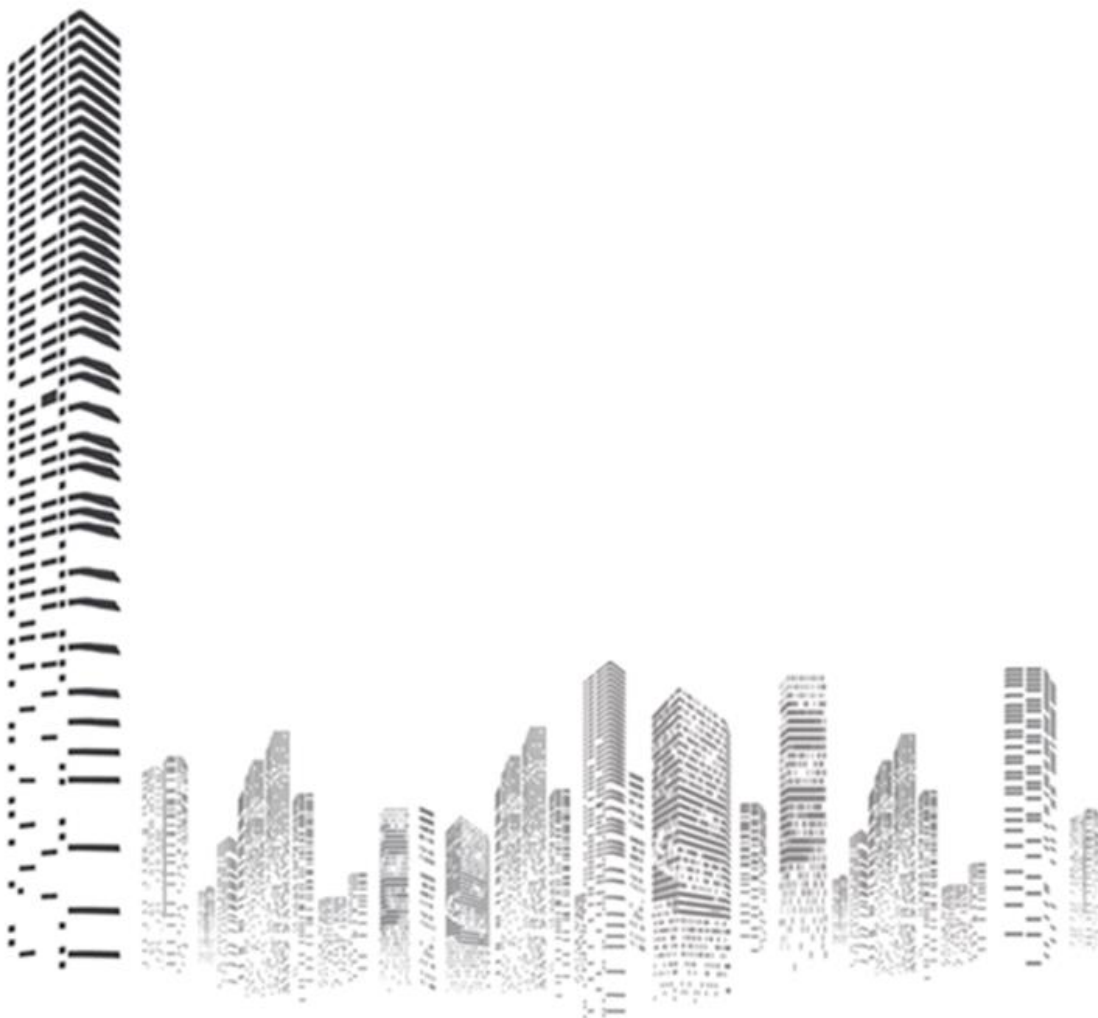


Lighting Intelligence and Control: Technical Specification Document



Revision History

Author	Date	Notes	Release versions
AJ & TF	2008	First Release	3.0
AJ & TF	2014	Second Release	3.2
TO & LC	7.6.2019	Updated to include DALI-2 where appropriate, DT8 colour control + supporting products and features, HCG, services and API integration	4.4
CD, BD & TF	30.04.2020	Updated to reflect changes in product and system.	4.5
TO	12.08.2020	950 Solution and DALI-2 updates	4.6
TO	03.01.23	Environment sensing and Digital services updates	4.7
TO	23.06.23	Auto heal added	4.8

Contents

Revision History	2
Contents	3
PART 1 - GENERAL	5
1.1 Introduction	5
1.2 Overview.....	6
1.3 Quality Assurance	8
PART 2 - FUNCTIONAL DESCRIPTIONS	9
2.1 Software	9
2.2 Groups.....	9
2.3 Scenes.....	9
2.4 Application Controller (Router)	10
2.5 Daylight Harvesting	11
2.6 Blinds Control	12
2.7 Occupancy Control	12
2.8 Tuneable White and Colour Control	13
2.9 Scheduler	13
2.10 Hardwired manual control panels.....	14
2.11 IR Receiver.....	14
2.12 Conditional response.....	15
2.13 Linked recall of output level settings	15
2.14 BMS / BAS.....	15
2.15 Control over Ethernet	16
2.16 Switch input	16
2.17 Analogue input.....	16
2.18 Serial control interface – RS232.....	17
2.19 Power interruptions	17
2.20 Fault resilience	17
PART 3 - PRODUCTS	18
3.1 Software platform	18
3.2 Lighting Application Controller (Router)	18
3.3 Sensors	19
3.4 Special movement sensor interface	21
3.5 Hardwired Manual Control Panels.....	21
3.6 Switch & voltage input unit	22
3.7 Miniature input unit	22
3.8 IR Remote	23
3.9 Luminaires	23
3.10 Load Interfaces – DIN Rail	23
3.11 Load Interfaces - Wall Mounting.....	24
3.12 Blinds controller	27
3.13 RS232 AV Interface.....	27

PART 4 - SERVICES	28
4.0	28
4.1 Digital Services Overview, Cloud based system.....	28
4.2 RESTful API	29
4.3 Local server-based system.	30
4.4 VPN Tunnelling for Remote Assistance	30
4.5 Security, Data and Privacy	30
PART 5 – GLOSSARY	32

PART 1 - GENERAL

1.1 Introduction

1. The overall objective is to achieve the most energy efficient lighting, whilst offering benefits to occupant wellbeing and be part of the smart/ intelligent building.
2. The lighting control system should allow live alteration of control scenarios that can be programmed through the configuration software such that they can be developed alongside the expectations of the design and end user.
3. The lighting control system shall provide energy management and reporting of lighting load status throughout the installation. It shall provide convenient and intuitive manual control, supported by appropriate automatic operation to minimise energy consumption.
4. The lighting control system shall be modular and scalable. It shall utilise digital network technology based on the open standards DALI or DALI-2 protocols for local field networks and Ethernet TCP/IP for the backbone infrastructure. In addition, for Architectural and Architainment Lighting use the system shall utilise RS485 high-speed serial data compatible with Helvar SDIM protocol and DMX512 for intelligent luminaires and entertainment interface.
5. The system shall be able to control DALI Type 8 LED drivers in compliance with the DALI IEC 62386 Part 209 standard, for tuneable white (colour temperature Tc) and full colour (x-y coordinate) loads.
6. The lighting system shall allow control of DALI emergency fittings by facilitating automation of Emergency Function and Duration Testing and generation of test reports.
7. To ensure simplicity and reliability, it is a requirement that the system network controllers / Application Controller (Router)s handle network connections directly. Systems that utilise additional converters or similar intermediary devices are not acceptable.
8. System intelligence shall be distributed and reside within the lighting ballasts, LED drivers, load controllers, input devices, gateways and network Application Controller (Router)s.
9. The installation shall be capable of forming a building wide lighting control system. Integration to BMS/BAS layer shall be provided using gateways, protocol convertors or software drivers. The system shall offer at minimum the ability to integrate via BACnet, OPC or the Niagara™ platform to facilitate seamless connection and communication.
10. Changes to the system shall be made by an Operator Workstation consisting of either a desktop PC or commissioning laptop computer. However, the PC shall not be an active control component within the system. After commissioning, the control system Application Controller (Router)s and devices shall retain all configuration and programming information required for the system to operate automatically without the PC being present.
11. The lighting control system shall allow local server or Cloud connectivity for the provision of monitoring and reporting purposes. RESTful API's shall be employed for 3rd party data access to the local server or cloud.

