

SECTION 26 09 43

ADDRESSABLE-FIXTURE LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes an addressable and digital lighting control system (LCS) composed of the following components:
 - 1. Control Devices
 - a. Lighting Control Panels
 - b. Central Manager with database and end-user application(s)
 - c. Virtual Central Manager
 - 2. Input Devices
 - a. Low Voltage Occupancy Sensors
 - b. Low Voltage Daylight Sensors
 - c. DALI Powerpacks
 - d. DALI Multi-Sensors (combined daylight, occupancy)
 - e. DALI Wallstations
 - f. Infrared Receiver and Transceiver
 - 3. End Devices
 - a. DALI LED drivers
 - b. DALI Fluorescent dimming ballasts
 - c. DALI Digital to Analog Converter (0-10V driver)
 - d. DALI CFL dimming ballasts
 - e. DALI field addressable relays
 - f. DALI relay panels
 - g. DALI dimming modules for incandescent and magnetic low voltage loads
 - 4. Software and Integration
 - a. Lighting Management Software (LMS)
 - b. XML Interface – for Web Services
 - c. Shade Interface
 - d. BACnet® Interface
- B. The lighting control system (LCS) shall meet all of the criteria, operating characteristics and performance parameters specified herein.
- C. The deployment team, contractor and manufacturer, shall provide, connect and furnish all equipment necessary for the proper and complete operation and service of the LCS as indicated in the engineering drawings and specified herein.

1.2 DEFINITIONS

- A. LCS: The term 'Lighting Control System' is defined as the interconnected set of hardware and software components that collectively serve to regulate the illumination levels of an interior and/or exterior space. The components that comprise the LCS are sub-categorized into four groups: LCS input devices, LCS end devices, LCS control equipment and LCS software and integration.
- B. DALI: Digital Addressable Lighting Interface used to transmit data to and from LCS input devices, LCS end devices and control equipment.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Complete list of all parts needed to install the Digital Addressable LCS.
- C. Shop Drawings:
 - 1. Floor Plans: Location, orientation and coverage area of each sensor, group designations and other specific design symbols and designations as required to define the installation, location and configuration of all control devices.
 - 2. Address Drawing: Reflected ceiling plan and floor plans, showing data-bus-connected devices, address for each device and device groups. The plans shall be based on construction plans, using the same legend, symbols and schedules.
 - 3. Point List and Data Bus Load: Summary list of all control devices, sensors, LED drivers and other loads connected to each data bus and total connected load for each data bus. Include percentage of rated connected load and device addresses.
 - 4. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
- D. Provide all manufacturer warranty dates, registration documents and information.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other sections.
 - 1. Show interconnecting signal and control wiring, as well as, interface devices that prove compatibility of inputs and outputs.
- B. Field quality-control reports.
- C. Sample Warranty: For manufacturer's special warranty.
- D. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
 - 1. Describe system features, operation and architecture in electronic and printed documentation. Include user account information, network access information and technical support contact information. All project-specific documentation shall be made available on a password protected section of the manufacturer's website, upon request of the end user.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

- A. Product Qualifications
 - 1. All products shall meet all applicable UL regulations.
 - 2. All products shall meet all applicable ANSI requirements.
 - 3. All products shall meet all applicable FCC regulations.
 - 4. All DALI products shall comply with the IEC Standard 60929 Annexes E and G.
 - 5. All products shall be installed in accordance to all applicable national electrical and local building codes.
 - 6. All products shall be subjected to a complete functional test at the factory, prior to shipment.
- B. Installer & Commissioner Qualifications
 - 1. The system shall be commissioned by a company that has no less than 3 years of experience in the installation of DALI lighting systems. References shall be provided upon request. The system shall be installed by a company that has experience in deploying dimmable lighting systems. References shall be provided upon request.
- C. Support
 - 1. First-available on-site or remote response time based on service contract and warranty terms
 - 2. Phone Support: Toll free technical support shall be available.
 - 3. Remote Support: The operational status of led drivers, critical programs, control hardware and computers can be monitored and diagnosed remotely.
- D. Manufacturer Qualifications
 - 1. All products shall be fabricated in an ISO-9000 compliant facility.

2. The manufacturer shall be experienced in the fabrication of DALI lighting control equipment for a minimum of 5 consecutive years.
3. Manufacturer shall be a member in good standing of AG-DALI, Digital Addressable Lighting Interface Working Group.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Include installation, programming and maintenance instructions.
- C. Do not install equipment until the following conditions can be maintained in spaces to receive equipment:
 1. Ambient temperature:
 - a. LCS: 0° C to 40° C (32° F to 104° F).
 - b. System computer: 10° C to 35° C (50° F to 90° F).
 - c. Relative humidity: Maximum 90%, non-condensing.
- D. LCS must be protected from dust during installation.
- E. Do not install products under environmental conditions outside manufacturer's absolute limits.
- F. Do not install sensors until building is operating at ambient temperature and humidity ranges that are consistent with those intended for buildings ultimate use.

1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.
 1. Warranty Periods:
 - a. A limited five (5) year warranty on fluorescent lighting ballasts from date of substantial completion.
 - b. A limited three (3) year warranty on all other hardware components of the LCS designed and manufactured by Eaton
 - c. A limited one (1) year warranty on the Lighting Management Software

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Eaton's Cooper Controls Business - Fifth Light Controls.
- B. All components of the LCS shall be fabricated, assembled and installed in a manner that maintains the performance criteria stated by the manufacturer. All components of the LCS shall be provided free of defects, damage or failure.

