rated EM Duration
525,DALI Failure Status
526,DALI EM Failure Status
530,Zone Controller Id
531,DALI Line Number
532,Device Category
533,DALI Device Types
534,DALI Level
535,DALI Target Level
536,Fade Time
540,EM Mode
541,EM Status
542,Duration Test Result
550,Colour Type
551,Average RGB Colour
552,Target RGB Colour
553,Average Colour Temp
554,Target Colour Temp
560,Minimum Level
561,Maximum Level
562,Average Level
563,Fade Time
564,Error Conditions
570,Minimum Lux
571,Maximum Lux
572,Average Lux
```

Please note that Ozuno does not endorse the use of YABE, nor does it provide technical support for the use of it.

Wireshark

The Wireshark software (https://www.wireshark.org/) can be used to view the details of BACnet messages going in and out of your computer.
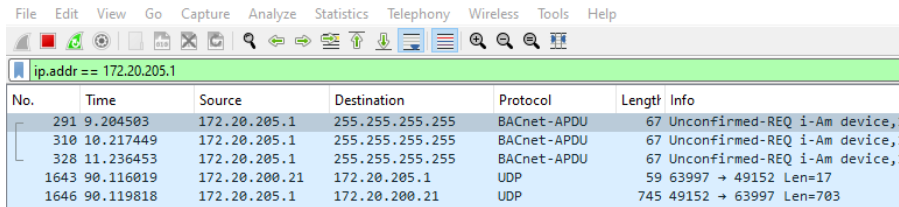
The screen shot below shows the software configured to filter messages to and from the IP Address of a Zone Controller while YABE is discovering the Zone Controller:

BACnet messages

When the device object properties are read, Wireshark does not recognise the messages as BACnet because they are using a different port, so it shows them as UDP messages, with no interpretation:
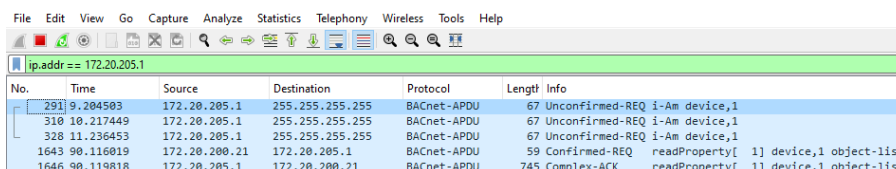

BACnet messages shown as UDP messages

To get Wireshark to correctly interpret these messages:

1. Right-click on one of them and select **Decode As**.
2. Change the selection under "Current" from **(none)** to **BVLC**:
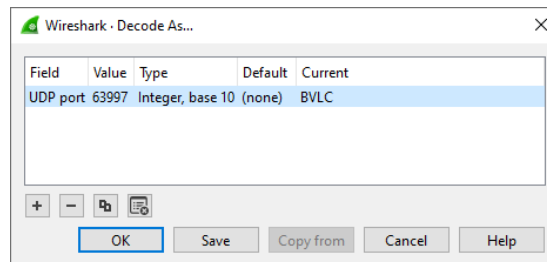
The Decode As form

3. Click on **OK**
4. The messages will now be shown as being BACnet:

BACnet messages, correctly interpreted

Protocol Implementation Conformance Statement (PICS)

Date: 2 April 2024
Vendor Name: Ozuno Holdings Pty. Ltd.
Vendor Id: 1362
Product Name: RAPIX Zone Controller
Product Model Number: DGOZ-ZONEC-4DA, DGOZ-ZONEC-2DA
Application Software Version: 12.6 and later
Firmware Revision: 12.6 and later
BACnet Protocol Version: 1
BACnet Protocol Revision: 7
Product Description: The RAPIX Zone Controller provides a gateway between BACnet and the RAPIX Lighting Control System.