1.2 Overview

1. The system shall be formed of local networks connected to Lighting Application Controller (Router)s. The Application Controller (Router)s themselves shall inter-connect and communicate via a backbone Ethernet network using TCP/IP.
2. The lighting control system shall be capable of co-existing on a building Ethernet network and structured cabling system if required. Alternatively, the lighting control system shall have the ability to operate as an independent system.
3. DALI networks shall utilise a suitable two-core data cable (which should be screened in electrically noisy environments). The installing contractor shall ensure that any network cable used within modular wiring or power-track type wiring systems is suitable for DALI use. To this end the contractor shall ensure that the cable type and wiring method is approved by the control specialist.
4. RS485 and DMX networks shall use two twisted pairs overall screened cable specified for wide bandwidth RS485 use. The contractor shall ensure that the cable type and wiring method is approved by the control specialist.
5. The Ethernet backbone cabling shall be of not lower specification than CAT 5e data cable terminated with RJ45 type connectors.
6. The system shall be designed in such a way that typically each floor of the building is provided with one or more local networks. System communication across networks and to Operator Workstation shall be through Application Controller (Router)s.
7. For reasons of back-bone data integrity, speed and reliability, hard wired data cable or optical fibre connections shall be used. However, wireless devices may be connected to the system to allow additional functions and flexibility. For example, the use of a wireless networked laptop computer for commissioning.
8. A monitoring service shall enable real time system health check visibility and remote assistance of the lighting control system. The service shall either be via a local server or a cloud-based system. The solution should be completely secure and compliant with the European GDPR.
9. All DALI devices connected to the system shall be fully compliant with the DALI Standards. Any devices provided by the control specialist that utilise the DALI bus, in addition to those covered by the DALI Standard, shall not cause any detrimental effect to the operation of the standard DALI devices or the local DALI communication network.
10. All DALI-2 devices connected to the system shall be certified in accordance with the appropriate DALI Alliance (DiiA) IEC62386 test standard and be listed as a certified product on <https://www.dali-alliance.org/products> database. Non-certified devices which are only DALI-2 "compliant", or words to that affect, will not be acceptable.
11. DALI networks and devices shall in general utilise full DALI addressing, reporting and feedback. The use of non-addressed DALI broadcast messages shall be accepted for channel control only.
12. The local DALI networks shall accommodate all luminaires including those with emergency fittings and control input devices. Sensors, manual control panels and other local control devices shall connect directly to the local DALI network. Systems requiring a separate data bus for control devices are not acceptable.
13. All local control devices and interface modules shall derive their power from the DALI network and require no other external power source. Where conventional switches or specialist sensors have been specified in areas controlled by the system, these may be connected to the DALI networks by suitable DALI input interfaces.

14. The control system design shall be such that the DALI networks remain within the constraints imposed by the DALI Standard. To allow for future expansion or modification of the system, local DALI networks shall be designed in such a way that a minimum of 30% spare capacity is allowed with respect to both the DALI power supply maximum load, and the number of connected DALI nodes.
15. Control shall be via the logical grouping of devices. Load interfaces that are to be controlled simultaneously shall be identified collectively as a "group". There shall be no limit to the number of load interfaces that can be included within a group. To allow freedom in respect of installation and configuration, there shall be no restrictions on how loads are functionally grouped for control with respect to their physical location or connection to the system.
16. A control input shall manipulate a "group". Points of control shall include, but not be limited to:
 - daylight harvesting devices
 - movement sensors
 - timer controlled scheduled events (with or without astronomic correction based on the local longitude and latitude)
 - manual control panels
 - colour control panels
 - touch screen interface
 - mobile and tablet apps
 - browser interfaces
 - wireless input devices
 - switch inputs
 - analogue inputs
 - RS232 serial interface
 - TCP and UDP control commands via Ethernet
 - BMS / BAS
17. In practical terms there shall be no limitation to the number of load interfaces or control input devices.
18. Programming access shall be by software application with connection to the system via Ethernet. Connection of multiple PCs shall be allowed. The system shall not require the connection of a PC for normal operation.
19. A system's programming shall be able to be saved to a computer file. It is expected that this shall be a feature of the programming application.

Conversely, a saved file shall be able to be restored to a system.
20. All load interfaces and control device functions shall be nameable. The names shall be of free format to facilitate meaningful descriptions. Names shall be entered during programming but held entirely by the system. The need for separate descriptive files held on a computer shall not be acceptable.

1.3 Quality Assurance

1. Proven competence

The controls manufacturer shall have a minimum of ten years proven record in the design, manufacture and world-wide support of professional lighting control equipment.

2. Processes

The manufacturer shall have a recognised quality system for the design, engineering and manufacturing processes registered to ISO 9001.

The manufacturer shall have a recognised environmental management system for the design, engineering and manufacturing processes registered to ISO 14001

The manufacturer shall be able to demonstrate commitment to the Waste Electrical and Electronic Equipment regulations (WEEE Directive).

3. Certification

All equipment shall carry CE and shall fully comply with the Restriction of Hazardous Substances regulations (RoHS Directive), proof of compliance shall be available from the manufacturer upon request.

Equipment safety shall be by the application of EN 60950-1. Alternative safety standards shall only be accepted where the manufacturer can demonstrate equivalence.

Insulation electrical safety testing shall be at not less than 4 kV RMS.

All equipment shall be specified for operation to Pollution Degree 2. The working ambient temperature range shall be 0 to 40 °C and to 90%, non-condensing, relative humidity.

Mains powered load interface units shall be rated for installation category (over voltage category) II.

Electromagnetic compatibility shall be demonstrated by the application of EN 55032 or EN 61000-6-3 emission standard and EN 55024 or EN 61547 immunity standard. Alternative standards shall only be accepted where the manufacturer can demonstrate equivalence.

Electrostatic discharge immunity shall be tested by the application of IEC 6000-4-2. Surge immunity simulating the effects of lightning strikes shall be tested by IEC 6000-4-5.

4. Warranty

All equipment shall carry a minimum of two years warranty under normal use and service to be free from defects in materials and manufacture. The warranty shall include programming and commissioning carried out by the manufacturer.

During the warranty period the manufacturer shall bear the costs of replacement or repair necessitated by equipment failure the cause of which being attributable to the manufacturer.

The warranty period shall commence from when the equipment is first energised after installation.

The manufacturer shall offer repair or make available new, refurbished units or replacement alternatives to ensure maintenance of functional operation of the installed equipment for a period of six years from the commencement of warranty.

5. Approved Manufacturers
Helvar Limited, Hawley Mill, Hawley Road, Dartford DA2 7SY, United Kingdom

PART 2 - FUNCTIONAL DESCRIPTIONS

2.1 Software

1. The system shall be provided with a comprehensive software package for the Operator Workstation that is used for the initial commissioning and setting to work of the installed devices.
2. It shall be possible to monitor the current state of the lighting and manually select pre-set levels or dim the lighting in any area of the building from the Operator Workstation or Browser.
3. The system shall provide reporting of information from DALI and DALI-2 drivers, ballasts and devices and generate alarms for failure conditions.

2.2 Groups

1. A group identifies “co-operative” devices, typically made up of several dimmer/load interfaces (lighting channels) and controlling user interfaces. Each group shall have a unique system number. A group is “global”, in that it can include any of the system devices regardless of their physical point of connection. All control actions and interactions shall be based on group associations.
2. Any number of load interface devices shall be able to exist in any one or more of the groups. A controlling user interface shall belong to a single group only. There shall be no limit to the number of Application Controller (Router)s that have devices defined within the same group.

2.3 Scenes

1. A “scene” is a description of the combined effect of the lighting levels made up of one or more controlled lighting channels operated collectively within a group. Variations between the channel levels can be used to set the mood, optimise the aesthetic effect or simply set practical lighting for the area. Recall of a scene is thereby a group command and as such allows any number of load interface devices to be included.

As requirements change, during the course of a day for example, different variations, “scenes”, may be required. Typically, an area will have four active scenes in addition to an off scene.

2. Scene levels shall be associated with each dimmer/load interface whereby up to 128 may be defined for each load by programming. Thereby within each group up to 128 scenes may be recalled.

Level resolution shall be 0.1% for commercial lighting and not more than 1% for architectural lighting.

The scene levels of each dimmer/load interface remain absolute regardless of the controlling group recall.

3. Where DALI Type 8 colour LED drivers are being controlled, colour and intensity shall also be incorporated into the scene for the first 16 of the 128 scenes.
4. To expedite programming, assignment of a control device to a group shall automatically assign default values to scenes. The default value shall be incorporated into the scene for the first 16 of the 128 scenes. However, all such assignments shall remain changeable by programming.

5. Fade times are absolute and is the time taken for the lighting to change from current levels to those of the recalled scene regardless of the differences in start and end levels.

The range of the programmable fade-time shall be up to 90 seconds for commercial lighting and up to 36 hours for architectural lighting with a resolution not exceeding 1 second.

Scene fade time shall be associated with the source of the scene recall. Systems with a fixed fade time per scene shall not be accepted.

6. All scene levels and fade times shall be stored by the system for use by a control device.

2.4 Application Controller (Router)

1. An Application Controller (Router) shall be fully autonomous. Application Controller (Router)s shall link via an Ethernet 10/100 network and use TCP/IP protocol. Each Application Controller (Router) shall have its own IP address that shall be fully programmable and allow co-existence on public or private networks. System data exchange, programming, system interrogation, and remote access control shall be via the Ethernet network connection.
2. Commercial Lighting - Lighting Application Controller (Router)s shall be DALI-2 certified application controllers. A choice of both DALI-2 Single Master Application Controllers and DALI-2 Multi Master Application Controllers shall be given from the manufacturer.

Application Controller (Router)s shall be capable of providing DALI communications and full network power of guaranteed 240mA and maximum 250mA for a minimum of 1 and maximum of 4 separate DALI networks from a single, non-modular hardware.

