Lutron Electronics Co., Inc.
HomeWorks Lighting Control System
Performance Specifications

PART 1 – GENERAL

1.01   SCOPE

The following specifications detail the minimum performance and related criteria for a Lighting Control System (LCS) proposed for this project. Any deviations from this specification must be documented in writing and submitted to the Architect prior to the issuance of any contracts and must also include all associated cost savings or additions, including but not limited to equipment, equipment installation, 120V power wiring labor and materials, programming, documentation and project management.

1.02   WORK INCLUDED

A. Authorized Contractor and/or Authorized Dealer (INSTALLER) shall furnish all equipment necessary for the proper installation of the devices as indicated on the drawings and specified herein. Equipment shall be installed according to the manufacturer's instructions and recommendations.
B. All 120V wiring and installation of any 120V devices (dimmers, switches, etc) to be completed by the Electrical Contractor.
C. Programming to be the responsibility of the Owner via a separate contract with a factory-authorized representative and/or INSTALLER of the specified equipment.

1.03   REFERENCES

A. Underwriters Laboratories Inc.
B. ISO 9001 Quality Standard
C. Canadian Standards Association
D. NOM Certification Mark
E. American Nation Standards Institute
F. Institute of Electrical and Electronic Engineers
G. Federal Communications Commission

1.04   PROJECT / SITE CONDITIONS

A. Lighting Controls shall operate in an ambient temperature range of 0°C (32°F) to 40°C (104°F) and 90% non-condensing relative humidity

1.05   QUALITY ASSURANCE

A. Manufacturer shall have a minimum of 10 years continuous experience in the design and manufacturing of architectural lighting products for both residential and commercial applications.
B. All devices shall be UL Listed, CSA Approved, FCC Approved or NOM Approved as appropriate. Dimmers shall be listed specifically for the required loads (i.e. incandescent, fluorescent, magnetic low voltage transformer). Manufacturer shall provide file card upon request.
C. Manufacturer shall maintain ISO 9001 certification and provide a copy upon request. ISO 9002 shall not be acceptable
D. Devices that utilize Radio Frequency (RF) communication shall have approval of local radio communications governing agency. Manufacturer must be able to submit proof of regulation compliance from said country upon request.
E. Every device shall be 100% end of line tested prior to shipment. Products, which are manufactured using a process other than 100% end of line testing, shall not be acceptable.

PART 2 – PRODUCTS

2.01   ACCEPTABLE MANUFACTURERS

    A. Lutron Electronics Co., Inc.
    B. The listing of a manufacturer as "acceptable" does not imply automatic approval. It is the sole responsibility of the electrical contractor to ensure that submittals made are for devices that meet or exceed the specifications included herein.

2.02   GENERAL

    A. LCS shall consist of the following equipment subcategories:
        1.   CENTRALIZED LIGHTING CONTROL PROCESSOR
        2.   WIRELESS CENTRALIZED LIGHTING CONTROL PROCESSOR
        3.   SOFTWARE
        4.   POWER PANELS AND ENCLOSURES
        5.   DIMMING CONTROL MODULES
        6.   QUIET FAN SPEED CONTROL MODULE
        7.   SWITCHING RELAY CONTROL MODULE
        8.   BI-DIRECTIONAL MOTOR CONTROL MODULES
        9.   WALLBOX MULTI-ZONE DIMMING MODULE
        10. LOCAL DIMMER AND SWITCH MODULES
        11. WIRELESS LOCAL DIMMER AND SWITCH MODULES
        12. KEYPADS
        13. WIRELESS KEYPADS
        14. AUXILIARY CONTROLS AND INTERFACES
        15. WIRELESS AUXILIARY CONTROLS AND INTERFACES
        16. HAND HELD PROGRAMMER
        17. INFRARED (IR) TRANSMITTERS
        18. CONTROLLABLE (MOTORIZED) WINDOW TREATMENTS
    B. Communications between devices and central processor
        1.   Devices shall communicate to the central processor via a low voltage wire or via Radio Frequency (RF). Devices that do not communicate via a low voltage wire or RF shall not be acceptable.
        2.   All devices, whether wired or RF, shall communicate and provide status information in real time using 2-way communications. Devices that do not communicate 2-way shall not be acceptable.

2.03   CENTRALIZED LIGHTING CONTROL PROCESSOR

    A. Electrical

1. All terminal block inputs on Processor shall be tested to meet or exceed the IEC 61000-4-2 standard.
2. Processor shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).
3. The environment in which the Lighting Control Processor (Processor) will reliably operate shall be in the following ranges
    a. Input voltage: 100-140 VAC, 50/60Hz.
    b. Ambient operating temperature: 0-40°C, 32-104°F
    c. Ambient operating humidity: 0-90% humidity, non-condensing
4. A Lithium battery capable of retaining data for 10 years shall back up the processor's memory.
5. Processor shall have no moving parts such as hard drives or cooling fans.
6. Processor shall be electronically upgradable via a Personal Computer locally or remotely through a modem or ethernet network connection. EEPROM-based firmware shall not be acceptable.

B. Interface
1. Lighting Control Processor (Processor) shall incorporate one or more RS-232 interfaces to allow connection to a Personal Computer for programming, control, diagnostic and/or upgrade purposes.
2. Lighting Control Processor (Processor) shall incorporate a minimum of one ethernet interface to allow connection to a Personal Computer for programming, control, diagnostic and/or upgrade purposes.
3. A modem may be connected to the RS-232 port to accommodate programming changes, control and/or diagnostics from remote locations.
4. One or more RS-232 interfaces or ethernet ports may be used for an existing or future external controller to communicate to the system.
5. Manufacturer shall publish the RS-232 protocol for the system to aid in integrating external controllers with the system.
6. LED's shall be provided to display diagnostic information.
7. Processor shall incorporate configurable communications links in which to communicate to system devices and up to 15 other Lighting Control Processors.
8. Processor shall incorporate the ability to add on wireless devices with the addition of a wireless interface such as a hybrid repeater.

C. Timeclock
1. A timeclock will allow up to 32,000 events to be programmed to occur without user intervention at specified times during the day in with relation to sunrise/sunset. Sunrise and sunset times will be calculated by specifying the latitude and longitude of the location of the system.
2. Internal timeclock shall be accurate to +/- one minute per month (specified as during data retention time).

D. Vacation Mode

1. Processor shall provide ability to record device states in the system for the purpose of future playback. Device states may be recorded every 5, 15, 30, 45 or 60 minutes for 1, 7 or 14 days.
2. It shall be possible to engage a "Vacation Playback Mode" so that device states that have been recorded can be played back "as recorded" or "with randomization" to give the residence or building an occupied look.
   E. Security Mode
1. Processor shall incorporate a programmable security mode event that may be triggered by a contact closure, button press, RS-232 command or timeclock event.
2. Security mode event will allow devices to be forced to a predetermined level, lights flashed and/or keypads disabled.
3. A contact closure, button press, RS-232 command, or a timeclock event may disengage security mode event. It may also be automatically disengaged after a predetermined amount of time.
4. After security mode event is exited, the system shall return to the previous state or revert to a pre-programmed state as specified.
   F. Programming
1. Processor shall be programmed using manufacturer-supplied software and a Personal Computer.
2. Processor shall provide the following programming capabilities: button-by-button programming, conditional logic programming, timeclock enable/disable, single action, toggle, advanced toggle, manual sequencing, automatic sequencing, raise/lower, and bi-directional RS-232.
3. It shall be possible to change light level programming without the need for a Personal Computer through the use of a Hand-Held Programmer or by using local dimmers and/or keypads to adjust the light levels, then saving the new levels using buttons designated as "Scene Saver" buttons.
4. It shall be possible to do Global Button Models, which track sequences on multiple keypads such that the sequences are synchronized.
   G. Failsafe Operation
1. All programmable information in the Processor including timeclock schedules, keypad button programming, vacation and security mode settings shall be retained in non-volatile memory and shall remain intact for 10 years in the case of power loss to the Processor.
2. In the event that one or more of the lighting control Processors is not present or is disabled, the following shall be possible:
      a. All circuits controlled by the system that were on prior to the power disruption shall remain on at the same intensity, and all circuits controlled by the system that were off prior to the power disruption shall remain off.
      b. Where dimming module assemblies are used, it shall be possible to turn on to any preset level, including off, any

lights controlled by these modules by installing and using a low-voltage dry-contact override switch, or by cycling the breaker feeding the module.

   c. During power disruption, it shall be possible to turn on, off, or dim to any level, any local dimming or switching control directly from the face of the control.

   d. During power disruption, it shall be possible to select a preset lighting scene, turn on, off, or dim each circuit to any level on any local wall-mounted, multi-zone, preset scene dimming module, directly from the face of the module.