2.2 SYSTEM DESCRIPTION

- A. Operation: Input signal from digital signal sources switch or dim DALI devices associated with LED drivers, fluorescent lighting fixtures and other LCS end devices.
 - 1. Each device and relay is connected to a digital data bus.
 - 2. Each DALI device and relay has a digital address and be operated by a digital signal.
 - 3. Each device or relay can be assigned to any or all of 16 available groups connected to a single data bus.
 - 4. Each LED driver may have as many as 16 preset lighting levels or scenes. Scenes can be programmed to LED drivers and may be applied to groups.
 - 5. Each fluorescent ballast may have as many as 16 preset lighting levels or scenes. Scenes can be programmed to fluorescent ballasts and may be applied to groups.
- B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application.
- C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with protocol described in IEC 60929, Annexes E and G, for DALI lighting control devices, wiring and computer hardware and software.
- E. Comply with UL 916.
- F. Comply with UL 924.

2.3 PERFORMANCE REQUIREMENTS

- A. DALI Requirements:
 - 1. Components: Individually addressable devices (such as LED drivers, relays, dimmers and switches) that are operated from digital signals received through a DALI-compliant bus, from data-entry and retrieval devices (such as PCs, personal digital assistants, hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs). Devices also report status to data-entry and retrieval devices though the bus.
 - 2. Digital Control: Use peer-to-peer communication and distributed logic, where the failure of any single component shall be automatically isolated and not affect global system functions.
- B. System Requirements
 - 1. Emergency Default: The LCS and lighting end devices must revert to a safe and acceptable default state in the event of a loss of the DALI bus situation. In order for the default state to be considered safe and acceptable, it must meet the following specifications:
 - a. Loss of Power to Lighting Relays: All relays being used for lighting control must default to the closed (On) position the instant that power is lost to their corresponding lighting circuit. Relays must remain in the closed (On) state until the supply of power is resumed, at which point all relays are to continue to remain in the closed (On) position until commanded otherwise.

- b. Loss of Power to the Lighting Control Panels: All lighting control panels are to be supplied with power from non-emergency circuits. In the event that power is lost to the lighting control panel, all of the lighting relays and led drivers that are connected to it shall revert to the full power (On) state and remain in this state until power is restored and they are commanded otherwise.
 - c. Loss of Power to Emergency Circuits: In the event that power is lost to the emergency circuits, all lighting relays that are supplied by emergency fixtures shall automatically revert to the default closed (On) position. When backup power is activated, all relays that are supplied by emergency fixtures shall be in the closed (On) state and are to remain in this state until commanded otherwise. All led drivers that are supplied by emergency circuits shall revert to the full power state and remain in this state the instant that backup power is activated until commanded otherwise.
 - d. Tamper Proof Settings: The default settings (or any other settings that pertain to the operation of the LCS during emergency conditions) of all lighting control equipment, DALI led drivers and lighting relays shall not be capable of being modified through either a manual or software provision by the user of the LCS.
 - e. UL 924 listed components: The default settings (or any other settings that pertain to the operation of the LCS during emergency conditions) of UL 924 listed components shall not be capable of being modified either manually or via software by the user, person responsible for commissioning or the manufacturer.
- 2. Central Control: All operating parameters of the LCS shall be configured from a central point of access through a web browser.
 - 3. Remote Access: All operating parameters of the LCS shall be configurable from any computing device with a web browser and an internet browser.
 - 4. User Access: The end user shall be capable of applying administrative rules to restrict the access privileges of each user. Access restrictions shall be applicable to the set of fixtures as well as the feature set available for those fixtures.
 - 5. System Clock: The time clock of the LCS shall be synchronized to internet standard time.
 - 6. Power Failure: The lighting system shall resume operation after a power outage to the state that it would have been in if the power outage had never occurred.
 - 7. Loss of Communication: DALI devices shall operate at a user-specified level in the event that communication is lost to the control panel.
 - 8. Time Scheduling: The daily power consumption cycle of each fixture shall be regulated by a programmable scheduling routine.
 - 9. Daylight Harvesting: The lighting system shall adjust light levels in response to varying ambient light levels in order to maintain a constant, user-specified light level at desk height. Ambient light levels shall be read from a network of daylight sensors that are distributed throughout areas that are candidates for daylight harvesting. Intelligent algorithms shall be used to minimize the number of sensors required.
 - a. Daylight Sensor Groupings: The set of light fixtures that are controlled by a given daylight sensor can span multiple DALI communication busses, shall be configurable through software and shall not require any manual wiring to modify. The system shall allow for light fixtures to be added or removed from given daylight sensor group through web software.