An Application Controller (Router) shall support full mandatory specification DALI networks, each offering independent control of up to 64 DALI devices for DALI-2 Single Master Application Controllers and 64 control gear (loads) + 64 control devices for DALI-2 Multi Master Application Controllers. Load and user interfaces shall co-exist as required, on the same DALI network. There shall be no restrictions requiring the grouping of loads with specific controls. It shall be possible to group any mixture of loads and user interfaces, across any of the Application Controller (Router)s in the system.

3. Architectural / Architainment Lighting - An Application Controller (Router) shall support full specification DALI networks, each offering independent control of up to 64 DALI devices. Load and user interfaces shall co-exist as required, on the same DALI network. There shall be no restrictions requiring the grouping of loads with specific controls. It shall be possible to group any mixture of loads and user interfaces, across any of the Application Controller (Router)s in the system.

An Application Controller (Router) shall support a high-speed serial network for controlling architectural dimmer cabinets. The protocol shall be compatible with Helvar SDIM and offer independent control and feedback from up to 252 dimming channels.

An Application Controller (Router) shall support a DMX network and shall be compatible with DMX 1990 and DMX E1.11 standards. The port shall be configurable as either DMX out or DMX in.

As DMX out, the port shall provide up to 512 independent channel control. The start address of the controlled channels shall be programmable to any within the 512 DMX boundary.

As DMX in, the port shall accept up to 512 channels for control of the Application Controller (Router) groups, DALI or S-DIM loads. The start address for the controlling channels shall be programmable to any within the 512 DMX boundary. The address mapping from DMX into the Application Controller (Router) groups, DALI or S-DIM loads shall also be programmable.

4. Each device shall be uniquely identified. In addition, a device shall be able to be named to make its identity and use clear to the user. Naming shall allow any mix or number of alphanumeric characters without a restrictive limit.
5. Each group shall be identified by a unique number given by the programmer as part of the system configuration. There shall be no restrictions on the numbering to allow such as the allocation of number blocks to specific areas for ease of programming association. In addition, a group shall be able to be named to make its identity and use clear to the user. Naming shall allow any mix or number of alphanumeric characters without a restrictive limit.
6. An Application Controller (Router) shall store group data that shall be defined and/or changed as required by programming. Any number of load interface devices shall be able to exist in any one or more of the groups. A controlling user interface shall belong to a single group only. There shall be no limit to the number of Application Controller (Router)s that have devices defined within the same group.
7. To facilitate system operational checks and expedite initial system set-up without the need to programme individual levels, several default level settings shall be provided for each load interface. These shall be held by the Application Controller (Router) and shall include 100%, 75%, 50%, 25% and 0%.

Each level setting for each load shall have a unique identity and in addition shall be able to be named to make its identity and use clear to the user. The name shall be of alphanumeric characters and without a restrictive limit to the number of characters.

The level identity shall remain the same regardless of the origin of group recall.

2.5 Daylight Harvesting

1. The system shall provide the means of exploiting available daylight to achieve energy savings. The implementation shall use light measurement techniques to ensure the maintenance of appropriate illuminance and shall be additional to that offered by dawn/dusk scheduling alone. Where different approaches may be best suited to the area to be controlled, alternative methods may be offered; for example, "open loop" or "closed loop" controls. In all cases user comfort shall not be compromised and control methods adopted shall give operational transparency to the occupants.
2. Open area control by scene modification:
Open, for example "leisure" or circulation areas, may use open loop control. A selected artificial lighting scene shall be automatically and proportionately modified in response to the changing daylight to maintain the desired combined illumination level of the controlled area. The proportionality shall be programmable over the range of daylight to allow site profiling to suit the structure of the area. A single sensor shall be able to be used with as many areas as required each with an individual profile. The artificial level changes shall be programmable to provide slow transitions that are aesthetically pleasing and not distracting. The location of the daylight sensor(s) shall be as specified by the lighting designer or as recommended by the controls manufacturer to ensure reliable and consistent performance through the changing seasons of a year.
3. Open area control by scene triggering:
The lighting scenes shall be automatically triggered in response to the changing daylight to maintain the desired combined illumination level of the controlled area. The trigger levels shall be programmable over the range of daylight to allow site profiling to suit the structure of the area. A single sensor shall be able to be used with as many areas as required each with an individual profile. The range of the programmable fade time shall be sufficient to allow aesthetically pleasing changes but with a resolution not exceeding 1 second.

4. Defined local area control:
Office and work areas shall use closed loop control to ensure the maintenance of a specified illuminance. A single sensor shall monitor the controlled area, for example a desktop, and adjust the group artificial light level dynamically to compensate in real time for the variations in daylight contribution and thereby maintain a constant illuminance. The speed of tracking shall be programmable to allow subjective adjustment.
5. The system shall also offer adjacent area tracking whereby areas not monitored directly by a sensor can be set to follow the controlled area either directly or as a percentage change. This is to facilitate large office control where daylight harvesting is most effective near the windows, but where light levels away from the windows may require a proportional change.
6. Multiple sensors placed within the same group shall offer light measurement averaging. There shall be no limit to the number of sensors that can be in the same group. The location of multiple sensors shall be as specified by the lighting designer or as recommended by the controls manufacturer to ensure reliable and consistent performance.

2.6 Blinds Control

1. Blinds shall be treated as a load interface with the same flexibility of associations and control. Multiple blinds in the same group shall operate simultaneously. Run time shall be programmable as if an output level to allow partial closure if needed.
2. Intelligent blinds shall be controlled via an RS485 physical link. Proprietary protocols shall be available for common intelligent blind brands to allow flexibility of choice, but only a single protocol shall be used per link.
3. Conventional motor-controlled blinds, curtains, shutters or similar loads shall be controlled by volt free power relays to allow flexibility of choice of motor type. Configuration shall be of paired relays programmable as either up/down control or direction/move for free choice of blind.
4. Where glare control is required, this shall be provided by a sun-tracking algorithm based on building location, time of year and room orientation and be fully automatic as a background function such that operation of the blind will assume the appropriate position.

Manual user override shall be provided to allow for personal choice.

2.7 Occupancy Control

1. Occupancy control shall be achieved using one or more movement detectors. Energy saving shall be provided using intelligent and programmable sensors. Presence, absence or a combined response shall be selectable for each controlled area. Multiple sensors placed within the same group shall allow co-operative control for large areas.
2. Presence detection:
One or more suitable movement sensors connected to the system shall initiate the automatic illumination of a controlled area. To facilitate initial configuration the system shall offer automatically assigned levels; however, there shall be no limitation on the programmable choice of levels thereafter.
3. Absence detection:
One or more suitable movement sensors connected to the system shall initiate the automatic reduction in illumination of a controlled area after a time of no movement detection.

By default, the absence response shall apply whenever the controlled area is using artificial illumination, however by programming it shall be possible to programme the response to apply only to specific lighting settings. The time of no movement detection prior to the response shall

be fully programmable between 90 seconds and 24 hours with a resolution of one second. Movement detected within this time-out period will reset the response as if occupancy had been continuous.

For user comfort, the response shall be in two stages with the selection of an intermediate stage prior to assuming the unoccupied settings. The time the intermediate stage is maintained shall be programmable from 90 seconds up to 24 hours with a resolution of one second. The intermediate and unoccupied settings shall be fully programmable. The default level for intermediate shall be 10% and unoccupied shall be 0%.

4. Corridor hold:
Additional areas such as access routes, stairwells and similar shall be able to be conditionally appended to a controlled space such that the illumination can be maintained as needed whilst the controlled space is in use.
5. Exit delay:
When unoccupied settings are selected for a presence-controlled area other than through the sensor input, for example when a manual control panel is used, an exit delay shall be provided to allow evacuation of the area. During the exit delay "presence" sensor inputs shall be ineffective, to avoid unwanted re-selection of occupied settings. The time of the exit delay shall be programmable from 90 seconds up to 24 hours with a resolution of one second.

2.8 Tuneable White and Colour Control

1. The system shall be capable of controlling DALI Type 8 LED Drivers for tuneable white and full colour control applications in compliance with the DALI IEC 62386 Part 209 standard.
2. The programming software shall be able to set colours graphically within its software. The software shall have the ability to set the x-y colour in a graphical colour space as well as numeric x-y coordinates. Colour temperature shall be able to be set to the numeric Kelvin or Mired value.
3. The user shall be able to control the colour and colour temperature through all the following methods by either easy to use colour wheels or colour sliders.
 1. Wall panel
 2. Phone app
 3. Tablet app
 4. Touch screen
4. The system shall support multiple user defined profiles for Dynamic Circadian Rhythm control, allowing appropriate usage based on aspect of the building, time of day or time of year. The profile shall be editable via a graphical interface. Pre-set rhythms shall be available in the software for customisation if desired. Any of the rhythms shall be able to be run as a shortened test sequence for client approval.

2.9 Scheduler

1. The system shall offer a scheduler whereby lighting settings can be automatically recalled relative to time, day and date. The scheduler shall include an "astronomic" function that can accept local latitude and longitude information and thence derive dawn and dusk times. The locally relevant data of the schedule shall be held in each Application Controller (Router).
2. Synchronisation to a system master clock-calendar shall be optional and selectable between Application Controller (Router)s and connected PC(s). In the event of a network disconnection an Application Controller (Router) shall continue the schedule autonomously. In the event of loss of power each clock shall continue to run for not less than two days.