2.04   WIRELESS CENTRALIZED LIGHTING CONTROL PROCESSOR

   A. Electrical
      1. All terminal block inputs on Processor shall be tested to meet or exceed the IEC 61000-4-2 standard.
      2. Processor shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).
      3. The environment in which the Lighting Control Processor (Processor) will reliably operate shall be in the following ranges
         a. Input voltage: 100-140 VAC.
         b. Ambient operating temperature: 0-40°C, 32-104°F
         c. Ambient operating humidity: 0-90% humidity, non-condensing
      4. Lithium battery provides ten years of data retention during normal power outages.
      5. Processor shall have no moving parts such as hard drives or cooling fans.
      6. Processor shall be electronically upgradable via a Personal Computer locally or remotely. EEPROM-based firmware shall not be acceptable.
      7. Processor shall be powered by a low-voltage transformer for safety reasons.
   B. Interface
      1. Lighting Control Processor (Processor) shall incorporate one or more RS-232 interfaces to allow connection to a Personal Computer for programming, control, diagnostic and/or upgrade purposes.
      2. Lighting Control Processor (Processor) shall incorporate a minimum of one ethernet interfaces to allow connection to a Personal Computer for programming, control, diagnostic and/or upgrade purposes.
      3. A modem may be connected to the RS-232 port to accommodate programming changes, control and/or diagnostics from remote locations.
      4. One or more RS-232 interfaces or ethernet port may be used for an existing or future external controller to communicate to the system.

5. Manufacturer shall publish the RS-232 protocol for the system to aid in integrating external controllers with the system.
6. LED's and a LCD screen shall be provided to display set-up and diagnostic information.
7. Processor shall incorporate configurable communications links in which to communicate to system devices and up to 15 other Lighting Control Processors.
8. Processor shall incorporate the ability to wire to a hybrid repeater.

C. Timeclock
1. A timeclock will allow up to 32,000 events to be programmed to occur without user intervention at specified times during the day in with relation to sunrise/sunset. Sunrise and sunset times will be calculated by specifying the latitude and longitude of the location of the system.
2. Internal timeclock shall be accurate to +/- one minute per year (specified as during data retention time).

D. Vacation Mode
1. Processor shall provide ability to record device states in the system for the purpose of future playback. Device states may be recorded every 5, 15, 30, 45 or 60 minutes for 1, 7 or 14 days.
2. It shall be possible to engage a "Vacation Playback Mode" so that device states that have been recorded can be played back "as recorded" or "with randomization" to give the residence or building an occupied look.

E. Security Mode
1. Processor shall incorporate a programmable security mode event that may be triggered by a contact closure, button press, RS-232 command or timeclock event.
2. Security mode event will allow devices to be forced to a predetermined level, lights flashed and/or keypads disabled.
3. A contact closure, button press, RS-232 command, or a timeclock event may disengage security mode event. It may also be automatically disengaged after a predetermined amount of time.
4. After security mode event is exited, the system shall return to the previous state or revert to a pre-programmed state as specified.

F. Programming
1. Processor shall be programmed using manufacturer-supplied software and a Personal Computer.
2. Processor shall provide the following programming capabilities: button-by-button programming, conditional logic programming, timeclock enable/disable, single action, toggle, advanced toggle, manual sequencing, automatic sequencing, global buttons, raise/lower, and bi-directional RS-232

G. Failsafe Operation
1. All programmable information in the Processor including timeclock schedules, keypad button programming, vacation and security mode

settings shall be retained in non-volatile memory and shall remain intact in the case of power loss to the Processor.

2. In the event that one or more of the lighting control Processors is not present, disabled, or un-powered, the following shall be possible:

    a. All circuits controlled by the system that were on prior to the power disruption shall remain on at the same intensity, and all circuits controlled by the system that were off prior to the power disruption shall remain off.

    b. During power disruption, it shall be possible to turn on, off, or dim to any level, any local dimming or switching control directly from the control.

    c. During power disruption, it shall be possible to select a preset lighting scene, turn on, off, or dim each circuit to any level on any local wall-mounted, multi-zone, preset scene dimming module, directly from the face of the module.

H. Radio Frequency Communication

1. Shall be capable of radio frequency communication to other radio frequency components of the LCS.

2. System shall incorporate 2-way communication so that the system tracks the state of devices

3. System shall be frequency modulated (FM) and have 60 communication channels.

4. Employs a method of frequency scanning at system setup, which allows the system to be configured for operation in the clearest communication frequency channel.

5. Processors can operate simultaneously, which allows for co-location of processors within a system.

6. Operates in compliance with FCC Part 15.231.

7. Utilizes an optional repeater network to extend range and ensure error-free communication.

2.05   SOFTWARE

A. Lighting Control System (LCS) shall be designed, programmed and diagnosed by using manufacturer-supplied Windows®-based software.

B. Software shall be compatible with the following Microsoft® operating systems:

1. Windows 2000, Windows NT 4.0

2. Windows XP

C. Software shall provide ability to design a whole-house lighting control system by inputting details about load wattage, loadtype, quantities, keypads and interfaces. Software shall be able to generate a bill of materials including required hardware based on information entered.

D. Software shall provide terminal screen in which user can upload programming, communicate with processor by using simple serial string

commands, perform real-time control of devices and perform diagnostics functions.

E. Software shall provide reporting capabilities to view and print reports such as bills of materials, high voltage wiring reports and addressing reports.

F. Software shall be capable of generating a typical bill of material (BOM) after control station and load data have been entered.

G. Software shall be capable of soft addressing which allows addressing after the product is installed without setting addressing means such as dip switches.

H. Software shall allow user to program system events using the following programming types:

    1. Conditional Logic Programming

        a. The desired button action is dependent upon a separate system device, variable state, sequence state, or time.

    2. Timeclock

        a. Enable/disable - The button can enable or disable the timeclock or certain timeclock events.

        b. Timeclock Programming - Timeclock events can be programmed using the following models:

            i. Default - The event will always perform the same action when triggered.

            ii. Automatic Sequence - The event shall play a series of presets in succession and terminate after a given number of loops, a given amount of time, or upon the trigger of another event that terminates the sequence.

            i. Conditional - The desired event action is dependent upon a separate system device, variable state, sequence state, or time.

    2. Timeclock events shall be triggered by the system based on time of day or on specified amount of time before or after sunrise or sunset times for the current day.

    3. Sunrise and sunset times shall be calculated by the software based on the input latitude and longitude of the project's location.