- b. Daylight Sensor Settings: All settings that govern the behavior of a given daylight sensor shall be adjustable through web software and shall not require any physical adjustment to the sensor itself.
 - c. Gradient Dimming: A single daylight sensor working in conjunction with lighting software shall be capable of providing separate control for up to 16 groups of light fixtures. Each group of light fixtures can have unique settings, including the lighting set point, so that location-specific conditions can be accommodated by a single sensor. Gradient dimming will allow for the row of light fixtures closest to the window to dim more than the next closest row of light fixtures (the third closest row dims more than the second closest row and so on for the 4th, 5th...16th rows) even though all rows are controlled by the same single sensor.
 - d. Electronic Enable/Disable: The daylight sensor shall be enabled and disabled through software in order to manage its operation on a scheduled daily basis.
10. Personal Control: Users shall customize the lighting levels in their own workspace. Building Management can apply restrictions to the range of lighting levels that can be programmed by each occupant to ensure conservation target are met. Access is provided from any computer or hand-held device that is connected to the internet. The light level of each fixture shall be controllable from 0-100%, in increments of 1%, for a specified duration of time.
- a. Number of Simultaneous Users: The system shall accommodate a minimum of five hundred (500) simultaneous web users.
 - b. Support Web Browsers: Microsoft Internet Explorer 11 or higher, Google Chrome 40 or higher.
11. Occupancy Detection: The system shall reduce the power consumption in vacant areas by reading the status of a network of low voltage occupancy sensors.
- a. DALI Occupancy Sensor Wiring: DALI capable occupancy sensors shall be wired directly to the two-wire DALI communication bus.
 - b. Low Voltage Occupancy Sensor Wiring: Low voltage occupancy sensors shall be wired to the DALI Powerpack as defined by the sensor type. This permits the Low Voltage Occupancy Sensor to obtain an individual DALI address.
 - c. Occupancy Sensor Groupings: The set of light fixtures that are controlled by a given occupancy sensor can span multiple DALI communication buses, shall be configurable through software and shall not require any manual wiring. The system shall allow for light fixtures to be added or removed from given occupancy sensor group through web software.
 - d. Occupancy Sensor Settings: All settings that govern the behavior of a given occupancy sensor shall be adjustable through web software and shall not require any physical adjustment to the sensor itself.
 - e. Occupancy Sensor Levels: Each occupancy sensor shall have a total of five (5) programmable lighting levels. These levels are defined as follows:
 - 1) Occupied Level: The Occupied Level represents the light level that fixtures will be commanded to when occupancy is detected. Light levels will remain at the Occupied Level until occupancy is no longer detected.
 - 2) Transition Levels: Transition Levels provide a gradual change in light levels when occupancy is no longer detected. Three (3) Transition Levels, each of

- which can be programmed with different light levels and timer values shall be provided.
- 3) Vacancy Level: The Vacancy Level represents the light level that fixtures will be commanded to when occupancy is no longer being detected and all Transition Levels have expired.
 - 4) Electronic Enable/Disable: The occupancy sensor shall be enabled and disabled through software in order to manage its operation on a scheduled daily basis.
12. Monitoring: The operational status of all system hardware and software components shall be routinely checked. Faults with led drivers and every other component of the system shall be automatically detected and electronic notifications shall be distributed. These notifications clearly illustrate the location of the device on the floor plan and the time that the fault was detected.
 13. Reporting: The energy consumption of the lighting system shall be viewed, tracked and recorded. Data shall be charted according to user-defined zones, which can be as small as an individual fixture or as large as a portfolio of buildings. Savings shall be presented in terms of energy, dollars and greenhouse gas emissions (if requested). The data presented is a computed value and does not require the installation of additional hardware. Alternatively, this software can be integrated with a physical metering system to present revenue grade energy measurements.
 14. Partitioning: The system shall allow users to define a space as a partitioned space. Users can define partitioned areas with up to four (4) sub-areas per partitioned area with specific control strategy for each sub-area. When the partitions/dividers are open, the space is used as one large room. When the partitions/dividers are close, each sub-area has a dedicated lighting control.
 15. Load Shedding: The system shall allow the building manager to apply a customized load shed reduction level to select devices. The system shall allow users to lock certain devices so that the light levels cannot be manipulated or overridden by users. Loading shedding shall be triggered via a maintained contact closure signal from an emergency system, PLC or certified OpenADR device. .
 16. Off-Hour Access: The system shall only activate the set of lights required by an occupant to perform their work during the off-hour time period. The system shall avoid turning on an entire quadrant or floor for when only an office, hallway and washroom are required. These lights can be activated in several ways, including a pass card, phone system or web software. Cleaning staff are accommodated by a programmed turn-on and shut-down sequence, which illuminates their work area in successive fashion.
 17. Zoning: The system shall be capable of configuring zones via software and avert the need to re-wire certain power distribution circuitry and lighting equipment as tenancy patterns change.
 18. Multi-Building Control: The LCS shall be capable of connecting to an off-site datacenter so that it can be operated as part of a multiple building control network.
 - a. Data Consolidation: Buildings operating on the multiple building networks shall have all information consolidated to a single report and view on the web interface. This allows for the total energy consumed by all buildings to be displayed in a single graph rather than one graph for each building. Information relating to the all reporting and monitoring functions (as described in this specification) shall be consolidated in this manner.

19. **Override Management:** The system shall be capable of handling several different commands targeted at the same fixture in a manner that is logical, pre-defined and acceptable to the end customer.

Graphical User Interface: The visual interface of the software shall import the floor plan design file in DXF or DWG format. All lighting fixtures, sensors and other components of the lighting system contained in the floor plan design file shall be recognized by the software and rendered into interactive objects on the graphical user interface.

2.4 INTEGRATION

A. Network Convergence

1. The LCS shall transmit data on the same Ethernet Communication Network used for computers, VOIP telephones and other IP devices running in the facility.
2. The LCS shall not incur noticeable latencies by running on the unified network.
3. The LCS shall operate with the same network hardware used for routing standard TCP/IP data packets.
4. The LCS server shall be either a physical server installed within an IT space or installed on a virtual machine.
5. The LCS shall not communicate using Multi-Cast or Broadcast IP traffic messages.
6. The LCS shall be capable of using either fixed IP addresses or DHCP and hostnames.
7. The LCS shall utilize up to 2048 bit encryption on all Web Server user sessions and third party Web Service communications.