3. Scheduler actions shall be to the clock calendar or relative to dusk and dawn, or any mixture thereof. Time resolution shall be to one second. It shall be possible to “offset” dusk and dawn times by up to 12 hours before or after their real times and such offsets shall have a resolution of one minute.
4. Until DALI emergency fittings are assigned a dedicated group schedule, the system shall automatically generate a schedule for Emergency Function and Duration testing and generate test reports to facilitate verification of correct operation prior to commissioning. The schedule shall include appropriate test intervals and out of hours timing.
5. There shall be no practical limit to the number of scheduled actions permitted.

2.10 Hardwired manual control panels

1. Wall switch-plate style control panels shall provide direct user control. These shall be simple in use, ergonomically styled and largely self-explanatory in function. All controls shall include LED indicators to show current state. Multifunctional keys where the response is historically dependent upon previous operation shall be avoided.
2. Each physical panel shall have a single DALI address such that multiple functions are sub-devices of the single address.
3. Push button key panels shall provide manual recall or modification of programmed lighting group settings. Each button shall be independent and fully configurable by programming to control any required group. There shall be no inherent limitations as to the use of each button. The number of buttons on a single panel shall be suitably limited to maintain simplicity of use.
4. Slider panels shall offer direct level control of a group lighting settings. The physical position of the slider shall relate directly to the control level. A programmable option shall allow “fade to off” or “fade to the load minimum level” when the slider is moved to its lowest setting. Multiple sliders controlling the same load interface(s) shall operate on the “last takes precedence” principal.
5. Rotary controls shall offer proportional control of a group lighting settings. The control shall be continuous, that is no end stop, and give relative change to the current settings. Clockwise rotation shall correspond to “raise” and anti-clockwise rotation to “lower”. The rate of modification shall be programmable for both slow and fast physical rotation. Where multiple rotary controls are used for the same load interface(s) then each shall give smooth relative change of the settings from the point of use with no step transitions through the change of control.

The control shall include an integral push switch, the function of which shall be programmable. Options shall include a toggle action between an “on” level and “off”. An LED shall indicate the switch status.

2.11 IR Receiver

1. All hard-wired manual control panels shall include an IR (infra-red) receiver to allow the use of a cordless controller. The nominal working range, when used in conjunction with the manufacturer’s specified transmitter, shall be four metres.
2. A minimum of seven programmable functions shall be provided. The IR functions shall be independent of, and not limited to, the functions of the control panel.
3. To permit the independent operation of multiple panels within close proximity, a programmable option shall be the choice of IR reception block. At least 10 alternative IR blocks shall be offered.

2.12 Conditional response

1. It shall be possible to create conditions for a control response. A condition shall be either true or false and thereby provide a means of logical control. The response to which the conditions are applied shall only occur if all the applied conditions are met, that is logically true.
2. A condition shall be allowed from any control input. Conditions shall thereby be able to be created by, but not be limited to, the action of a manual control panel, occupancy control, daylight harvesting, switch and voltage inputs, and scheduled events with astronomic correction based on the local longitude and latitude. Thereby any control input shall be able to apply a conditional response to any other input.
3. A conditional action shall include the ability to inhibit or permit a selected control response. (A typical application being to inhibit manual control panels during out of office hours.)
4. A conditional action shall include the ability to execute an alternative control response to that of the selected source. (A typical application is the change of function of input devices when room partitions are moved.)
5. Any mixture or quantity of conditions shall be allowed to be combined by logical “and” and “or” statements.
6. Nesting of conditions shall be permitted to any depth. To simplify programming a complex set of conditions shall be able to be defined as a single condition and thereafter used as such.

2.13 Linked recall of output level settings

1. The automatic recall of two or more light level settings in sequence shall be provided by linking. There shall be no limitations as to the choice of settings to link, the order of selection, or the number of settings in the link sequence.
2. A linked setting shall be recalled at the end of a link time that shall be programmable up to 45 hours with a resolution not exceeding 1 second. The link time shall be separately programmable for each link. A link sequence shall end when the last setting in the link sequence is executed, or when a “condition” that terminates the link is applied.
3. Linking shall be permitted to any previous member of a link sequence to create a closed loop, or continuous cycle. A cycle shall continue until a “condition” that terminates the link is applied.

2.14 BMS / BAS

1. The system shall offer BMS / BAS connectivity to the lighting system by use of IP or via a gateway, providing connection to common network protocols such as BACnet, OPC and Modbus, along with many proprietary network protocols.
2. The client application shall be provided by the host BMS / BAS, or any third-party equipment needing to interact with the lighting control system. The ease of interaction and presentation of data shall be entirely dependent upon the client.
3. BMS / BAS connectivity shall provide the recall and modification of group or load interface lighting levels, system status and device status where available.
4. Remote connection shall be entirely under the control of the user but typically it would be assumed to be a standard Ethernet network connection which could be the same physical layer as that of the lighting control system.

2.15 Control over Ethernet

1. The system shall allow an external client to open a TCP connection to any Application Controller (Router). The use of UDP shall also be permitted. Data management shall be by the lighting control system such that all data exchange shall be via the targeted Application Controller (Router) regardless of its physical system connection. General protocol and target port numbers for incoming messages shall be provided by the control specialist.
2. System queries shall include device type and parameters, and time and date.
3. Control shall include the recall and modification of programmed group light level settings and in addition shall allow the storing of group lighting levels and setting of time and date.
4. Control shall allow initiation and termination of Emergency Function and Duration testing at both device and group levels.
5. The system shall be able to originate user defined Ethernet messages. Entry shall be optionally in ASCII, hexadecimal or decimal with a specified target IP, port number and whether TCP or UDP is to be used. Triggering of the message shall be programmable from any system control source.
6. The system shall optionally be able to output all event actions as Ethernet messages and thereby allow external monitoring of system activity.

2.16 Switch input

1. An interface shall provide a connection point for one or more volt-free contact closures. Voltage source from the interface shall be isolated and at extra low voltage potential. Loop current shall be less than 1 mA.
2. The interface shall have a single DALI address such that multiple switch inputs are sub-devices of the single address. For address efficiency it is thereby preferred for each interface to handle multiple inputs.
3. The use of non-specialist cable shall be permitted with a maximum length of 50 metres.
4. Execution of control actions shall be permitted on the closing edge contact, opening contact or due to the state of the switch, open or closed. Available actions shall include those of the manual push button key panels.
5. Other than by the DALI constraints there shall be no limit to the number of switch interfaces that can be connected to a DALI network.

2.17 Analogue input

1. An interface shall provide an isolated connection point for one or more extra low voltage DC sources. The input voltage range shall be for 0 to 10 Volts and shall be scaled linearly as 0 to 100% of input. Input impedance shall not be less than 7k5 ohms.
2. The interface shall have a single DALI address such that multiple inputs are sub-devices of the single address. For address efficiency it is thereby preferred for each interface to handle multiple inputs.
3. The use of non-specialist cable shall be permitted with a maximum length of 50 metres.

4. Execution of control actions shall be permitted on a rising voltage, a falling voltage or due to the voltage level. Available actions shall include those of the manual push button key panels.
5. Other than by the DALI constraints there shall be no limit to the number of analogue interfaces that can be connected to a DALI network.

2.18 Serial control interface – RS232

1. An interface shall provide system control via an RS232 port. The port shall be bi-directional with separate receive input and transmit output. Port configuration shall comply with standard RS232 practice to give compatibility with PC serial com ports and third-party equipment equivalents.
2. The interface shall connect to and be powered by a DALI network. However, the interface shall not itself have a DALI address and shall not affect address limits. Other than by the constraints of the power supply loading there shall be no limit on the number of interfaces that may be connected to a DALI network.
3. Control shall be as if a manual push-button key was operated on the DALI network and shall thereby allow recall of any of the pre-programmed light level settings. As control shall emulate a keypress, key function changes made by programming shall automatically be affected without any changes being required to the RS232 control.
4. The RS232 port set up and protocol shall be published by the control specialist for use by third party integrators as needed.
5. Available feedback shall include the key LED tell-back that shall allow indication of key presses originating elsewhere in the system.

2.19 Power interruptions

1. The actions carried out at power up shall be programmable, and shall include the state of conditional responses, linking and scheduled events.
2. The recovery from a power interruption shall be deterministic. It shall either continue as if no interruption had occurred, that is restore settings as they were prior to the interruption including the correct state of scheduled events or power up in a programmable defined way.

2.20 Fault resilience

1. The system shall be fault resilient whereby a device or cable failure shall not compromise the remaining system elements. Failure of a DALI sub-net shall in no way inhibit operation of remaining sub-nets barring the loss of interaction. Loss of integrity of the backbone Ethernet shall not inhibit autonomous operation of the remaining segments.
2. In the event of a device failure the system shall provide automatic configuration and programming of a replacement part such that service repair is by failed device substitution only. There shall be no mandatory requirement of holding pre-configured/programmed devices or the need of expert user knowledge of the Operator Workstation for routine maintenance.

PART 3 - PRODUCTS

3.1 Software platform

1. The controls specialist software package shall run under Microsoft Windows 10, Windows 8 and Windows 7™
2. The package shall include defined operating modes that shall include:
 - Monitoring of the system and its components
 - Live interaction with system elements
 - Live programme editing
 - Offline programme editing
3. Programmable password access shall allow operator security levels to inhibit accidental system changes.