    4. Default Models

        a. Single action - The button will always perform the same action, regardless of the number of times it is pressed.

        b. Dual Action - The button will perform one action on press, and a separately programmable action upon release of the button.

        c. Toggle - The button will toggle between a programmable "ON" state and the default "OFF" state.

        d. Additional features available on default are cycle dim and double-tap.

            i. Cycle Dim / Scene Saver - Pressing and holding the button will raise the level of the lighting programmed to that button. Upon releasing the button, the lighting will

remain at the new level. By pressing and holding again, the button will lower the lighting programmed to that button. Upon releasing the button, the lighting will remain at the new level. Alternately, pressing and holding the button will cause the current light levels of the affected lights to be saved. The next time the button is pressed, the lights will go to the new levels. These saved levels can be captured via the terminal screen and saved on the PC.

ii. Double-Tap - A quick double-tap of the button will activate a separately programmable preset.

e. Advanced Toggle - The button will toggle between a programmable "ON" state and a programmable "OFF" state.

f. Manual Sequencing - The button will cycle through multiple presets. The sequence shall be programmable to advance to the next preset on a button press or after a specified amount of time has elapsed.

g. Automatic Sequence - The button shall play a series of presets in succession and terminate after a given number of loops, a given amount of time, or upon a button press.

h. Raise/Lower
   i. Master Raise/Lower - Raise/Lower the last button affected on that keypad
   ii. Single-Scene Raise/Lower - Raise/Lower the lighting preset assigned to the button.

i. Raise / Stop / Lower / Stop - The button will cycle shades through a raise – stop – lower – stop sequence every time the button is pressed, with a timeout on the raise and lower steps. If there are multiple buttons using the same programming, these buttons will synchronize together such that a press of one button that starts the shade lowering can be stopped from another button. A further press on any button will start the shade raising and so on.

j. Fan Speed Control - The button will cycle through different fan speeds (high, medium-high, medium-low, low) and off. All buttons programmed the same will synchronize as described in number 8 Raise / Stop / Lower / Stop above.

k. Manual Sequence with Tracking - The button will behave as a Manual Sequence button described above with the additional capability that the active step of the sequence can be automatically changed to match the current levels of the lights in the system. Furthermore, all buttons programmed the same will synchronize as described in number 8 Raise / Stop / Lower / Stop above.

2.06   POWER PANELS AND ENCLOSURES

A.   Mechanical
1.   Panels shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).
1.   Panels shall be wall or recess mountable. Enclosure shall be NEMA Type 1 and IP-20 rated as specified by IEC 60529. Panel shall be constructed of steel with steel gauge of type required by UL508. Panel must fit between standard wall stud spacing (14 3/8"). Contractor shall reinforce wall as required.
2.   Panels shall be available as pre-assembled control panels or as field-assembled modular control panels.
   a.   Pre-assembled Control Panels
      i.   Panels shall be completely pre-assembled and factory tested by the manufacturer prior to shipment. The contractor shall be required to provide input feed wiring, load wiring, and control wiring. Unless otherwise specified, no other wiring or assembly by the contractor shall be required.
   b.   Field-assembled Modular Control Panels
      i.   The contractor shall be required to provide input feed wiring, load wiring, control wiring, and installation and wiring of a Centralized Lighting Control Processor, and separate power module assemblies as necessary.
3.   All input feed, load, and control terminals shall be front accessible without the need to remove power module assemblies or other components.
4.   Panels shall be passively cooled via free-convection, unaided by fans. Systems that are fan dependent or fan assisted for cooling of components are not acceptable. Systems that require or recommend regularly scheduled maintenance for air filtration components are not acceptable.
5.   Panels with breakers shall be available from the manufacturer.
B.   Electrical
1.   Panels suited for power modules shall contain from one to eight power module assemblies. The following power module types are acceptable:
   a.   Dimming Control Modules
   b.   Bi-directional Motor Control Modules
   c.   Switching Relay Control Modules
   d.   Quiet Fan Speed Control Modules
2.   Unless the panel is a dedicated feed-through-type panel, low-voltage enclosure or otherwise indicated, panels shall contain branch circuit protection for each power module assembly.
   a.   Branch Circuit Breakers in 120 Volt Panels shall have the following performance characteristics:

       i.   Be UL 489 listed as a molded case circuit breaker for use on lighting circuits.

      ii.   Contain a visual trip indicator and shall be rated at 10,000 AIC unless otherwise noted. Panel shall accept breakers rated up to 22,000 AIC without the need for additional externally mounted equipment. With the use of approved series rated external current limiting main breakers, circuits shall be operable up to 100,000AIC.

       i.   Be thermal-magnetic in construction for overload, short-circuit, and over-temperature protection. The use of fully magnetic breakers shall not be acceptable, even when used in conjunction with individual dimmer thermal cut-out devices.

      ii.   Be replaceable without moving or replacing power module assemblies or other components of the panel.

     iii.   Be switching duty (SWD) rated so that loads can be switched off via the breakers.

   b. Branch Circuit Breakers in 220-240 Volt Panels shall have the following performance characteristics

       i.   Branch circuit breakers used in residential applications shall be certified to meet the IEC 60898 standard. When used in commercial applications, the branch circuit breakers shall be certified to meet the IEC 60947 standard.

      ii.   Shall be rated at 6,000 AIC unless otherwise noted. Panel shall accept breakers rated up to 15,000 AIC (residential) or 25,000 AIC (commercial) without the need for additional externally mounted equipment.

     iii.   Be thermal-magnetic in construction for overload, short-circuit, and over-temperature protection. The use of fully magnetic breakers shall not be acceptable, even when used in conjunction with individual dimmer thermal cut-out devices.

     iv.   Be replaceable without moving dimmer assemblies or other components of the panel.

3. Panel shall provide a mounting location and/or means of wiring a Centralized Lighting Control Processor.

4. Panel should have minimum UL listed short circuit current rating (SCCR) of 42,000A. Panels not providing this level of short circuit current protection shall not be acceptable.

5. Panels suited for power modules shall be shipped in a mechanical BYPASS position via a jumper bar inserted between the input and load terminals for each power module assembly to allow panel to be used as a temporary lighting panel with no possibility of power module failure due to short-circuit condition. These jumpers shall carry the full-rated load current and shall be reusable at any time. Mechanical

bypass device must allow for switching operation of connected load with the power module removed via a circuit breaker. Bypass devices that are integral to the power module are not acceptable.

6. Panels suited for power modules which allow the dimmers to be loaded to greater than 80% of the wiring ampacity as specified by the NEC shall not be acceptable.

7. Panels requiring the neutral feeder to be sized larger than any individual phase feeder shall not be acceptable.

8. Panels suited for power modules shall provide capability to electronically assign each circuit to any zone in the system. Panels using mechanical switches, rewiring, or EEPROMs shall not be acceptable.

9. All line-voltage connections in the panel must be made with a visible positive mechanical connection. Pin and socket or stab-in connectors shall not be acceptable.

2.07 DIMMING CONTROL MODULE

A. Mechanical
1. Dimming control module shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).

B. Electrical
1. Each dimmer module shall contain four dimmers. Each dimmer may be controlled independently or in combination with any other dimmer within a panel or with dimmers from other panels within the system. Each dimmer module shall be rated for 16A. The total load across all four dimmers within a module is not to exceed 16A, however, any one dimmer within the module is capable of operating the entire 16A load.

2. Under fully-loaded operating conditions, all semiconductor devices shall operate at a minimum 20ºC (36ºF) safety margin below the component manufacturer's maximum component temperature rating at a 40ºC (104ºF) ambient room temperature.

3. A positive air gap switch shall be employed by each dimmer module to ensure that the load circuits are open when the "off" function is selected from the control system for all dimmers in the module. Individual dimmers in an OFF state shall not exceed 5mA of leakage current.

4. Dimmer shall be capable of withstanding inrush current of 50 times operating current typically generated by a full circuit of switching electronic non-dim ballasts.

5. Each dimmer shall compensate for incoming line voltage variations such as changes in RMS voltage, frequency shifts, harmonics and line noise. Dimmer shall be capable of maintaining constant light level with no visible flicker under the following conditions:
   a. ±2% change in RMS voltage/cycle

b. ±2 Hz change in frequency/second
c. Dimmers that do not regulate the dimmer output in real time shall be unacceptable.

6. Dimmer output voltage shall be a minimum 98% of input voltage at maximum intensity setting under full load conditions.

7. Each dimmer shall incorporate an electronic "soft-start" default at initial turn-on that smoothly ramps the lights up to the appropriate levels within 0.5 seconds.

8. Once installed as part of a complete system, the semiconductor used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.