BACnet Standardized Device Profiles Supported (Annex L):

☐ BACnet Cross-Domain Advanced Operator Workstation (B-XAWS)

☐ BACnet Advanced Operator Workstation (B-AWS)

☐ BACnet Operator Workstation (B-OWS)

☐ BACnet Operator Display (B-OD)

☐ BACnet Advanced Lighting Workstations (B-ALWS)

☐ BACnet Lighting Operator Display (B-LOD)

☐ BACnet Advanced Life Safety Workstation (B-ALSWS)

☐ BACnet Life Safety Workstation (B-LSWS)

☐ BACnet Life Safety Annunciator Panel (B-LSAP)

☐ BACnet Advanced Access Control Workstation (B-AACWS)

☐ BACnet Access Control Workstation (B-ACWS)

☐ BACnet Access Control Security Display (B-ACSD)

☐ BACnet Advanced Elevator Workstation (B-AEWS)

☐ BACnet Elevator Workstation (B-EWS)

☐ BACnet Elevator Display (B-ED)

☐ BACnet Advanced Lighting Control Station (B-ALCS)

☐ BACnet Lighting Control Station (B-LCS)

☐ BACnet Building Controller (B-BC)

☐ BACnet Advanced Application Controller (B-AAC)

☐ BACnet Application Specific Controller (B-ASC)

☐ BACnet Smart Actuator (B-SA)

☐ BACnet Smart Sensor (B-SS)

☐ BACnet Lighting Supervisor (B-LS)

☐ BACnet Lighting Device (B-LD)

☐ BACnet Advanced Life Safety Controller (B-ALSC)

☐ BACnet Life Safety Controller (B-LSC)

☐ BACnet Advanced Access Control Controller (B-AACC)

☐ BACnet Access Control Controller (B-ACC)

☐ BACnet Advanced Elevator Controller (B-AEC)

☐ BACnet Elevator Controller (B-EC)

☐ BACnet Elevator Monitor (B-EM)

☐ BACnet Router (B-RTR)

☒ BACnet Gateway (B-GW)

☐ BACnet Broadcast Management Device (B-BBMD)

☐ BACnet Access Control Door Controller (B-ACDC)

☐ BACnet Access Control Credential Reader (B-ACCR)

☐ BACnet Secure Connect Hub (B-SCHUB)

☐ BACnet General (B-GENERAL)

BACnet Interoperability Building Blocks Supported (Annex K):
DS-RP-B Read Property
DS-RPM-B Read Property Multiple
DS-WP-B Write Property
DS-COV-B Change of Value

Segmentation Capability:
☐ Able to transmit segmented messages   Window Size
☐ Able to receive segmented messages   Window Size

Standard Object Types Supported:

Object Type	Can be created dynamically	Can be deleted dynamically
Device	No	No
Analog Value	No	No
Binary Value	No	No
Multi-state Value	No	No

Device Objects

The Device objects support the following optional properties:

Property Number	Read/ Write	Data Type	Usage	Details
28	R	Char String	Description	Zone Controller name

Analog Value Objects

The Zone objects support the following optional and custom properties:

Property Number	Read/ Write	Data Type	Usage	Details
28	R	Char String	Description	Zone name
103	R	Enumerated	Reliability	As per ASHRAE Standard 135-2020
513	R	Boolean	Occupancy	0 = unoccupied 1 = occupied.
550	R	Unsigned	Zone Colour Type	0 = none 1 = Colour Temperature 2 = RGB 3 = RGBW
551	R	Unsigned	Average RGB(W) colour	See Custom Properties section
552	R/W	Unsigned	Target RGB(W) colour	See Custom Properties section
553	R	Unsigned	Average Colour Temp.	Kelvin
554	R/W	Unsigned	Target Colour Temp.	Kelvin
560	R	Real	Min. level within the Zone	Uses selected Zone level scaling
561	R	Real	Max. level within the Zone	Uses selected Zone level scaling
562	R	Real	Ave. level within the Zone	Uses selected Zone level scaling
563	W	Real	Fade time	See Custom Properties section
564	R	Unsigned	Error condition	See Custom Properties section
570	R	Real	Min. Lux within the Zone	
571	R	Real	Max. Lux within the Zone	
572	R	Real	Ave. Lux within the Zone	

The Operating Property objects support the following optional properties:

Property Number	Read/ Write	Data Type	Usage	Details
28	R	Char String	Description	Operating Property name
103	R	Enumerated	Reliability	As per ASHRAE Standard 135-2020

The DALI unit objects support the following optional and custom properties:

Property Number	Read/ Write	Data Type	Usage	Details
28	R	Char String	Description	Device name
103	R	Enumerated	Reliability	As per ASHRAE Standard 135-2020

512	R	Char String	Short Descriptor	If only DALI Output units are selected, format is:
				    Controller.Line.Address
				If all DALI device types are selected, format is:
				    Controller.Line.Type.Address

514	R	Unsigned	DALI Address	DALI Output Unit: Short Address DALI Input Unit: Short Address RAPIX Unit: Extended Address
515	R	Boolean	Emergency Battery Failure	True = failure (EM units only)
516	R	Boolean	Emergency Lamp Failure	True = failure (EM units only)
518	R	Boolean	Communication Failure	True = failure
519	R	Unsigned	GTIN	
520	R	Unsigned	Serial Number	
521	R	Unsigned	OEM GTIN	
522	R	Unsigned	OEM Serial Number	
524	R	Unsigned	Rated Emergency Duration	Minutes (EM units only)
525	R	Unsigned	DALI Failure Status	DALI Output Units only. As per 62386-102: Bit 0 (LSB) Control Gear Failure Bit 1 Lamp Failure Bit 2 Lamp On Bit 3 Limit Error Bit 4 Fade running Bit 5 Reset (default) State Bit 6 No Address Bit 7 (MSB) Power Cycle seen
526	R	Unsigned	DALI Emergency Failure Status	DALI EM Units only. As per 62386-202: Bit 0 (LSB) Circuit Failure Bit 1 Battery Duration Failure Bit 2 Battery Failure Bit 3 EM Lamp Failure Bit 4 Function test max delay exceeded Bit 5 Duration test max delay exceeded Bit 6 Function Test failed Bit 7 (MSB) Duration Test failed
530	R	Unsigned	Zone Controller Id	
531	R	Unsigned	DALI Line number	1 to 8
532	R	Unsigned	Device category	0 = unknown 1 = output unit (Control Gear) 2 = input unit (Control Device) 3 = RAPIX unit
533	R	Unsigned	DALI Device Types supported	DALI Output Units only. Bit-field, with bit N being set if DALI Device Type N is supported.