3.2 Lighting Application Controller (Router)

1. The Application Controller (Router) shall be in the form of a modular plastic enclosure for EN 50022 M36 DIN rail mounting, of not more than ten module widths.
2. Status indicators shall be visible with the Application Controller (Router) mounted showing operation of the communications ports, facilitating installation and system checking.
3. LCD Display: Application Controller (Router)s with 4 DALI networks shall contain an inbuilt, full colour and backlit LCD display of 320x240 pixels. The main function of this display will be for advanced facilitation of the installation and system checking such as to test the communication of the DALI networks by flashing the lights and displaying DALI network status and faults.
4. Commercial Lighting - The Application Controller (Router) shall be self-contained, requiring only a protected mains supply for operation, and shall accept any AC supply in the ranges 90 - 250 Volts and 45 - 65 Hz either without adjustment or as a product variant with fixed supply input of 230v or 110v options. The requirement for additional external power supplies is not acceptable.

DALI ports: These shall be of double insulation rating, each with integral guaranteed 240mA, maximum 250mA DALI supply. DALI ports shall be independent, each allowing the individual control of up to 64 DALI devices for DALI-2 Single Master Application Controllers and 64 loads + 64 control devices for DALI-2 Multi Master Application Controller

5. Architectural / Architainment Lighting - The Application Controller (Router) shall be self-contained, requiring only a protected mains supply for operation, and shall accept any AC supply in the ranges 90 - 250 Volts and 45 - 65 Hz without adjustment. The requirement for additional external power supplies is not acceptable.

DALI ports: These shall be of double insulation rating, each with integral guaranteed 240mA, maximum 250mA DALI supply. DALI ports shall be independent, each allowing the individual control of up to 64 DALI devices.

Dimmer port: This shall allow full specification high-speed RS485 port of double insulation rating from both the mains supply and DALI ports. Connection shall be via a two-part screw terminal connector. A separate terminal shall be provided for the earth screen connection. The use of a common 0-volt reference and screen connection shall not be accepted. Optional cable termination shall be provided.

DMX port: This shall allow full specification high-speed RS485 port of double insulation rating

from both the mains supply and DALI ports. Connection shall be via a two-part screw terminal connector. A separate terminal shall be provided for the earth screen connection. The use of a common 0-volt reference and screen connection shall not be accepted. Optional cable termination shall be provided.

Compatible with DMX 1990 and DMX E1.11 standards. The port shall be configurable as either DMX out or DMX in and shall be RDM ready.

As DMX out, the port shall provide up to 512 independent channel control. The start address for the controlled channels shall be programmable to any within the 512 DMX boundary.

As DMX in, the port shall accept up to 512 channels for control of any load interface connected to the Application Controller (Router). Control across Application Controller (Router)s shall be via Group control.

6. Network connection: This shall allow Ethernet network connection to be made via an RJ45 connector for 10/100 Mbit operation over Cat5e cabling. This Medium Dependent Interface port shall provide automatic crossover (auto MDI/MDI-X) to allow the use of common cable termination practice and thereby shall avoid the need of selective crossover cabling.
7. Memory: The data for all connected devices and all associated system data shall be held in non-volatile memory and shall be retained for not less than 10 years in the event of loss of power.
8. Auto-heal: This is the process by which a single newly connected DALI/ DALI-2 device is given the same short address as a single missing DALI/DALI-2 device of the same type on the DALI-2 application controller subnet. I.e. the new device automatically replaces the missing device and adopts its programming without the need of an engineer to program it. Auto-healing should be able to be enabled or disabled per DALI-2 application controller subnet.

3.3 Sensors

1. Integrated Sensor:
An integrated ceiling-mounting unit shall provide luminance measurement and movement detection. The sensor elements shall be separate to ensure no interaction and to give defined performance. The sensor shall have the option to have IP65 rating. The sensor shall have the option to be provided in white or black finishes.
2. PIR Sensors:
Movement detectors using PIR technology. A range of sensors shall be available to suit various applications such as small office, large office and high bay. The sensor shall have the option to have IP65 rating. The sensor shall have the option to be provided in white or black finishes.
3. Microwave sensors:
Movement detectors using microwave technology. A range of sensors shall be available to suit various applications such as open plan, corridor and warehousing. Sensitivity shall be programmable from the specialist software package.
4. External Daylight Sensor:
Photodiode sensor with linear scaling for daylight measurement up to 150,000 LUX. IP 55 rated housing and UV resistant.
5. Environmental Sensor:
Environmental Sensors should be able to measure the following parameters from its surrounding environment:
 - a) Occupancy

- b) Light
- c) Temperature
- d) Humidity
- e) Sound
- f) tVOC (Total Volatile Organic Compounds)
- g) eCO₂ (Equivalent Carbon Di-Oxide)

Environmental sensors should be able to connect to two different types of lighting control networks

- a) Wired DALI-2 networks connected to DALI-2 multi-master application controllers such as the Helvar Imagine Solution
- b) Wireless Bluetooth Low Energy (BLE) mesh systems such as the Helvar ActiveAhead Solution

Environmental sensors should also be able to collect additional environmental and IAQ data wirelessly from “Extension” sensors.

Environmental sensors should be fitted with an inbuilt BLE wireless radio for connection to the BLE Mesh lighting control system network and for receiving of Satellite sensor measurements. Environmental sensors should be recessed ceiling mountable, and DC powered.

Firmware updates of the Environmental sensor should be possible via a Smart Phone Application wirelessly over Bluetooth to ensure future proofness of the product and solution.

6. Extension Sensor

Extension sensors can be battery, DC or AC powered and will advertise their measurement data as Bluetooth Low Energy (BLE) beacons for the Environmental sensor to receive and pass the extension sensor data through to the DALI-2 or BLE mesh based Lighting Control system.

Extension sensors should fulfil at least 1 of three main purposes:

- a) Provide a different location of measurement, measuring the same or subset of the Environmental sensor parameters. e.g. temperature measurement between 1.1 to 1.7m mounting height.
- b) Add new sensing parameters which is not possible from the Environmental sensor e.g. air pressure.
- c) Add an increased accuracy method of measuring the same or subnet of Environmental sensor parameters

Extension sensors should advertise a Unique Identifier (UID) along with the sensor measurement data. Extension sensors should be assigned to Environmental sensors using the Extension sensor UID to allow the additional measurement data to be channelled through specific Environmental sensors. The process of assigning Extension to Environmental sensors should be achieved via a smart phone app.

- 7. The DALI connection shall use two-part screw terminal connectors to allow disconnection of the sensor module whilst maintaining the DALI wiring integrity.
- 8. The sensor shall be powered from the DALI network. Other than the DALI power constraints and the limits imposed by DALI addressing there shall be no limit to the number of sensors supported by the system.
- 9. All sensors shall be capable of being flush or surface mounting. Surface mounting shall be achieved using suitable adaptors. Mounting adaptors shall have the option to be provided in white or black finishes.

3.4 Special movement sensor interface

1. Where a special sensor is required an appropriate interface shall allow connection of the sensor to the DALI network. The choice of sensor shall be in collaboration with the controls specialist to ensure compatibility to the system. Where practicable the interface shall allow powering of the sensor from the DALI network.
2. Functionality shall be the same as that of the other movement detectors.
3. The interface shall be of small size capable of being fitted internal to the sensor with nominal dimensions of 20x50 mm by 10 mm thick plus captive connection leads.

3.5 Hardwired Manual Control Panels

1. Controls shall connect to one of the DALI networks of a Application Controller (Router). Communication and the provision of operating power shall be via the DALI network. Maximum current drawn by an individual control shall not exceed 10 mA.
2. Controls shall be mountable within a BS 5733:1995 back-box of 47 mm depth. Construction shall be modular such that a control panel is made up of one or more control modules. Modules shall clip into single gang or double gang module mounting frames for attachment to the back-box.

A single gang frame shall accept a single control module and fit into a single gang back-box. A double gang frame shall accept up to three control modules and fit into a double gang back-box. Any mixture of control modules shall be permitted. A matching blanking module shall be used when less than three modules are required in a double gang back-box.

3. The DALI connection shall use two-part screw terminal connectors for maintaining DALI wiring integrity or quick release terminals to allow disconnection of the scene control panel. The connectors shall be internally linked to facilitate link-through wiring of the DALI pair.
4. Where provided integral IR receiver lens shall be discrete and of a significantly smaller proportion to manual controls. The lens shall give wide-angle coverage with a high sensitivity cone of nominal 60 degrees.
5. Control panel fascia options shall include, but not be limited to, white plastic, polished brass and brushed stainless steel and shall use "secret fixing" (no visible screws or fastenings). In addition, the manufacturer shall offer custom panel solutions to allow continuity of style and finish where standard panel options are unsuitable.
6. Push-button modules:
Buttons shall give mechanical movement with tactile feedback of operation. Button style, size and spacing shall give easy operation without risk of multi-button operation. The buttons shall be organised in columns of not more than 5 buttons and not more than two columns to a single module. LED tell-back indication shall be provided. Customisation of button labelling shall be allowed.
7. Touch-control modules:
Touch controls shall provide haptic feedback of operation. Standard layouts shall be provided for buttons and horse-shoe style control elements. Module finish shall be available in glass or acrylic materials in white or black. LED tell-back indication shall be provided.
8. Touch-control modules: Customisation
The touch control module shall allow for customisation incorporating additional functional elements such as sliders. Graphical configuration shall allow the unique labelling of buttons, layout of the control elements, colour and background.