9. Dimming assemblies shall operate the sources/load types listed below in sections a through d with a smooth continuous Square Law dimming curve or on a non-dim basis. Dimmers shall be electronically assigned to the appropriate load type/dimming curve and can be reassigned at any time. Universal-type dimmers that do not adjust the dimming curve based on load type shall not be acceptable.

    a. Incandescent, Tungsten and Magnetic Low Voltage Transformer
        i. Dimmer shall contain circuitry specifically designed to control and provide a symmetrical AC waveform to the input of magnetic low voltage transformers.
        ii. Dimmer shall not cause a magnetic low voltage transformer to operate above the transformer's rated operating current and temperature. Dimmers using back-to-back SCR construction that could fail open causing DC power to flow into a Magnetic Low Voltage load are not acceptable.
    b. Electronic Low Voltage Transformer
        i. Dimmer shall be capable of operating electronic low voltage transformers directly or through the use of an external interface by the same manufacturer.
        ii. Dimming shall not adversely affect sound rating of the electronic transformers. In addition, no flicker or interaction shall occur at any point in the dimming range.
        iii. Dimmers shall provide the ability to dim lamps down to 0% (blackout). Minimum light levels shall be user adjustable in order to compensate for different loading of each dimmer.
    c. Fluorescent Electronic Dimming Ballast
        i. Dimming ballasts and controls shall be provided by same manufacturer.

ii. Dimmer shall be able to control Lutron TuWire ballasts without the use of external interfaces.

iii. Dimmer shall be capable of operating Lutron 3-wire fluorescent dimming ballasts through the use of an external interface by the same manufacturer.

iv. Dimmer shall be capable of operating 0-10V, DSI, or PWM controlled dimming ballasts through the use of an external interface by the same manufacturer.

v. Refer to general section 16580 for dimming ballast specifications and performance.

vi. See fixture schedule and/or load schedule for specific ballast model numbers.

d. Neon and Cold Cathode

i. Dimmer shall provide the ability to dim lamps down to 10% of full light output when used with normal (low) power factor transformers.

ii. The lamp performance over the range specified shall be continuous and free of flicker or striations.

iii. Neon lamps must be manufactured and installed with strict attention paid to proper transformer size, proper lamp pressurization, and exclusion of any impurities within the lamp. Details of product manufacture and installation shall be defined according to a published neon/cold cathode dimming application guide supplied by the dimming manufacturer.

iv. The electrical contractor is responsible for proper neon or cold cathode lamp and wiring installation.

10. Dimmer shall provide a minimum of 4096 steps of dimming throughout the dimming range. Unless otherwise specified, dimming shall be performed in a manner that the "steps" of light are not visible. Dimmers that have visible "steps" of light intensity throughout the control range shall not be acceptable.

2.08   QUIET FAN SPEED CONTROL MODULES

A. Mechanical
1. Quiet Fan Speed Control Modules shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).

B. Electrical
1. Each Fan Speed Control module shall provide control for up to 4 independent ceiling fans. Each output may be controlled independently or in combination with any other dimmer/output within a panel or with dimmers/outputs from other panels within the system. Each output shall be rated for 2A maximum.

2. The fan speed control module shall provide 4 speeds: Low, Medium, Medium-High, Full plus OFF. Fan speed control modules that provide less than 4 speeds and OFF shall not be acceptable

3. Under fully-loaded operating conditions, all semiconductor devices shall operate at a minimum 20ºC (36ºF) safety margin below the component manufacturer's maximum component temperature rating at a 40ºC (104ºF) ambient room temperature.

4. A positive air gap switch shall be employed by each module in the panel to ensure that the load circuits are open when the "off" function is selected from the control system for all outputs in the module. Individual outputs in an OFF state shall not exceed 5mA of leakage current.

5. Once installed as part of a complete system, the semiconductor used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.

2.09   SWITCHING RELAY CONTROL MODULE

A. Mechanical
　　1. Switching relay control module shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).
B. Electrical
　　1. Module will properly operate with input power of 108-264 VAC 50/60Hz
　　2. Each module shall provide switching control for up to four non-dim or motor loads. Each of the four loads is supplied by its own input and can be a maximum of 16 Amps (1/3 HP @120–240V). Each output may be controlled independently or in combination with any other dimmer/output within a panel or with dimmers/outputs from other panels within the system. Each module shall be rated for 64A. The total load across all four outputs within a module is not to exceed 64A, however, any one output within the module is capable of operating up to a 16A load.
　　3. Under fully-loaded operating conditions, all semiconductor devices shall operate at a minimum 20ºC (36ºF) safety margin below the component manufacturer's maximum component temperature rating at a 40ºC (104ºF) ambient room temperature.
　　4. A positive air gap switch shall be employed by each module to ensure that the load circuits are open when the "off" function is selected from the control system for all outputs in the module. Individual outputs in an OFF state shall not exceed 5mA of leakage current.

5. Outputs shall be capable of withstanding inrush current of 50 times operating current typically generated by a full circuit of switching electronic non-dim ballasts.

6. Each output shall incorporate triac arc suppression technology to extend relay life.

7. Once installed as part of a complete system, the semiconductor used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.

2.10   BI - DIRECTIONAL MOTOR CONTROL MODULES

A. Mechanical
1. Bi-directional motor control modules shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).

B. Electrical
1. Module shall be capable of controlling up to 4 independent 120 VAC 3 wire motors. Each output may be controlled independently or in combination with any other dimmer/output within the panel or with dimmers/outputs from other panels within the system. Each motor can be a maximum of 5 Amps (1/4 hp) up to a maximum 16 Amps for the entire module.

2. Module shall have terminals for "direction 1", "direction 2" and neutral.

3. For each motor the module shall employ two mechanically interlocked relays to insure positive protection that both "direction 1" and "direction 2" motor windings are not energized at the same time.

4. Module shall have a programmable delay between changing from "direction 1" and "direction 2" to prevent any motor damage due to quick direction changes.

5. Module shall have a programmable maximum time that either "direction 1" and "direction 2" motor windings can be left in the energized state.

6. Under fully-loaded operating conditions, all semiconductor devices shall operate at a minimum 20ºC (36ºF) safety margin below the component manufacturer's maximum component temperature rating at a 40ºC (104ºF) ambient room temperature.

7. A positive air gap switch shall be employed by each module in the panel to ensure that the load circuits are open when the "off" function is selected from the control system for all outputs in the module.

Individual outputs in an OFF state shall not exceed 5mA of leakage current.

8. Once installed as part of a complete system, the semiconductor used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.

2.11 WALLBOX MULTI-ZONE DIMMING MODULE

A. Mechanical
1. Wallbox multi-zone dimming module shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).
2. Wallbox multi-zone dimming module shall be able to control six dimming zones while occupying the space of a standard four-gang wallbox.

B. Electrical
1. Each wallbox multi-zone dimming module shall contain six dimmers. Each dimmer may be controlled independently or in combination with any other dimmer. Each dimmer module shall be rated for 800Watts. The total load across all six dimmers within a module is not to exceed 2000Watts.
2. Under fully-loaded operating conditions, all semiconductor devices shall operate at a minimum 20°C (36°F) safety margin below the component manufacturer's maximum component temperature rating at a 40°C (104°F) ambient room temperature.
3. A positive air gap switch shall be employed by each dimmer module to ensure that the load circuits are open when the "off" function is selected from the control system for all dimmers in the module. Individual dimmers in an OFF state shall not exceed 5mA of leakage current.
4. Dimmer shall be capable of withstanding inrush current of 50 times operating current typically generated by a full circuit of switching electronic non-dim ballasts.
5. Each dimmer shall compensate for incoming line voltage variations such as changes in RMS voltage, frequency shifts, harmonics and line noise. Dimmer shall be capable of maintaining constant light level with no visible flicker under the following conditions:
   i. ±2 Hz change in frequency/second
   ii. Dimmers that do not regulate the dimmer output in real time shall be unacceptable.
6. Dimmer output voltage shall be a minimum 98% of input voltage at maximum intensity setting under full load conditions.