B. BAS Integration

1. The integration of the LCS and other Building Automation Systems (BAS) shall meet the objectives listed as follows:
 - a. Provide the ability to communicate with the BAS via BACnet IP
 - b. Requires only one network connection per system
 - c. The BMS system shall be able to discover the following objects via the BACnet Interface shall support the following commands:
 - 1) Read device (DALI device) status
 - 2) Read Lamp status
 - 3) Read Light level
 - 4) Read what override is active
 - 5) Send override to a device
 - 6) Set override type (high priority, normal)
 - 7) Set light level
 - 8) Set duration
 - 9) Calling Preset DALI scene
 - 10) Set scene ID
 - 11) Set duration for a scene
 - 12) Set scene level
 - 13) Read lights on/off status for a group of fixtures
 - 14) Send override to a group of fixtures
 - 15) Set light level for a group of fixtures
 - 16) .Read ballast status for a group of fixtures

- 17) Read lamp status for a group of fixtures
- 18) Read power consumption for a group of fixtures
- 19) Set Light level for a group of fixtures via scenes
- 20) Set the priority of the override command sent to a group of fixtures
- 21) Read occupancy sensor status
- 22) Read daylight sensor reading

C. VOIP Telephone System

1. The LCS shall support the following models of VOIP telephones by publishing an application designed specifically for the unique user interface of each phone:
 - a. Cisco Unified IP Phone 7906G2
 - b. Cisco Unified IP Phone 7911G3
 - c. Cisco Unified IP Phone 7931G4
 - d. Cisco Unified IP Phone 79405
 - e. Cisco Unified IP Phone 7941G6
 - f. Cisco Unified IP Phone 7942G7
 - g. Cisco Unified IP Phone 7945G8
 - h. Cisco Unified IP Phone 7960G9
 - i. Cisco Unified IP Phone 7961G10
 - j. Cisco Unified IP Phone 7962G11
 - k. Cisco Unified IP Phone 7965G12
 - l. Cisco Unified IP Phone 7975G13
 - m. Cisco Unified IP Conference Station 7937G
2. Features:
 - a. The following user features shall be provided through the VOIP telephone system:
 - 1) Dimming control over lights on a group and individual fixture basis.
 - 2) Scene control over lights on a group and individual fixture basis.
 - 3) Tube fault detection.
 - 4) Service report and dispatch.
3. User Access
 - a. The set of lights controlled by a given VOIP telephone shall be regulated through a user access policy.
 - b. The user access policy shall allow for each VOIP telephone to control a unique set of light fixtures.
 - c. Facility managers shall be able to regulate the set and number of fixtures assigned to a given user.
 - d. The LCS shall link each user to a VOIP telephone based on the unique identifier of the VOIP telephone.
 - e. The set of lights controlled by a given VOIP telephone shall be regulated based on the access level of the user associated with the unique identifier of the VOIP telephone.
4. Number of Simultaneous User Connections
 - a. The LCS shall be capable of supporting five thousand (5,000) simultaneous VOIP telephone connections.
 - b. The LCS shall not incur noticeable latencies when multiple users send commands through the VOIP telephones at the same time.
5. Wiring

- a. The LCS shall connect to the VOIP telephone system through a single Ethernet connection point.
 - b. The LCS and the VOIP telephone system shall exchange data through an XML Web Services Protocol.
6. User Set Up
- a. The LCS shall provide a user set up application consisting of a visual interface that is accessible by the supported web browsers to set up each VOIP telephone user.
 - b. The user set up application shall import the DXF file and provide a visual mechanism to link each user to their respective lighting fixtures.
- D. XML Integration
- 1. Transmission of data between the LCS and 3rd party systems using Web Services.
 - 2. The XML Integration shall publish all key operating parameters of the LCS for the read and write operations required to implement intelligent integration strategies.
 - 3. XML Integration can be used for AV integration, Fire, Security and other 3rd party coordination.
 - 4. Control: The XML interface shall provide read/write access to all LCS end devices.
- E. Shade Integration
- 1. Transmission of data between the LCS and 3rd party shading systems.
 - 2. Shade control shall be available through BACnet IP for Embedia shades, MechoNet RS232 Protocol for Mechosystems shades, Somfy RS-485 Protocol for Somfy shades and contact closure for all other shades.
 - 3. The LCS shall support the following shade commands (Up, Down, Stop, Position, Tilt) based on shade manufacturer and communication protocol. Users shall be able to send these commands via the DALI Wallstation.
 - 4. The LCS shall communicate to multiple shade manufacturers, including but not limited to: MechoShade®, Somfy, Embedia, and Beckhoff.

2.5 CONTROLLER/GATEWAYS

- A. Lighting Control Panels
- 1. Internal circuitry shall be protected by a fused receptacle.
 - 2. Shall provide Class I/II NEC separation.
 - 3. Lighting Control Panel shall include a Local Controller to host the web-based software application and data.
 - 4. Lighting Control Panel shall include the DALI Bus Controller as an interface between the web-based software application and lighting led drivers, sensors, keypads and low voltage switches.
 - 5. Lighting Control Panel shall provide 2-way communication to software application via an Ethernet protocol.
 - 6. Lighting Control Panel shall provide 2-way communication to lighting led drivers via the DALI protocol.