9. Rotary control module:
The control shall be of large diameter and low profile for ease of use. Tactile feedback shall give feel of rotation.

The integral push switch shall be concentric to the rotary. The mechanical movement shall be sufficient to give good tactile feedback.

10. Slider module:
Single or twin slider controls shall be offered in a single module. Sliders shall be vertical to the module and shall have a nominal travel of 30 mm. The LED indicating an active slider shall be integral to the slider control. The control knob shall be circular and similar in size to that of a push-button control.
11. EnOcean Wireless Gateway:
EnOcean control panels shall connect to one of the DALI networks of a Application Controller (Router) via a gateway. Communication and the provision of the gateway operating power shall be via the DALI network. Maximum current drawn by the gateway shall not exceed 20 mA.

Each EnOcean gateway shall support up to 20 EnOcean control panels.

3.6 Switch & voltage input unit

1. The Input Interface Unit shall be in the form of a modular plastic enclosure for EN 50022 M36 DIN rail mounting, of not more than four modules width. It shall provide eight inputs, four of which shall be optionally configurable as DC voltage analogue inputs.
2. The unit shall be powered from the DALI network and require not more than 10 mA for operation.
3. The DALI connection shall use two-part screw terminal connectors to allow disconnection of the input unit whilst maintaining the DALI wiring integrity. The connector shall be 6-way internally linked as three pairs to facilitate link-through wiring of the DALI pair and optional screen without the need for terminal sharing of the wiring.
4. All input connections shall use screw terminals that allow the connection of flexible cable of up to 2.5 sq.mm. Cable lengths up to 50 metres shall be permitted.
5. All inputs shall be double insulated from the DALI supply.
6. When configured for switch use the inputs shall be suitable for use with volt-free contact closures, and with such input shall provide 0.5mA loop current.
7. When configured for analogue use, the inputs shall be suitable for connection to devices such as light sensors giving a DC output voltage. The working range shall be 0 to 10 Volts DC with an input impedance of 7.5 kohms. Connection of up to ± 15 Volts shall be tolerated without damage.

3.7 Miniature input unit

1. A miniature input unit shall provide a convenient interface for mechanical switches used in wall switch-plates and such items as room partition detection switches.
2. A cable inline style unit shall provide four switch inputs in a compact form for installation in locations such as an electrical back-box. Nominal dimensions shall be 20x30 mm by 10 mm thick excluding the connecting cable.

3. A terminal style unit shall provide four switch inputs together with four connections for LED tell back indication. Nominal dimensions shall be 23x30 mm by 15 mm thick including the terminals.
4. A unit shall be powered from the DALI network and require a maximum of 8 mA.
5. The inputs need not be isolated from the DALI network. The inputs shall accept volt-free contact closure and provide 0.5 mA loop current.

3.8 IR Remote

1. The remote control shall be application specific, without unnecessary buttons or functions; and preferable limited to seven functions in total.
2. The unit shall be battery powered, lightweight, and easily held within the hand. The battery shall be a common, readily available type and easily changed.
3. The functions shall include “off”, “raise”, “lower” and four light settings. The different functions shall be clearly identified.
4. Each remote control shall offer a means of selection to the matching panel reception block to avoid the need for dedicated remote-control spares. The selection of reception block shall be by an internal switch to avoid accidental operation.

3.9 Luminaires

1. All luminaires shall be equipped with ballasts or drivers meeting the DALI or DALI-2 specification in respect of remote control.
2. To obviate any compatibility issues and as far as is practicably possible, the same manufacturer should produce the control system and luminaire ballast or driver. Otherwise the contractor shall ensure that the control system and luminaires are compatible in consultation with the manufacturers concerned.
3. In the event that a luminaire is specified for which no DALI control-gear exists, control-gear compliant to the EN 60929 1-10V analogue control standard shall be substituted. In accordance with the specification of the lighting designer these should then be either circuit controlled or individually controlled using suitable DALI or DALI-2 compatible load controllers from the control specialist's product range.

3.10 Load Interfaces – DIN Rail

1. Dedicated load interfaces shall be self-contained mains powered modules, requiring only a protected mains supply for operation, and shall accept any AC supply in the ranges 90 - 250 Volts and 45 - 65 Hz without adjustment.
2. An interface shall be in the form of a modular plastic enclosure for EN 50022 M36 DIN rail mounting.
3. Power connections shall use screw terminals and allow for the connection of flexible cable of up to 2.5 sq.mm.
4. General lighting dimmers shall have universal load handling suitable for, but not limited to:
 - Mains voltage incandescent lamps
 - LED lamps, mains voltage

- LED lamps, low voltage using dimmable driver
- Low voltage halogen lamps using dimmable conventional transformers
- Low voltage halogen lamps using dimmable electronic transformers
- Cold cathode lamps using dimmable conventional or electronic transformers

Alternative dimming laws shall allow programme selection of the most suitable for the desired visual impact. The laws shall include but not be limited to a linear light law and the IES square law.

The dimmed output shall be regulated to compensate for supply voltage and frequency fluctuations. For a 10% change in supply voltage the output shall change by less than 1%, limited to the supply as maximum. There shall be no visible change in output with a frequency change of up to 4 Hz per second, within the working range of 45 to 65 Hz

The power losses per channel shall not exceed 1% relative to its full load rating. Standby losses shall not exceed 0.01% of the dimmer rating.

5. Ballast controllers shall provide power switching and isolated extra low voltage control. The control protocol shall be programmable and shall include, but not be limited to:
 - 1 to 10 Volts as per EN 60929
 - DALI Broadcast
 - 0 to 10 Volts source control
 - PWM
 - DSI™

Control drive shall allow connection of up to 50 controllable ballasts; assuming a maximum ballast loading of 2 mA.

Power switching shall be by use of electro-mechanical relays having high inrush rating suitable for switching electronic fluorescent ballasts in accordance with the requirements of EN 60929 for 1-10V controllable ballasts.

Switching arrangement shall be single pole normally open contacts. Air gap off shall be maintained by the absence of leakage components allowing contactor control for high current or multi-phase circuit loads.

6. Switching units shall use electro-mechanical relays having high inrush rating suitable for low power factor loads such as fluorescent ballasts. Air gap off shall be maintained by the absence of leakage components. Where snubber components are required these shall be fitted by the contractor as specified by the load supplier and in compliance with the recommendations of the control specialist.

Switching arrangement shall be single pole normally open contacts.

7. Control shall be user selectable and shall be DALI, DMX or via a high-speed RS485 serial link and shall be compatible with the Helvar SDIM protocol. The RS485 unit loading shall be such as to allow not less than 250 channels to be controlled on a single link without repeaters or other intermediary devices.
8. Each module shall allow full manual operation in the absence of system control.

3.11 Load Interfaces - Wall Mounting

1. Dimmer cabinets shall be wall-mounting, fully self-contained multiple channel units embodying the protective switchgear, cable management and field wiring terminals. The enclosure shall be of metal construction of IP 20 rating and shall have an anti-corrosion finish or be protectively painted.

Access to switch-gear shall be restricted by means of a lockable door that incorporates a viewing window for checking the switch-gear status.

The controls specialist shall be able to supply cabinet variants as appropriate to achieve installation and cost efficiencies.

2. Construction of the cabinets shall be two-part whereby a chassis frame shall provide the means of mounting and shall contain all site-wiring power cable termination points, incoming protective switchgear and outgoing load terminals. For ease of circuit identification, the load terminals shall be organised in triples with associated controlled live, neutral and earth connections.

Cable access shall be provided from the top, base and rear of the frame. A clear run shall be provided to allow cable transit through from top to base, the cross-sectional area of which shall not be less than 80 sq. cm. Where gland plates are provided these shall include a suitable quantity of knockouts of 20 mm and 25 mm diameter.

3. The dimmer component shall be a fully enclosed self-contained multiple channel module capable of being easily fitted and removed from the wall mounting chassis frame without the need of specialist tools and without the need to disturb field wiring. This shall facilitate completion of site wiring and testing prior to dimmer installation and thereafter service exchange.
4. Power connections to the dimmer module shall be by means of chassis frame pre-wired flying leads with plugs. Parking connectors shall be provided within the frame such that each channel can be linked through as required for circuit wiring checks or circuit operation in the absence of the dimmer module.
5. The dimmer module shall be a fully self-contained unit embodying all control and power management circuitry.
6. The cabinets and/or variants thereof, shall provide 230 Volt 50/60 Hz single or three-phase operation. Operational limits shall be not less than 90 to 260 Volts with auto-tracking of frequency from 45 to 65 Hz. Cabinet rating shall be up to a maximum of 63 Amps per phase.

The contractor shall ensure the correct power feed rating and protection to the cabinets.