7. Each dimmer shall incorporate an electronic "soft-start" default at initial turn-on that smoothly ramps the lights up to the appropriate levels within 0.5 seconds.

8. Once installed as part of a complete system, the semiconductor used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.

9. Dimming assemblies shall operate the sources/load types listed below in sections a through d with a smooth continuous Square Law dimming curve or on a non-dim basis. Dimmers shall be electronically assigned to the appropriate load type/dimming curve and can be reassigned at any time. Universal-type dimmers that do not adjust the dimming curve based on load type shall not be acceptable.

    a. Incandescent, Tungsten and Magnetic Low Voltage Transformer
        i. Dimmer shall contain circuitry specifically designed to control and provide a symmetrical AC waveform to the input of magnetic low voltage transformers.
        ii. Dimmer shall not cause a magnetic low voltage transformer to operate above the transformer's rated operating current and temperature. Dimmers using back-to-back SCR construction that could fail open causing DC power to flow into a Magnetic Low Voltage load are not acceptable.

    b. Fluorescent Electronic Dimming Ballast
        i. Dimming ballasts and controls shall be provided by same manufacturer.
        ii. Dimmer shall be able to control Lutron TuWire ballasts without the use of external interfaces.
        iii. Dimmer shall be capable of operating Lutron 3-wire fluorescent dimming ballasts through the use of an external interface by the same manufacturer.
        iv. Dimmer shall be capable of operating 0-10V, DSI, or PWM controlled dimming ballasts through the use of an external interface by the same manufacturer.
        v. Refer to general section 16580 for dimming ballast specifications and performance.
        vi. See fixture schedule and/or load schedule for specific ballast model numbers.

    c. Neon and Cold Cathode
        i. Dimmer shall provide the ability to dim lamps down to 10% of full light output when used with normal (low) power factor transformers.

ii. The lamp performance over the range specified shall be continuous and free of flicker or striations.

iii. Neon lamps must be manufactured and installed with strict attention paid to proper transformer size, proper lamp pressurization, and exclusion of any impurities within the lamp. Details of product manufacture and installation shall be defined according to a published neon/cold cathode dimming application guide supplied by the dimming manufacturer.

iv. The electrical contractor is responsible for proper neon or cold cathode lamp and wiring installation.

10. Dimmer shall provide a minimum of 128 steps of dimming throughout the dimming range. Unless otherwise specified, dimming shall be performed in a manner that the "steps" of light are not visible. Dimmers that have visible "steps" of light intensity throughout the control range shall not be acceptable.

2.12   LOCAL DIMMER AND SWITCH MODULES

A. Lighting controls shall meet applicable requirements of UL 20 and UL 1472 regarding the inclusion of a visible, accessible air gap off switch and the limited short circuit test.

B. Lighting controls for magnetic low voltage fixtures shall be end-of-line tested to ensure that any operating condition (including an unloaded transformer) does not overheat the transformer

C. Lighting controls and electronic dimming ballasts for fluorescent fixtures shall be manufactured and supplied by the same manufacturer or as an approved system by both the ballast and control manufacturer.

D. Lighting controls shall provide power failure memory. Should power be interrupted, and subsequently returned, the lights will come back on to the level set prior to the power interruption. Restoration to a default level shall not be acceptable. Additionally, lighting controls storing presets shall retain the preset levels in memory.

E. Lighting controls shall provide fail-safe operation. In the event that communication with the system is interrupted, all local lighting controls will still operate, offering local control.

F. Lighting control faceplate shall attach using no visible means of attachment.

G. Manufacturer shall ensure the following items regarding product color:
   1. Coordinated product color matching shall be provided on request.
   2. Color variation of any control in the same product family shall not exceed   E=1, CIE L*a*b color space units.
   3. Visible parts shall exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674-89. Manufacturer to submit proof of testing upon request.

H. Lighting controls shall be 100% end-of-line tested for proper electrical, functional and tactile operation before shipment from the factory. Manufacturers who end-of-line test by sampling shall not be acceptable.

I. Dimmers
1. General
   a. Dimmers shall provide full-range, continuously variable control of light intensity.
   b. Dimmers shall have a small, raised slider or raise/lower rocker to the right of the tapswitch. Tapswitches shall remain flush with the wallplate in both the on and off state. Controls shall be thin profile with no exposed heatsink/yoke.
   c. When the lights are on, the slider or raise/lower rocker shall change the light level. Tapswitch shall turn lights on to the preselected level, or off. Switches shall have a factory set high-end light level.
   d. An actuator accessible from the front of the unit, with the wallplate attached, shall activate a mechanical air-gap switch disconnecting power from the load during "safety off" condition; no leakage current shall be present at the fixture(s). This front accessible safety switch shall be separate from the tapswitch and small slider or raise/lower rocker.
   e. Controls shall be capable of on/off and mechanical air-gap "safety off" from up to 9 additional locations using aesthetically coordinated auxiliary electronic tapswitches.
   f. Within rated capacity, dimmers shall be available for direct control of incandescent, magnetic low voltage, fluorescent (3-wire line voltage), or electronic low voltage lighting loads.
   g. Controls shall be capable of operating at the rated capacity; this includes modified capacities for ganging configurations, which may or may not require the removal of fins. Operation at rated capacity shall be possible across the full ambient temperature range, without shortening design lifetime.
   h. Dimmer shall provide smooth and continuous Square Law dimming curve, for the full slider travel, on their rated load per The IESNA Lighting Handbook, 9th edition, p. 27-4.
   (j) Controls shall meet ANSI/IEEE Std. C62.41-1980, tested to withstand voltage surges of up to 6000V and current surges of up to 200A without damage.
   (k) Dimmers shall be designed to reduce interference with radio, audio, and video equipment.
   (l) Auxiliary electronic tapswitch shall wire using conventional 3-way and 4-way wire runs.
2. Incandescent/Magnetic Low Voltage (MLV) Transformer Dimmers
   a. Dimmers shall have a high-end of no less than 90% of line voltage.

  b. Dimmers shall contain circuitry specifically designed to control and provide a symmetrical AC waveform to the input of magnetic low voltage transformers per UL1472 section 5.11.

  c. Dimmers shall not cause a magnetic low voltage transformer to operate above the transformer's rated operating current or temperature.

  d. Dimmers shall be able to control separate interfaces or boosters, to allow control of electronic low voltage transformers and fluorescent (Lutron Tu-Wire, 0-10V control, and Lutron 3-wire line voltage control ballasts).

 3. Fluorescent Dimming Ballast Dimmers

  a. Dimmers shall be provided to operate the following ballasts:
   i. Hi-lume® Architectural Dimming Ballasts (1% 3-wire)
   ii. Hi-lume® Compact™ Lamp Dimming Ballasts (5% 3-wire)
   iii. Eco-10™ Lighting Management Dimming Ballasts (10% 3-wire)

  b. Dimmers and ballasts shall be produced by the same manufacturer to ensure proper ballast/control compatibility

J. Switches

 2. Electronic Tapswitches shall be available for on/off control of 120VAC incandescent, magnetic low voltage, electronic low voltage, magnetic and electronic fluorescent non-dimmable ballast loads up to 1000W/VA.

 3. Auxiliary Electronic Tapswitches shall provide multi-location switching and mechanical air-gap switch. Up to 9 Auxiliary switches may be used.

 4. Tapswitches shall remain flush with the wallplate in both the on and off state. Controls shall be thin profile with no exposed heatsink/yoke.

 5. An actuator accessible from the front of the unit, with the wallplate attached, shall activate a mechanical air-gap switch disconnecting power from the load during "safety off" condition; no leakage current shall be present at the fixture(s). This front accessible safety switch shall be separate from the tapswitch and small slider or raise/lower rocker.

 6. Controls shall be capable of on/off and mechanical air-gap "safety off" from up to 9 additional locations using aesthetically coordinated auxiliary electronic tapswitches.