7. The Lighting Control Panel shall include the required hardware to interface with low voltage analog devices and maintained or momentary digital devices..
 8. Lighting Control Panel shall be mounted in a tamper-proof electrical cabinet.
 9. The Lighting Control Panel shall allow remote diagnosis of its operational status.
- B. Local Controllers
1. Each Lighting Control Panel shall have a Local Controller
 2. The Local Controller shall:
 - a. Host the control application as well as the user interface to manage the devices connected to the Lighting Control Panel.
 - b. Have a configurable IP address
 - c. Support up to 32 distributed DALI buses.
 - d. Support up to 256 digital and analogue low voltage devices
 - e. Provide limited interfaces for integration with building management systems and IP telephony:
 - 1) 5 Mobile Users,
 - 2) 250 BACnet objects,
 - 3) 25 VOIP phone connections.
- C. Central Manager
1. The Central Manager shall acts as a system wide historian and global database that holds the system's event journal.
 2. The Central Manager shall allow user to manage the lighting system centrally. All changes made from the Central Manager shall automatically replicate to the local controllers connected to the Central Manager.
 3. The Central Manager shall be installed within an IT space or installed on a virtual machine.
 4. The Central Manager shall provide data security methods for backup and restore capabilities.
- D. Virtual Central Manager
1. The Virtual Central Manager shall be installed on a VMWare® based virtual machine
 2. The Virtual Central Manager shall provide the same functional as the Central Manager.
- E. The DALI Bus Controller (DBC) links the distributed data buses with a USB connection to the Local Controller. The Local Controller provides computer configuration, control, analysis and maintenance. The DBC and Local Controller operate independently and continue to process local inputs and schedules when disconnected from the LAN. The DBC and Local Controller shall provide local intelligence and features including the following:
1. Integrated real-time clock with automatic daylight savings adjustment and leap-year correction.
 - 2.
 3. Automatic time schedules, to control groups for scheduled occupancy with support for holiday exceptions.

4. Computer Monitoring and Configuration: The DBC and Local Controller shall allow configuration, monitoring and analysis from PCs on the Ethernet LAN.
- F. Each data bus shall have the capacity to control 64 addressable devices, using NFPA 70, Class 2 control circuit.
1. Each data bus shall have the capacity to control up to 16 groups and scenes.
 2. LED indicator lights for Ethernet status (link, send and receive), power-on and LAN failure.
 3. Linking of switch and sensor inputs to relay and LED driver outputs.
 4. Viewing relay and LED driver output status.
 5. Controlling relay and LED driver outputs.
 6. Setting device addresses.
 7. Assigning switch and sensor inputs and relay and LED driver output modes.
- G. Allow connection of the following DALI-compliant addressable devices:
1. Integral luminaire switching and dimming ballast and drivers.
 2. Switching relays.
 3. 0-10V dimming modules.
 4. Two-wire dimming modules.
 5. Occupancy and photoelectric sensors.
 6. Low voltage powerpacks.
 7. Wallstations for user interface functionality.

2.6 USER INTERFACES

- A. Workstation:
1. A laptop PC, with Microsoft Windows operating system and access to the web-based LCS management software.
 2. Include licenses, documentation and storage media and licensing for a minimum of five (5) concurrent users.
- B. DALI Wallstations
1. DALI wallstations shall provide continuous dimming control via a DALI connection to a Lighting Control Panel.
 2. DALI Wallstation Wiring: DALI wallstations shall not be part of the DALI bus wiring to the Lighting Control Panel.
 3. DALI Wallstation Groupings: The set of light fixtures that are controlled by a given button shall be configurable through software and shall not require any manual wiring. The system shall allow for light fixtures to be added or removed from given groups through web software.
 4. DALI Wallstation Settings:

- a. All settings that govern the behavior of the wallstation buttons shall be adjustable through the Lighting Management Software and shall not require any physical adjustment to the device itself.
 - b. The buttons behavior shall be programmable using conditional logic off of a state variable such as time of day or partition status.
 - c. A button shall support three level toggles, i.e. three different Go to level commands.
5. Dynamic Duration: All commands sent from the wallstation shall expire after a specified time period. The duration of this time period shall be programmable, based on the time of day that the wallstation is activated. This will allow for the time duration to differ at various times of day. Each keypad can have a different dynamic duration.
6. DALI Wallstation Functionality:
- a. DALI wallstations shall provide one touch On/Off functionality as well as press and hold dimming.
 - b. Different groups of lights shall be assigned to different buttons on each wallstation.
 - c. The same button can be used to control lights and shades
- C. Low Voltage Wallstations
1. Low voltage wallstations shall provide continuous dimming control via a low voltage connection to a Lighting Control Panel.
 2. Low Voltage Wallstation Wiring: Low voltage wallstations shall not be wired to switch the AC power line nor shall they be wired directly to any lighting led drivers or any other lighting end device. Low voltage wallstations shall only be wired to a low voltage lighting control panel through a multi (X) conductor, low voltage cable that meets the following specifications: 16AWG/X, plenum rated, FT6; where X is the number of buttons on the keypad plus one (1).
 3. Low Voltage Wallstation Groupings: The set of light fixtures that are controlled by a given button shall be configurable through software and shall not require any manual wiring. The system shall allow for light fixtures to be added or removed from given groups through web software.
 4. Low Voltage Wallstation Settings: All settings that govern the behavior of a given wallstation shall be adjustable through web software and shall not require any physical adjustment to the device itself.
 5. Dynamic Duration: All commands sent from the wallstation shall expire after a specified time period. The duration of this time period shall be programmable, based on the time of day that the wallstation is activated. This will allow for the time duration to differ at various times of day. Each keypad can have a different dynamic duration.
 6. Low Voltage Wallstation Functionality: Low voltage wallstations shall provide one touch On/Off functionality as well as press and hold dimming. Different groups of lights shall be assigned to different buttons on each keypad.
- D. Touchscreen Controllers
1. Manufacturer: Eaton's Cooper Controls Business.
 2. Communication: Internet Protocol.
 3. Interface: 5.7" resistive touch screen.
 4. Connections: wired directly to the lighting control network (or network switch) via a Cat5e Ethernet connection.