7. Individual channel ratings shall be up to 10 Amps RMS for an ambient temperature of 40 °C.

Higher ambient temperatures shall be permitted by means of channel de-rating up to a maximum ambient of 50 °C. The temperature-rating relationship shall be provided by the controls specialist and the contractor shall ensure compliance with loading limits.

8. Incoming power distribution and protection and individual channel load terminals shall be pre-wired. There shall be sufficient wiring space to accommodate cable termination loop allowance.
9. General lighting dimmers shall have universal load handling suitable for, but not limited to:
 - Mains voltage incandescent lamps
 - LED lamps, mains voltage
 - LED lamps, low voltage using dimmable driver
 - Low voltage halogen lamps using dimmable conventional transformers
 - Low voltage halogen lamps using dimmable electronic transformers
 - Cold cathode lamps using dimmable conventional or electronic transformers

Alternative dimming laws shall allow programme selection of the most suitable for the desired visual impact. The laws shall include but not be limited to a linear light law and the IES square law.

The dimmed output shall be regulated to compensate for supply voltage and frequency fluctuations. For a 10% change in supply voltage the output shall change by less than 1%, limited to the supply as maximum. There shall be no visible change in output with a frequency change of up to 4 Hz per second, within the working range of 45 to 65 Hz

The power losses per channel shall not exceed 1% relative to its full load rating. Standby losses shall not exceed 0.01% of the cabinet rating.

10. Ballast controllers shall provide power switching and isolated extra low voltage control. The control protocol shall be programmable and shall include, but not be limited to:

- 1 to 10 Volts as per EN 60929
- DALI Broadcast
- 0 to 10 Volts source control
- PWM
- DSI™

Control drive shall allow connection of up to 50 controllable ballasts; assuming a maximum ballast loading of 2 mA.

Power switching shall be by use of electro-mechanical relays having high inrush rating suitable for switching electronic fluorescent ballasts in accordance with the requirements of EN 60929 for 1-10V controllable ballasts.

Switching arrangement shall be single pole normally open contacts. Air gap off shall be maintained by the absence of leakage components allowing contactor control for high current or multi-phase circuit loads.

11. Switching units shall use electro-mechanical relays having high inrush rating suitable for low power factor loads such as fluorescent ballasts. Air gap off shall be maintained by the absence of leakage components. Where snubber components are required these shall be fitted by the contractor as specified by the load supplier and in compliance with the recommendations of the control's specialist.

Switching arrangement shall be single pole normally open contacts.

12. Control shall be user selectable and shall be DALI, DMX or via a high-speed RS485 serial link and shall be compatible with the Helvar SDIM protocol. The RS485 unit loading shall be such as to allow not less than 250 channels to be controlled on a single link without repeaters or other intermediary devices.
13. Each dimmer module shall have a hard-wire level override input to allow connection of such as fireman's switch if required. The input shall be suitable for use with a volt-free contact closure. The input shall appear as a high impedance voltage source not exceeding 5 Volts. A single input shall be used for all channels of a module; however the override level shall be individually programmable for each channel.
14. Each module shall have a user interface to allow channel set-up configuration and circuit testing prior to system control. The interface shall be menu driven with an information display for clarity of operation and push buttons for function selection.

A lock-out facility shall allow a controlling system to inhibit local parameter changes of a configured system.

15. Each module shall allow full manual operation in the absence of system control.

16. All programmable features shall be retained indefinitely by the dimmer in the event of power loss.

3.12 Blinds controller

1. A DALI controlled interface shall allow the control of two motor-controlled blinds, curtains, shutters or similar loads.
2. Each channel shall consist of two separate 10A single pole normally open power relays functionally interlocked for blind control. Each channel shall have programmable options for open/close operation or power/up-down. The run time (time the relays are closed) shall be programmable in one-second increments to not less than four minutes.
3. To accommodate variations in blind design the power relays shall be configured as volt-free double insulated circuits to allow freedom of supply and load connections, including multi-phase and extra low voltage DC operation.

3.13 RS232 AV Interface

1. An RS232 Interface Unit shall be in the form of a modular plastic enclosure for EN 50022 M36 DIN rail mounting, of not more than two module widths. It shall provide both transmit and receive ports. Both ports shall fully comply with RS232 voltage and current drive specifications.
2. The unit shall be powered from the DALI network and require not more than 15 mA for operation.
3. The DALI connection shall use two-part screw terminal connectors to allow disconnection of the input unit whilst maintaining the DALI wiring integrity. The connector shall be 6-way internally linked as three pairs to facilitate link-through wiring of the DALI pair and optional screen without the need for terminal sharing of the wiring.
4. RS232 connections shall use screw terminals that allow the connection of flexible cable of up to 2.5 sq.mm.
5. The RS232 ports shall be double insulated from the DALI.

PART 4 - SERVICES

4.0

The service shall be structured around several core abilities to provide the additional facilities to the building owner, occupants and facilities managers to enable the ongoing development of the building operations over its lifetime.

Services shall be deployed using either of two options. These being by a cloud-based solution or locally installed server. The service shall in both cases be capable of VPN Tunnelling for remote assistance.

1. If the service deployment uses a cloud-based system: It shall comprise of both a web browser interface and an API interface. Access to the web interface and the APIs shall be encrypted and authenticated, preventing unauthorized parties to access or to read data.
2. If the service deployment uses a local server-based system: It shall comprise of a software architecture that allows for complete installation of Client/Server provision on a single PC or distributed across multiple PC's with the server database accessible from workstation locations installed with the client software.

4.1 Digital Services Overview, Cloud based system

1. The system shall be capable of enabling services by connecting the lighting control system to a Cloud Gateway, then the Cloud Gateway to a Cloud infrastructure.
2. The role of the Cloud Gateway shall be to securely access and send the data collected by the lighting control system to the cloud infrastructure. The cloud-based infrastructure shall be where the data is securely stored and processed.
3. The protocol that shall be used to communicate between the Cloud Gateway and the cloud is MQTT secured by leveraging TLS 1.3 at the transport layer. The cipher suite used for TLS is ECDHE-ECDSA-AES128-GCM-SHA256. Authentication between the Cloud Gateway and Cloud shall use AWS signature version 4.
4. The Cloud Gateway shall be able to use standard Ethernet or wireless networks for communication.
5. Only authenticated users of a particular site shall be able to gain access to the data.
6. Communication to the lighting system shall also be possible through the use of RESTful API's. These shall be accessible via the same Cloud Gateway.

Digital services should provide "Insights" into the operation, space usage and occupant wellbeing performance of the building.

Monitoring and reporting of the data should be available through the Insights cloud platform. Service abilities provided shall include but not be limited to;

- Monitoring the lighting system status such as faults and issues
- Energy consumption of the lighting installation
- Occupancy reporting indicating space usage. This data should be available as both a graph of occupancy with filters for space and time as well as a graphical floorplan "heatmap" with a 24 hour playback feature for particular historical day of the user's choice since connection
- Operating (burn hours) of the luminaires
- Temperature reporting as a graph with filters for space and time

- Environmental reporting as a graph with filters for space and time such as for Co2

Over the air updates should be possible for the Insights cloud platform to add or improve the reporting and insights as well as to ensure future proofness of the solution over the lifetime of the installation.

3. Service delivery shall use a common architecture as well as common components and views. These shall include but not be limited to;

- Dashboard to provide priority information such as status, alerts or energy usage.
- Floorplan, for visualisation of the lighting system status, alerts, usage and user control. The floor plan allowing for representation in 2D or 3D with the ability for the user to Pan, Tilt and Zoom.
- Scheduler, to allow the user ability to set overrides or functional requirements
- Reporting to allow for analysis and exporting of status, alerts, energy and usage information
- Tree structured representation of the lighting system interactions to provide a logical process flow
- Alerts shall be available via email notifications

4.2 RESTful API

Communication to the system shall be possible through RESTful API's. The available data items for retrieval shall include:

<u>/sites'</u>	providing detailed information about all of the sites that a user has access to with each site having its unique 'id' for site specific data retrieval. The data shall include site location, description and images
<u>/sites/{siteid}/devices</u>	Information about the devices connected to the particular site.
<u>/sites/{siteid}/devices/count</u>	The numeric count of devices connected to the lighting system.
<u>sites/{siteid}/devices/{deviceid}</u>	Information about a specific device connected to a site.
<u>/sites/alerts/summary</u>	An alerts summary for all sites accessible by the current user.
<u>/sites/{siteid}/alerts</u>	Information about the state of the devices in a system. The information shall include but not be limited to: <ul style="list-style-type: none"> • Application Controller (Router) missing • Missing device • Short circuit • Network address over limit • Current over limit in subnet • Bad comms • Lamp failure • Unrecognized DALI • Non-compliant • Cloud gateway connection failure • Faulty device
<u>/sites/{siteid}/logs/Application Controller (Router)Event</u>	Returns the system logs for all of the Lighting Application Controller (Router) workgroups for a specific site.