2.13 WIRELESS LOCAL DIMMER AND SWITCH MODULES

A. Lighting controls shall meet applicable requirements of UL 20 and UL 1472 regarding the inclusion of a visible, accessible air gap off switch and the limited short circuit test.

B. Lighting controls for magnetic low voltage fixtures shall be end-of-line tested to ensure that any operating condition (including an unloaded transformer) does not overheat the transformer.

C. Lighting controls and electronic dimming ballasts for fluorescent fixtures shall be manufactured and supplied by the same manufacturer or as an approved system by both the ballast and control manufacturer.

D. Lighting controls shall provide power failure memory. Should power be interrupted, and subsequently returned, the lights will come back on to the level set prior to the power interruption. Restoration to a default level shall not be acceptable. Additionally, lighting controls storing presets shall retain the preset levels in memory.

E. Lighting controls shall provide fail-safe operation. In the event that communication with the system is interrupted, all local lighting controls will still operate, offering local control.

F. Lighting control faceplate shall attach using no visible means of attachment.

G. Manufacturer shall ensure the following items regarding product color:
   1. Color variation of any control in the same product family shall not exceed $\Delta E=1$, CIE L*a*b color space units.
   2. Visible parts shall exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674-89. Manufacturer to submit proof of testing upon request.

H. Lighting controls shall be 100% end-of-line tested for proper electrical, functional and tactile operation before shipment from the factory. Manufacturers who end-of-line test by sampling shall not be acceptable.

I. Dimmers
   1. General
      a. Dimmers shall provide continuously variable control of light intensity from 0 to 90% RMS voltage.
      b. Dimmers shall have an integral antenna that requires no installation effort and cannot be modified by the user via ordinary means.
      c. An actuator accessible from the front of the unit, with the wallplate attached, shall activate a mechanical air-gap switch disconnecting power from the load during "safety off" condition; no leakage current shall be present at the fixture(s). This front accessible safety switch shall be separate from the tapswitch and raise/lower rocker.
      d. Controls shall be capable of on/off and mechanical air-gap "safety off" from up to 9 additional locations using aesthetically coordinated auxiliary electronic tapswitches.
      e. Within rated capacity, dimmers shall be available for direct control of incandescent, magnetic low voltage, or fluorescent (3-wire line voltage) lighting loads.
      f. Dimmer shall be capable of operating at the rated capacity. Operation at rated capacity shall be possible across the full

ambient temperature range, without shortening design lifetime.

g. Dimmer shall provide smooth and continuous Square Law dimming curve, for the full slider travel, on their rated load per The IESNA Lighting Handbook, 9th edition, p. 27-4.

h. Controls shall meet ANSI/IEEE Std. C62.41-1980, tested to withstand voltage surges of up to 6000V and current surges of up to 200A without damage.

i. Dimmers shall be designed to reduce interference with radio, audio, and video equipment.

j. Remote dimmers shall wire using conventional 3-way and 4-way wire runs.

k. The dimmer shall have a column of 7 LEDs that give the user visual feedback of the lighting level.

l. A dimmer shall be available that is able to control up to 1000Watts/VA in a single gang wallbox.

2. Incandescent/Magnetic Low Voltage (MLV) Transformer Dimmers

a. Dimmers shall have a high-end of no less than 90% of line voltage.

b. Dimmers shall contain circuitry specifically designed to control and provide a symmetrical AC waveform to the input of magnetic low voltage transformers per UL1472 section 5.11.

c. Dimmers shall not cause a magnetic low voltage transformer to operate above the transformer's rated operating current or temperature.

d. Dimmers shall be able to control separate interfaces or boosters, to allow control of electronic low voltage transformers and fluorescent (Lutron Tu-Wire, 0-10V control, and Lutron 3-wire line voltage control ballasts).

3. Electronic Low Voltage Dimmers

a. An in wall dimmer shall be made available to dim electronic low voltage loads.

b. Dimmer shall provide reverse phase control signal to electronic low voltage transformer(s).

c. Dimmers shall have a high-end of no less than 90% of line voltage.

J. Switches

1. Electronic Tapswitches shall be available for on/off control of 120VAC incandescent, magnetic low voltage, electronic low voltage, magnetic and electronic fluorescent non-dimmable ballast loads up to 8A.

2. Remote switches shall provide multi-location switching and mechanical air-gap switch. Up to 9 remote switches may be used.

3. An actuator accessible from the front of the unit, with the wallplate attached, shall activate a mechanical air-gap switch disconnecting power from the load during "safety off" condition; no leakage current

shall be present at the fixture(s). This front accessible safety switch shall be separate from the tapswitch and raise/lower rocker.

4. Controls shall be capable of on/off and mechanical air-gap "safety off" from up to 9 additional locations using aesthetically coordinated auxiliary electronic tapswitches.

5. A status LED shall be provided to give the user visual feedback of the ON or OFF state of the switch.

K. Lamp Dimmer

1. A lamp dimmer shall be made available.

2. The lamp dimmer shall have a user interface consistent with wall dimmers that can be purchased.

3. The lamp dimmer cord shall be 6 feet long so that the lamp dimmer can be placed on a table that can be a reasonable distance from the receptacle.

4. The lamp dimmer shall have light level status LEDs.

2.14   KEYPADS

A. General

1. Wiring from the Centralized System Processor to the keypads shall be low voltage type Class 2 wiring (PELV).

2. Keypad faceplate shall attach using no visible means of attachment.

3. Keypads shall be available engraved with specified button or scene descriptions, furnished to the manufacturer prior to fabrication. Any silk-screened borders, logos, graduations, etc., shall use a graphic process that chemically bonds the graphics to the faceplate, resisting removal by scratching, cleaning, etc.

4. Manufacturer shall ensure the following items regarding product color:

a. Coordinated product color matching shall be provided on request.

b. Color variation of any keypad in the same product family shall not exceed (E+I, CIE L*a*b color space units).

c. Visible parts shall exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674-89. Manufacturer to submit proof of testing upon request.

5. Keypad shall be capable of conditional logic programming, timeclock enable/disable, single action, dual action, toggle, cycle dim, double-tap, advanced toggle, manual sequencing, automatic sequencing, and raise/lower.

a. Definition of Conditional Logic Programming - The desired button action is dependent upon a separate system device, variable state, sequence state, or time.

b. Timeclock enable/disable - The button can enable or disable the timeclock or certain timeclock events.

c. Single action - The button will always perform the same action, regardless of the number of times it is pressed.

d. Dual Action - The button will perform one action on press, and a separately programmable action upon release of the button.

e. Toggle - The button will toggle between a programmable "ON" state and the default "OFF" state.

f. Additional features available on single action, dual action, and toggle are cycle dim and double-tap.

g. Cycle Dim - Pressing and holding the button will raise the level of the lighting programmed to that button. Upon releasing the button, the lighting will remain at the new level. By pressing and holding again, the button will lower the lighting programmed to that button. Upon releasing the button, the lighting will remain at the new level.

h. Double-Tap - A quick double-tap of the button will activate a separately programmable preset.

i. Advanced Toggle - The button will toggle between a programmable "ON" state and a programmable "OFF" state.

j. Manual Sequencing - The button will cycle through multiple presets. The sequence shall be programmable to advance to the next preset on a button press or after a specified amount of time has elapsed.

k. Automatic Sequencing - The button shall play a series of presets in succession and terminate after a given number of loops, a given amount of time, or upon a button press.

l. Raise/Lower
   i. Master Raise/Lower - Raise/Lower the last button affected on that keypad
   ii. Single-Scene Raise/Lower - Raise/Lower the lighting preset assigned to the button.