5. Power: 24 VDC power supply.
 6. Touchscreen Functionality: Touchscreens shall accommodate custom dimming levels and time durations over multiple groups of fixtures. Touchscreen shall also be programmable to apply multiple pre-set lighting scenes as defined through the web software.
 7. Customization: Touchscreens shall have the ability to stream custom graphics or interfaces, depending on user need.
 8. Groups and settings: All touchscreen attributes, including fixture groups, scenes and graphical interface, shall be customizable through the software and shall not require rewiring or reprogramming at installed location for required changes.
- E. Personal Digital Assistant: Handheld, with custom graphical user-interface software, supplied by the controller/gateway supplier. The software shall provide for all DALI-protocol programming commands to be applied to the controller/gateway via a tethered connection.
- F. Infrared Programming Assistant: Handheld, with custom graphical user-interface software, supplied by the controller/gateway supplier to program the manual switches.

2.7 LIGHTING MANAGEMENT SOFTWARE

- A. Provide system software license that is designed, manufactured and warranted by a single manufacturer.
- B. Lighting Management Software capabilities:
1. Product: Fifth Light Lighting Management Software
 2. Allows user to program, configure and manage the lighting system from a web browser over a TCP/IP connection, i.e. no software application is required to be installed on a remote client (example: desktop, laptop) to access the Lighting Management Software
 - a. Support web browser: Microsoft Internet Explorer, Google Chrome
 - b. Supports multiple platforms and devices: tablet, desktop, laptop, smartphone
 - c. Optimized for displays of 1024 by 768 pixels or higher
 3. Allows manufacturer specialist, end user to:
 - a. Design the system:
 - 1) Import CAD drawings of the building and automatically identify device types (wallstations, fixture types, etc...)
 - 2) Define schedule profiles
 - 3) Define scenes
 - 4) Define fixture types
 - 5) Configure wallstations buttons
 - 6) Define occupancy/vacancy sensor profiles
 - 7) Define daylighting profiles
 - 8) Define partitioned/sub-areas
 - 9) Define emergency lighting
 - 10) Define Fire alarm
 - 11) Configure shade interface
 - 12) Configure BAS interface
 - b. Startup

- 1) Provide address to each device
- 2) Adjust daylighting profile
- c. Maintain
 - 1) View
 - 2) Monitor the status of each device
 - 3) Energy and Power consumption per building, floor, group of devices, device

2.8 FIXTURE SWITCHING AND DIMMING

- A. Each LED driver or group shall be addressable and shall include On/Off, fade, dimming, scene settings and other standard DALI control functions and are required to meet the sequence of operation.
- B. LED drivers: Comply with requirements in Section 265100 "Interior Lighting" for LED drivers and the following:
 1. Starting Method: Turns On at previously set light level.
 2. Dimming Range: 100 to 10 percent of rated lumens, unless otherwise indicated.
 3. Input Voltage Range: 108 to 305V.
- C. 0-10V Addressable Dimming Modules (Digital to Analog Converter [DALI DAC])
 1. Communication: DALI protocol.
 2. Power: From the DALI bus.
 3. Maximum Current Draw: 3.75 mA.
 4. Communication Connections: Two wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.
 5. Power Ratings: Up to 4A Ballast 120/277/347 VAC.
 6. Dimming Control: 0-10V, 50 mA max current sink.
 7. Mounting: Fixture or conduit (90° elbow and mounting clips included).
 8. UL 924 Listed component.
- D. Addressable Dimming Modules
 1. Communication: DALI protocol.
 2. Power: From the DALI bus.
 3. Maximum Current Draw: 3.75 mA.
 4. Communication Connections: Two wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.
 5. Power Ratings: Up to 20A, 120 VAC.
 6. Dimming Control: Forward phase dimming control for incandescent and magnetic low voltage loads.
 7. Mounting: Junction box.
 8. Control and communication operations of the ballast shall be immune to noise and power disturbances.

- E. Driver shall meet the following operating parameters:
 - 1. Operating Voltage: 120 to 347 VAC (+5%/-10%) as per application requirements.
 - 2. Protection: End of lamp life and inrush current limiting circuitry.
 - 3. Warranty: Five (5) years.
 - 4. Bi-directional digital communication.

- F. The ballast shall be wired per manufacturers recommendations.
 - 1. The ballast must be properly grounded to earth ground.
 - 2. The maximum length of blue and red wires shall not exceed three (3) ft.
 - 3. The maximum length of the yellow wires (when needed) shall not exceed four (4) ft.

- G. Driver shall return the following programmable parameters:
 - 1. Power on level.
 - 2. Short, search and random addresses.
 - 3. Groups 0-7 and 8-15.
 - 4. Scenes 0-15.
 - 5. Minimum and maximum dimming levels.
 - 6. Fade time and fade rate.
 - 7. System and power failure levels.
 - 8. Physical minimum level.
 - 9. Device type.
 - 10. Version number.