534	R	Unsigned	DALI Level	0 to 254 (DALI Output Units only)
535	R	Unsigned	DALI Target Level	0 to 254 (DALI Output Units only)

Property Number	Read/ Write	Data Type	Usage	Details
536	R	Unsigned	DALI Fade Time	0 to 15 (DALI Output Units only)
540	R/W	Unsigned	EM Mode	0 = Normal (set to stop test) 1 = Function Test in progress (set to start test) 2 = Duration Test in progress (set to start test) 3 = Rest Mode 4 = Emergency Mode 5 = Extended Emergency Mode 6 = Inhibit Mode
541	R	Unsigned	EM Status	DALI EM Units only. As per 62386-202: Bit 0 (LSB) Inhibit mode Bit 1 Function test done Bit 2 Duration test done Bit 3 Battery fully charged Bit 4 Function test pending Bit 5 Duration test pending Bit 6 Identification active Bit 7 (MSB) Physically selected
542	R	Unsigned	Duration Test Result	Minutes (DALI EM Units only)
550	R	Unsigned	Device Colour Type	DALI Colour Units only. 0 = none 1 = Colour Temperature 2 = RGB 3 = RGBW
551	R	Unsigned	Average RGB(W) colour	DALI Colour Units only
552	R/W	Unsigned	Target RGB(W) colour	DALI Colour Units only
553	R	Unsigned	Average Colour Temp.	Kelvin (DALI Colour Units only)
554	R/W	Unsigned	Target Colour Temp.	Kelvin (DALI Colour Units only)

Binary Value Objects

The Scene objects support the following optional properties:

Property Number	Read/ Write	Data Type	Usage	Details
28	R	Char String	Description	Scene name
103	R	Enumerated	Reliability	As per ASHRAE Standard 135-2020

The Flag objects support the following optional properties:

Property Number	Read/ Write	Data Type	Usage	Details
28	R	Char String	Description	Flag name
103	R	Enumerated	Reliability	As per ASHRAE Standard 135-2020

BACnet Data Link Layer Options:
☐ ARCNET (ATA 878.1), 2.5 Mb. (Clause 8)
☐ ARCNET (ATA 878.1), EIA-485 (Clause 8), baud rate(s) _____
☒ BACnet IP, (Annex J)
☐ BACnet IP, (Annex J), BACnet Broadcast Management Device (BBMD)
☐ BACnet IP, (Annex J), Network Address Translation (NAT Traversal)
☐ BACnet IPv6, (Annex U)
☐ BACnet IPv6, (Annex U), BACnet Broadcast Management Device (BBMD)
☐ BACnet/ZigBee (Annex O) _____
☐ Ethernet, ISO 8802-3 (Clause 7)
☐ LonTalk, ISO/IEC 14908.1 (Clause 11), medium: _____
☐ MS/TP master (Clause 9)
☐ Point-To-Point, EIA 232 (Clause 10), baud rate(s):
☐ Point-To-Point, modem, (Clause 10), baud rate(s):
☐ BACnet Secure Connect (Annex AB)
☐ Other:

Device Address Binding:
Is static device binding supported? (This is currently necessary for two-way communication with MS/TP slaves and certain other devices.) ☐ Yes   ☒ No

Networking Options:
☐ Router, Clause 6 - List all routing configurations, e.g., ARCNET-Ethernet, Ethernet-MS/TP, etc.
☐ Annex H, BACnet Tunneling Router over IP

Character Sets Supported:
Indicating support for multiple character sets does not imply that they can all be supported simultaneously.
☒ ISO 10646 (UTF-8)   ☐ IBM/Microsoft   ☐ DBCS   ☐ ISO 8859-1
☐ ISO 10646 (UCS-2)   ☐ ISO 10646 (UCS-4)   ☐ JIS X 0208

Gateway Options:
This gateway supports the RAPIX Lighting Control System, and connected DALI devices.

Change History

Rev	Date	Updated By	Comment
1	11 April 2024	DS	First Release
2	19 Aug 2024	DS	Added details to Zone Error Status table.
3	22 Oct 2024	DS	Added explanation of the system architecture. Added Zone Lux level properties.

Contact Information

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