6. LED status of buttons shall be fully programmable to the following types: Room, Scene, Pathway, Always On, Momentary On, via RS232 LED, and Conditional Logic.

   a. Definition - Room
      i. LED is on (true) when at least one of the zones programmed on the Press preset is on. Otherwise, the LED is off (false).
      ii. Reverse LED logic may be applied. The LED will be off when true, and on when false.

   b. Definition - Scene
      i. LED is on (true) when all of the zones are at the exact levels programmed on the Press preset. Otherwise the LED is off (false).

   ii. Reverse LED logic may be applied. The LED will be off when true, and on when false.

  c. Definition - Pathway
   i. LED is on (true) when all of the zones programmed on the Press preset are on at any level. Otherwise, the LED is off (false).
   ii. Reverse LED logic may be applied. The LED will be off when true, and on when false.

  d. Always On
   i. LED is always on (true), regardless of what the button does.

  e. Momentary On
   i. LED is only on (true) while the button is pressed. As soon as the button is released, the LED is off (false).

  f. Via RS232 LED
   i. LED is turned on (true) and off (false) via RS232 command.

  g. Conditional Logic
   i. LED will follow Room, Scene, or Pathway logic for the Conditional preset it is assigned to.

 7. Control functions can be redefined through the use of system setup software.

B. Standard Keypads

 1. Architectural Style with slim buttons
  a. Shall be available in 5, 10, or 15 slim buttons with LEDs.
  b. Shall have two additional large buttons with no LEDs located at bottom of keypad.

 2. Architectural Style with large buttons
  a. Shall be available in 6 or 9 buttons with LEDs.

 3. Designer Style
  a. Shall be available in 5 and 10 buttons with LEDs.
  b. Shall be available with additional Raise/Lower toggle switch at bottom of keypad
  c. Shall fit Designer-Style Wallplate opening.

 4. Architrave Style
  a. Shall be available in 5 slim buttons with LEDs
  b. Shall have two additional slim buttons with no LEDs located at bottom of keypad.
  c. Shall be available in narrow and wide configurations
  d. Wide keypad shall be provided with special wallbox for mounting in wall.

 5. Two-Button Style
  a. Shall be available in 2 buttons with integral LEDs.
  b. Shall provide two contact closure inputs that provide separate functionality from buttons on face of keypad.

 6. European Style

a. Shall be available in 2, 4, and 8 buttons with integral LEDs.
b. The 4 and 8 button keypads shall have additional buttons at bottom of keypad:
   i. One additional button with no LED and/or two additional raise/lower buttons with no LEDs.
7. SeeTouch Style
   a. Shall be available in 2,3, 5, and 7 buttons with LEDs and backlit buttons.
   b. Shall have Button kits available to customize keypads for 1-7 buttons.
   c. Shall provide two contact closure inputs that provide separate functionality from buttons on face of keypad.

C. Keypads with integrated Infrared (IR) receivers
1. Designer Style
   a. Shall be available in 5 buttons with LEDs.
   b. Shall have an integral infrared (IR) receiver at bottom of keypad.
   c. Shall fit Designer-Style Wallplate opening
   d. IR receiver shall be compatible with infrared transmitters specified by same manufacturer.
2. European Style
   a. Shall be available in 4 and 8 buttons with integral LEDs.
   b. The keypads shall have additional buttons at bottom of keypad:
   c. One additional button with IR receiver (no LED), and two additional raise/lower buttons with no LEDs.
   d. IR receiver shall be compatible with infrared transmitters specified by same manufacturer.
3. SeeTouch Style
   a. Shall be available in 4 buttons with LEDs and backlit buttons.
   b. Shall have additional buttons at bottom of keypad:
      i. One additional button with IR receiver (no LED) and two additional raise/lower buttons with no LEDs.
   c. IR receiver shall be compatible with infrared transmitters specified by same manufacturer.
4. Ceiling-Mounted Infrared (IR) Receiver
   a. Shall allow the use of IR Transmitters without the requirement for a wall-mounted keypad with an IR receiver.
   b. IR receiver shall be compatible with infrared transmitters specified by same manufacturer.

2.15 WIRELESS KEYPADS

A. General

1. Keypads shall have an integral antenna, which is not available for modification.
2. Keypad shall use radio frequency communication to determine system status and process local events.
3. Keypad faceplate shall attach using no visible means of attachment.
4. Keypads shall be available engraved with specified button or scene descriptions, furnished to the manufacturer prior to fabrication. Any silk-screened borders, logos, graduations, etc., shall use a graphic process that chemically bonds the graphics to the faceplate, resisting removal by scratching, cleaning, etc.
5. Manufacturer shall ensure the following items regarding product color:
    a. Coordinated product color matching shall be provided on request.
    b. Color variation of any keypad in the same product family shall not exceed (E+I, CIE L*a*b color space units).
    c. Visible parts shall exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674-89. Manufacturer to submit proof of testing upon request.
6. Keypad shall be capable of conditional logic programming, timeclock enable/disable, single action, dual action, toggle, cycle dim, double-tap, advanced toggle, manual sequencing, automatic sequencing, and raise/lower.
    a. Definition of Conditional Logic Programming - The desired button action is dependent upon a separate system device, variable state, sequence state, or time.
    b. Timeclock enable/disable - The button can enable or disable the timeclock or certain timeclock events.
    c. Single action - The button will always perform the same action, regardless of the number of times it is pressed.
    d. Dual Action - The button will perform one action on press, and a separately programmable action upon release of the button.
    e. Toggle - The button will toggle between a programmable "ON" state and the default "OFF" state.
5. Additional features available on single action, dual action, and toggle are cycle dim and double-tap.
    a. Cycle Dim - Pressing and holding the button will raise the level of the lighting programmed to that button. Upon releasing the button, the lighting will remain at the new level. By pressing and holding again, the button will lower the lighting programmed to that button. Upon releasing the button, the lighting will remain at the new level.
    b. Double-Tap - A quick double-tap of the button will activate a separately programmable preset.

c. Advanced Toggle - The button will toggle between a programmable "ON" state and a programmable "OFF" state.
d. Manual Sequencing - The button will cycle through multiple presets. The sequence shall be programmable to advance to the next preset on a button press or after a specified amount of time has elapsed.
e. Automatic Sequencing - The button shall play a series of presets in succession and terminate after a given number of loops, a given amount of time, or upon a button press.
6. Raise/Lower
a. Master Raise/Lower - Raise/Lower the last button affected on that keypad
b. Single-Scene Raise/Lower - Raise/Lower the lighting preset assigned to the button.
7. LED status of buttons shall be fully programmable to the following types: Room, Scene, Pathway, Always On, Momentary On, via RS232 LED, and Conditional Logic.
a. Definition - Room
i. LED is on (true) when at least one of the zones programmed on the Press preset is on. Otherwise, the LED is off (false).
ii. Reverse LED logic may be applied. The LED will be off when true, and on when false.
b. Definition - Scene
i. LED is on (true) when all of the zones are at the exact levels programmed on the Press preset. Otherwise the LED is off (false).
ii. Reverse LED logic may be applied. The LED will be off when true, and on when false.
c. Definition - Pathway
i. LED is on (true) when all of the zones programmed on the Press preset are on at any level. Otherwise, the LED is off (false).
ii. Reverse LED logic may be applied. The LED will be off when true, and on when false.
d. Always On
i. LED is always on (true), regardless of what the button does.
e. Momentary On
i. LED is only on (true) while the button is pressed. As soon as the button is released, the LED is off (false).
f. Via RS232 LED
i. LED is turned on (true) and off (false) via RS232 command.
g. Conditional Logic

i. LED will follow Room, Scene, or Pathway logic for the Conditional preset it is assigned to.
8. Control functions can be redefined through the use of system setup software.
B. Standard Keypads
1. Designer Style
a. Shall be available in 5 buttons with LEDs.
b. Shall be available with additional Raise/Lower toggle switch at bottom of keypad.
c. Shall fit Designer-Style Wallplate opening.
2. SeeTouch Style
d. Shall be available in 2,3, 5, and 7 buttons with LEDs and backlit buttons.
e. Shall have Button kits available to customize keypads for 1-7 buttons.
f. Shall be available in an IR Version, dependent upon desired button configuration.
g. IR receiver shall be compatible with infrared transmitters specified by same manufacturer.
h. Shall be capable of 120Vac and 24Vac operation.
i. Buttons are able to be changed in the field.
3. Tabletop Keypads
a. Cordless Tabletop Keypads shall be powered by (2) AAA batteries.
b. Cordless battery-powered Tabletop Keypads shall remain unpowered until a button is pressed, which actuates the device. This conserves battery lifetime.
c. Cordless Tabletop Keypads shall be capable of wake-up and execute a command on first button press or be able to wake up on first button press and then execute a command on second button press