- H. Driver shall return the following status parameters:
 - 1. Actual dim level.
 - 2. Ballast status and tube status.
 - 3. Lamp power On.
 - 4. Limit error.
 - 5. Reset state.
 - 6. Missing short address.
 - 7. Contents of volatile memory.

2.9 SENSORS

- A. Addressable Multi-Sensors
 - 1. Communication: DALI protocol.
 - 2. Power: From the DALI bus.
 - 3. Maximum Current Draw: 3.75 mA.

4. Connections: Two (2) wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.
 5. Sensing Technologies: Occupancy, daylight and temperature.
 6. Daylight Sensing Range: 0-400 lux.
 7. Daylight Sensing Coverage: Light input within 60° cone.
 8. Occupancy Detection Technology: Passive infrared.
 9. Occupancy Detection Coverage Area: 600 sq. ft. or 1,200 sq. ft.
 10. Occupancy Detection Angle: 360°.
 11. Mounting: Junction box or ceiling tile.
 12. Groups: The set of fixtures controlled by a given multi-sensor shall be completely configurable through software and can span multiple DALI communication buses.
 13. Timers: All times shall be configurable through the web software and shall not require any manual configuration of settings prior to installation. Timer values can range from 1 second to 24 hours.
- B. Low Voltage Occupancy Sensors
1. Communication: Low voltage signal.
 2. Power: From lighting control panel or DALI Powerpack.
 - a. Lighting Control Panel Connections: Three (3) wires for power, control and common (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated).
 - b. DALI Powerpack Connections: Five (5) wires for power, control, common, daylighting and commissioning (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated).
 3. Occupancy Sensing Technologies: Dual Technology, PIR (Passive Infrared) and/or Ultrasonic technology.
 4. Occupancy Detection Coverage Area: Options available from 500 sq. ft. or 2,000 sq. ft.
 5. Occupancy Detection Angle: 360° or linear.
 6. Mounting: Junction box or ceiling tile.
 7. Groups: The set of fixtures controlled by a given multi-sensor shall be completely configurable through software and can span multiple DALI communication buses.
 8. Timers: All times shall be configurable through the web software and shall not require any manual configuration of settings prior to installation. Timer values can range from 1 second to 24 hours.

2.10 RELAYS

- A. Relays: Electrically operated, mechanically held single-pole switch, rated 20A at 277V. Short-circuit current rating shall not be less than 5 kA. With pilot light indicating when relay is closed and latched. Control shall be by DALI digital data bus. Relay status shall be displayed when queried by lighting management software.

- B. Relay Panel: A single enclosure with incoming lighting branch circuits, relays and connection to the DALI digital control network.
 - 1. Barriers to separate low voltage and line voltage components.
 - 2. Directory: Cover mounted, identifying each relay with its device address and naming the load controlled.
- C. Individually Mounted Relays
 - 1. Enclosure: Standard outlet box or NEMA 250, Type 1, unless otherwise indicated.
 - 2. Directory: Cover mounted, identifying each relay with its device address.
- D. Addressable Field Relays
 - 1. Communication: DALI protocol.
 - 2. Power: From the DALI bus.
 - 3. Maximum Current Draw: 3.75 mA.
 - 4. Communication Connections: Two (2) wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.
 - 5. Power Ratings: Up to 20 A at 347 VAC.
 - 6. Field relays shall be capable of controlling plug loads.
 - 7. Mounting: Junction box.
- E. Relay Panels
 - 1. Communication: DALI protocol.
 - 2. Power: From the DALI bus.
 - 3. Maximum Current Draw: 3.75 mA (per relay).
 - 4. Communication Connections: Two (2) wires (16/18AWG, FT6, non-twisted, non-shielded, non-polarized and plenum rated) connected to the DALI communication bus.
 - 5. Power Ratings: Up to 20A at 347 VAC (per relay).
 - 6. Relay panels shall be capable of controlling plug loads.
 - 7. Number of Relays: Up to 24 or 48.

2.11 LOW VOLTAGE DEVICES

- A. Infrared Transceiver and Receiver:
 - 1. Product: IRTR
 - 2. Provide contact closure based on status of the partition wall (open/close) enabling automatic update of the lighting control logic within the partitioned space.

2.12 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 260519 "Low Voltage Electrical Power Conductors and Cables."

- B. Class 2 Control Cables: Multi-conductor cable with copper conductors no smaller than No. 18 AWG, complying with Section 260519 "Low Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multi-conductor cable with copper conductors no smaller than No. 14 AWG, complying with Section 260519 "Low Voltage Electrical Power Conductors and Cables."
- D. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e for horizontal copper cable.
- E. Communication wires shall be polarity insensitive and shall not require shielding or twisting. Plenum rated 18 AWG 2 conductor cable shall be sufficient.
- F. Control wires shall be rated for the voltage of the power supply in order to be capable of being run in the same conduit as power wires.
- G. Communication wires shall be capable of withstanding connection to the line voltage for an indefinite period of time without incurring any damage.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways. Conceal raceway and cables, except in unfinished spaces.
 - 1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Wiring Method: Conceal conductors and cables in accessible ceilings and walls where possible.
- D. Wiring within Enclosures: Bundle, lace and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 IDENTIFICATION

- A. Identify system components, wiring, cabling, boxes, cabinets and terminals. Comply with identification requirements specified in Section 260553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring and components; install warning signs complying with Section 260553 "Identification for Electrical Systems."
- C. Identify all ceiling-mounted controls with data bus number and device address.