<u>/sites/{siteId}/sensors/{sensorId}/movements</u>	Provides occupancy movement information for a specific sensor in a given time interval.
<u>/sites/{siteId}/sensors/{sensorId}/movements/count</u>	The total count of occupancy movements for a specific sensor in a given time interval.
<u>/sites/{siteId}/sensors/{sensorId}/occupancy</u>	The occupancy state for a specific sensor at a given time.
<u>/sites/{siteId}/sensors/energy/summary</u>	Returns total consumption of the energy data values for the specified site.
<u>/sites/{siteId}/emergency-tests/results</u>	Returns list of emergency test results on a given site.
<u>/sites/{siteId}/sensors/environmental/summary</u>	Returns environmental data from environmental sensors

4.3 Local server-based system.

1. The system shall be capable of enabling services by connecting the lighting control system to a local on-premise Windows based software solution.
2. The solutions software architecture shall allow for Client/Server applications and comprise of the following components:
 - Windows services that can be distributed across multiple PC's or reside in one.
 - Client GUI Desktop Application
 - SQL Server Database (SQL Server Express through to managed SQL Servers)
 - Integral iOS/Android Applications.
3. The solutions hardware requirement shall be scalable from a single PC to multi-processor virtual machines depending on the size of the lighting control system.

4.4 VPN Tunnelling for Remote Assistance

The system shall be capable of providing a VPN Tunnelling solution for remote assistance. To ensure the highest security and data privacy, the tunnelling solution shall be third party tested and audited in accordance with the ISAE3000 Assurance Standard.

Two-factor authentication for access shall be required such as a physical or software key and a secure password. Only industry standard and proven technologies such as the RSA cryptosystem, AES encryption, Diffie–Hellman key exchange and TLS sessions shall be utilised.

4.5 Security, Data and Privacy

1. Principles
 - **Privacy** shall strictly follow the General Data Protection Regulation (GDPR).
 - **Pre-configuration:** Cloud Gateways shall be preconfigured so that it can only access, collect, store and send data for the site it is purposely destined to.
 - **Encryption:** All data transferred shall be systematically encrypted, using TLS 1.2
 - **Data integrity:** In addition to the encryption, commercial grade AWS (Amazon Web Services) shall be utilised to ensure data integrity for the cloud-based infrastructure.

- **Authentication:** Only authenticated entities and persons shall be eligible to access data and services. The authentication shall be “white listed” by default, meaning that no person nor entity would be eligible to access the data and service by default. The authentication mention shall be based on AWS signature version 4.
2. Data transfer
The data transfer between the client and cloud shall be secured by using HTTPS protocol. The only eligible data destination is the manufacturer’s cloud infrastructure. To ensure data transfer integrity from the Cloud Gateway to the cloud, all transactions and involved parties shall be systematically authenticated before data is transmitted.
 3. Data privacy
The service provider and manufacturer shall not collect, store or use data that would directly or indirectly permit the authentication of a person in a building. All data collected shall be collected as anonymous and not traceable back to individuals
 4. Data Storage Location
The cloud servers used shall default to be in the EU. Different locations shall be available on request
 5. Data ownership
The service provider and manufacturer shall not claim any ownership over the data collected.

PART 5 – GLOSSARY

Absence detection	<i>Where lights that have been turned on via a user interface or some other means, are automatically turned off once an area has been vacated</i>
API	<i>Application Programming Interface</i>
Architectural lighting control	<i>A control system that is used in conjunction with light sources to enhance a buildings architectural features or to create a particular ambiance in a space</i>
ASCII	<i>American Standard Code for Information Interchange. A code for information exchange between computers and devices made by different companies</i>
Astronomic time clock	<i>A time clock that calculates sunrise and sunset for a given location on the earth's surface</i>
AV	<i>Audio Visual</i>
AWS	<i>Amazon Web Services</i>
Ballast	<i>An electrical device for starting and regulating fluorescent and discharge lamps</i>
BAS	<i>Building Automation System</i>
BLE	<i>Bluetooth Low Energy</i>
BMS	<i>Building Management System</i>
Building background files (plans)	<i>A drawing imported into the control system software which allows the display of typically, a reflected ceiling plan of the area concerned. The plan details the building footprint and principle features such as cellular offices, meeting rooms etc.</i>
CAT 5e	<i>Four pair of twisted telephone wires capable of up to 100 million bits (100Mbps) data transmission for up to 100 meters</i>
Closed loop control	<i>A control system in which all adjustments necessary to maintain the system occur automatically through a direct feedback signal from the sensor</i>
Corridor hold	<i>A control scenario which will maintain ("hold") on lighting (typically a corridor or circulation areas), when other lighting is on. Also known as Corridor Linking or Group Dependency</i>
DALI	<i>Digital Addressable Lighting Interface</i>
DALI-2	<i>Updated standard of DALI providing improved quality, interoperability and functionality compared to the original DALI</i>
DALI broadcast	<i>Where Dali signals are transmitted from a device in an unaddressed format</i>
Daylight harvesting	<i>A technique where natural daylight passing into a space through windows and skylights is used to allow a reduction in the amount of artificial light provided</i>

Ethernet	<i>A local area network allowing several computers and/or devices to transfer data over a communications cable.</i>
Exit delay	<i>A delay between selecting an off command and the lights turning off</i>
Hexadecimal	<i>A numbering system in base 16. A single 8-bit byte can be fully represented as two hexadecimal digits</i>
HTTPS	<i>Hypertext Transfer Protocol Secure. An extension of the Hypertext Transfer Protocol (HTTP). It is used for secure communication over a computer network and is widely used on the Internet.</i>
Icons	<i>A pictorial image used in a graphical user interface to represent a luminaire or other device</i>
Illuminance	<i>The density of the luminous flux incident on a surface</i>
Interface	<i>A connection point between two systems, or a user and a system</i>
IAQ	<i>Indoor Air Quality</i>
IP addressing	<i>The numerical sequence that serves as an identifier for an Internet server or device</i>
IR (infra-red) receiver	<i>A device that receives infrared signals, typically from a handheld transmitter</i>
LCD	<i>Liquid Crystal Display</i>
LED	<i>Light Emitting Diode</i>
LED tell-back	<i>A visible indication of the selected button of a control panel by the use of an LED</i>
Lighting load	<i>A light source, lamp or connected circuit of lights</i>
LMS	<i>Lighting Management System</i>
Grouping	<i>A number of luminaires or circuits which are configured in software to work cooperatively</i>
GDPR	<i>General Data Protection Regulation</i>
Luminaire	<i>A light fixture containing one or more light sources</i>
Mains borne signalling	<i>A method that utilises a control signal superimposed on a mains power system without the need for separate control cables</i>
MQTT	<i>Message Queuing Telemetry Transport is an ISO standard (ISO/IEC PRF 20922)</i>
Modular wiring	<i>A pre-manufactured cabling system consisting of plug together wiring sections and distribution hubs</i>
Network node	<i>A device or item of equipment occupying a single unique address point on a system network</i>

Networking wireless Application Controller (Router)s	<i>A device for connecting to a system using wireless connection</i>
Occupancy sensors	<i>A device for detecting the presence of a person or people within in a space</i>
OLE	<i>Object Linking and Embedding. Allows objects from one application to be embedded within another</i>
OPC	<i>Open Protocol Connectivity. A set of connectivity standards for automation from the OPC Foundation</i>
Open loop control	<i>A control system where the resultant action is not directly monitored by the controlling sensor. e.g. an external sensor controlling internal lighting.</i>
Operator Workstation	<i>Desktop or Laptop PC used to set-up, configure and monitor a lighting control system</i>
PC	<i>Personal Computer</i>
Power-track	<i>Multi pole Bus Bar style, electrical power distribution system</i>
Presence detection	<i>Where a sensor is used to turn lights on when presence is detected within the sensor coverage area, and off again once the area is vacated</i>
RESTful API	<i>RESTful API is an application program interface (API) that uses HTTP requests to GET, PUT, POST and DELETE data</i>
R.F.	<i>Radio Frequency</i>
RoSH	<i>European directive relating to the Restriction of Hazardous Substances</i>
Rotary control	<i>A user interface consisting of a rotary knob. The knob is rotated to increase or decrease light level</i>
Application Controller (Router)	<i>A device for connecting DALI networks together using an Ethernet network. The Application Controller (Router) also retains the system configuration information for its connected DALI networks</i>
RS232 serial interface	<i>A standard for serial data transmission between computers and peripheral devices</i>
Scene control panels	<i>Programmable multi button user interface</i>
Scheduler	<i>An automatic programme which generates system event commands according to the time of day</i>
Sensors	<i>Devices for detecting presence or light level etc.</i>
Serial com ports	<i>A communications port for passing information in a serial data stream e.g. RS 232</i>
Slider panels	<i>A user interface consisting of a linear slider. The slider is raised or lowered to increase or decrease light level</i>
TCP/IP	<i>Transmission Control Protocol / Internet Protocol</i>
TLS	

Transport Layer Security is a cryptographic protocol that provides end-to-end communications security over networks and is widely used for internet communications

UDP

User Datagram Protocol. A protocol within the TCP/IP protocol suite that is used in place of TCP. UDP is known as a stateless protocol, as it makes no provision for acknowledgement of packets received

UID

Unique Identifier

Volt-free contact

A pair of contacts that are neither connected to any other point or earth, and can therefore be used in any circuit

VPN

Virtual Private Network

WEEE

European directive relating to **Waste Electrical and Electronic Equipment**

Windows™

An operating system from Microsoft's Windows family of operating systems

Workgroup

A collection of Application Controller (Router)s which communicate as part of a system

END