- D. Label each device cable within 6 inches (152 mm) of connection to bus power supply or termination block.

3.3 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation
 - 1. Test continuity of each circuit.
 - 2. Ensure standby voltage across the DALI lines (V_{DALI}) is within the following range: $9.5VDC < V_{DALI} < 22.5 VDC$, as specified in the DALI protocol.
 - 3. Ensure that there is no continuity from one DALI communication line to the other.
 - 4. Ensure that there is no continuity from the DALI loop to ground.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Test each bus controller using a portable PC.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Correct malfunctioning units on-site where possible and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Field Test Reports
 - 1. Printed list of all points created from actual queries of all addressed control points to include LED drivers, manual controls and sensors.
 - 2. Event log verifying the performance of all devices generating event messages to include occupancy sensors, control buttons, alarm messages and any other change of value messages.
 - 3. Trend data for all daylight zones covering a period of no less than one week and demonstrating performance consistent with the submitted computer models for those spaces.
- D. Lighting controls will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies bus controllers and describes query results. Include notation of deficiencies detected, remedial action taken and observations made after remedial action.

3.4 STARTUP SERVICE AND SUPPORT

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Activate light fixtures and verify that all lamps are operating at 100%.
 - 3. Confirm correct communications wiring, initiate communications between DALI devices and controller/gateways and program the LCS according to approved configuration schedules, time-of-day schedules and input override assignments.

- B. Startup service shall include the following on-site activities as part of deployment requirements.
 - 1. The commissioning agent shall visit the site on a scheduled basis, as per contract provisions.
 - 2. Wiring and Hardware Review: All wiring connections and electrical equipment included in the scope of the LCS shall be assessed.
 - 3. Field Testing: All DALI loop communication connections, sensor connections and Ethernet connections shall be verified in accordance to a specified testing procedure.
 - 4. Final Inspection: All of the connections relating to the LCS shall be tested and verified.

3.5 STARTUP AND PROGRAMMING

- A. Provide factory certified field service engineer to make minimum of three site visits for each major construction phase (parking garage completion, maintenance completion) to ensure proper system installation and operation under following parameters:
 - 1. Qualifications for factory certified field service engineer.
 - a. Minimum experience of two (2) years training in the electrical/electronic field.
 - b. Certified by the equipment manufacturer on the system installed.
 - c. Visit duration shall be suitable to accomplish required tasks.
 - B. First Visit. (Make first visit prior to installation of wiring).
 - 1. Review:
 - a. Low voltage wiring requirements.
 - b. Separation of power and low voltage/data wiring.
 - c. Wire labeling.
 - d. Lighting Management Panel locations and installations.
 - e. Control locations.
 - f. Computer jack locations.
 - g. Load circuit wiring.
 - h. Network wiring requirements.
 - i. Connections to other equipment.
 - j. Installer responsibilities.
 - k. Power panel locations.
 - 2. Systems Integration: LCS manufacturer shall provide a factory certified Field Service Engineer on-site to meet with Owners' Representatives, Project Consultant and other related equipment manufacturers to discuss equipment and integration procedures.
- C. Second Visit. (Make second visit upon completion of installation of network LCS).
 - 1. Review:
 - a. Verify connection of power wiring and load circuits.
 - b. Verify connection and location of controls.
 - c. Energize lighting management panels and download system data program.
 - d. Address devices.
 - e. Verify proper connection of panel links (low voltage/data) and address panel.

- f. Download system panel data to dimming/switching panels.
 - g. Check dimming panel load types and currents and supervise removal of bypass jumpers.
 - h. Verify system operation control by control.
 - i. Verify proper operation of manufacturers interfacing equipment.
 - j. Verify proper operation of manufacturers supplied PC and installed programs.
 - k. Configure initial groupings of LED drivers for wall controls, daylight sensors and occupant sensors.
 - l. Initial calibration of sensors.
 - m. Obtain sign-off on system functions.
2. Tuning: LCS manufacturer shall coordinate an on-site meeting with Commissioning Agent, Owner and Project Consultant to make required lighting adjustments to the system for conformance with the original design intent.
- D. Third Visit
- 1. Engage a factory-authorized service representative on-site to train Owner's maintenance personnel to adjust, operate and maintain the control unit and operator interface. Training shall be digitally recorded and provided to the Owner.
 - 2. The end customer shall be trained in the usage of the system within 1 month of completion of the startup process. A second training session shall be scheduled within 6 months of final startup.
 - 3. On-site Walkthrough: LCS manufacturer shall provide a factory certified Field Service Engineer on-site to demonstrate system functionality to the Commissioning Agent and Owner.

3.6 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at substantial completion, service agreement shall include software support for five (5) years.
- B. Upgrade Service: At substantial completion, update software to latest version. Install and program software upgrades that become available within five (5) years from date of substantial completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment, if necessary.

3.7 MAINTENANCE

- A. Offer renewable service contract on yearly basis, to include parts, factory labor and annual training visits.
- B. Make service contracts available up to ten (10) years after date of system startup.

3.8 CLOSEOUT ACTIVITIES

- A. Training Visits: LCS manufacturer shall provide two (2) day additional on-site system training to Owners personnel.
- B. System Optimization Visit: LCS manufacturer shall provide a factory certified Field Service Engineer on-site within 6 months after completion of final construction phase to evaluate system usage and discuss opportunities to make efficiency improvements that will fit with the current use of the facility.

END OF SECTION