2.16 AUXILIARY CONTROLS AND INTERFACES

A. Shading Interface
1. A shading interface shall be offered such that system can send shades to a precise level, with incremental adjustments of 1/16 of an inch.
2. A single shading interface shall be able to control up to 96 individual shades.
B. Telephone Interface
1. General
a. Telephone interface shall allow a user to activate lighting scenes and other system functions from any touchtone telephone, either inside the home or anywhere in the world.

b. Telephone interface shall allow up to 10 buttons (0 through 9 on the telephone keypad) to be programmed individually.
   c. Custom voice messages may be recorded in the telephone interface to indicate the precise function of each of the 10 buttons.
   d. A user-selected personal access code prevents unauthorized system access.
   e. The telephone interface complies with UL, CSA and FCC regulatory approvals. Any telephone interface that does not comply with these regulatory approvals shall not be acceptable.
2. Mechanical
   a. The telephone interface has a RJ-14 connector for a single phone line from the phone company, and an RJ-14 connector for phones inside the home. The telephone interface may share a phone line with household phones and answering machines. It is compatible with voice-mail services provided by local telephone companies.
3. Electrical
   a. The Ringer Equivalent Number for the telephone interface shall be 0.6A

C. Contact Closure Inputs
   1. Mechanical
      a. Contact Closure Input board (CCI) shall have (8) 2-terminal removable connectors, one per input. Each terminal shall accept up to four #18 AWG (1.0mm^2) wires.
      b. CCI shall contain 1 Infrared receiver compatible with infrared transmitters specified by same manufacturer.
      c. CCI shall have LEDs for diagnostic purposes. 1 LED shall be used for determining if communications are present from the centralized lighting control processor, 1 LED shall flash when IR received, and 1 LED shall flash when valid infrared signals are received.
   2. Electrical
      a. Inputs can be used with ground-referenced, solid-state outputs if the outputs have an on-state saturation voltage of less than 2 VDC at 10 milliamps and an off-state leakage of less than 50 microamps. Dry-contact or solid-state outputs must be capable of switching 15 VDC at 10 milliamps.

D. Contact Closure Outputs
   1. Mechanical
      a. Contact Closure Output board (CCO) shall have (8) 3-terminal non-removable connectors, one per output (normally closed, normally open, and common). Each terminal will accept up to four #18 AWG (1.0mm^2) wires.

b. CCO shall contain 1 Infrared receiver compatible with infrared transmitters specified by same manufacturer.
c. CCO shall have LEDs for diagnostic purposes. 1 LED shall be used for determining if communications are present from the centralized lighting control processor, 1 LED shall flash when IR received, and 1 LED shall flash when valid infrared signals are received. Each output shall have a feedback LED that turns on when the normally-open contact is connected to common.
d. CCO shall have a means of operating in manual control mode. While in manual control mode, the state of each relay shall be able to be toggled by pressing the corresponding button.

2. Electrical
a. Relay Contact Ratings
   i. Up to 30 VDC - Resistive Load 1A, Inductive Load 0.2A
   ii. Up to 30 VAC - Resistive Load 0.5A, Inductive Load 0.1A
b. Normally open and normally closed outputs can be programmed via system software to provide either momentary (pulsed) or maintained (latching) functionality.

E. RS-232
1. Processor shall incorporate (2) RS-232 ports in which to integrate with other RS-232-based devices, upload programming, and perform diagnostics. Manufacturer shall provide the RS-232 protocol required for communication with processor.

F. Ethernet
1. Processor shall incorporate one or more ethernet ports in which to integrate with other ethernet-based devices, upload programming, and perform diagnostics. Manufacturer shall provide the protocol required for communication with processor

G. DMX-512
1. Control shall be capable of converting 256 system zone intensities to 256 continuous DMX-512 channel intensities.

2.17   WIRELESS AUXILIARY CONTROLS AND INTERFACES

A. Visor Control Receiver
1. Visor control receiver shall be able to receive radio frequency command signals from up to 10 visor control transmitters from same manufacturer or equivalent for a total of 70 possible button press combinations.
2. Visor control receiver to have 4 dry contact closure outputs, which are to be triggered only by the visor control transmitter(s) or equivalent.

3. Each dry contact output shall have a manual switch, which can activate the relay.

B. Visor Control Transmitter
1. Visor control transmitter shall have label pockets, which allow for preprinted or custom printed labeling of buttons.
2. Visor control transmitter will have 3 buttons, which can be pressed for a total of 7 different button press combinations.
3. Visor control transmitter shall have an integral antenna, such that it cannot easily be modified.

C. Radio Frequency Contact Closure Input
1. Radio frequency contact closure input shall have 6 contact closure inputs.
2. A local button on the Radio Frequency Contact Closure Input shall be capable of activating the input closure event.

D. Repeater
1. Repeaters shall be available, which will extend RF range and enhance communication reliability of the system.
2. Repeater shall be capable of enabling test mode, which will enable user to verify the RF range of devices.
3. Repeater shall be able to be wired to the processor or another repeater allowing an extension of range over only using RF

2.18 HAND-HELD PROGRAMMER

A. General
2. A Hand-Held Programmer (HHP) may be used on any new or existing installation to reprogram light-level settings stored inside the centralized lighting control processor without the need for a personal computer.
3. System modifications made by the HHP are stored to the central processor immediately, without the need for system uploads, reliance on volatile memory, etc.
4. Allows the lighting designer to alter light levels while in the same space as the lights, not the equipment closet the processor usually resides in.
5. Light levels, fade times and delay times may be adjusted using the HHP

B. Electrical
1. Obtains power from a Class 2 low voltage power supply, thus ensuring electrical safety for the user.

2.19 INFRARED (IR) TRANSMITTERS

A. Five-button Infrared (IR) Transmitter

1. Transmitter shall be capable of recalling 5 preset scenes and raise/lower.
2. Transmitter shall have a range of 50 feet (line of sight) from the IR receiver.
3. Nine-button Infrared (IR) Transmitter
4. Transmitter shall be capable of recalling 9 preset scenes and raise/lower.
5. Transmitter shall have a range of 50 feet (line of sight) from the IR receiver.

B. Two-button Infrared (IR) Transmitter
1. Transmitter shall be capable of recalling 2 preset scenes and raise/lower.
2. Transmitter shall have a range of 30 feet (line of sight) from the IR receiver.

C. One-button Infrared (IR) Transmitter
1. Transmitter shall be capable of recalling 1 preset scene and raise/lower.
2. Transmitter shall have a range of 30 feet (line of sight) from the IR receiver.

2.20   CONTROLLABLE (MOTORIZED) WINDOW TREATMENTS

A. Operation
1. The Electronic Drive Unit shall operate without exceeding a 44dBA Sound Pressure Level (SPL) measured three (3) feet from the motor.
2. The system shall make no audible clicks when the motor starts or stops.
3. For systems with multiple Electronic Drive Units, Drive Units are electronically synchronized and will start, stop and move smoothly in unison at all times.
4. Each Electronic Drive Unit within the system shall store multiple intermediate presets positioned anywhere along the system travel and a full open and full close shade limit. Electronic Drive Unit shall position the shade fabric to ± 1/16" of preset positions.
5. Electronic Drive Unit and system controls shall have a 10 year power failure memory for preset positions, open and close limits, shade grouping, and system configuration.

B. Capacity
1. System shall allow for up to 96 devices per communication link including EDU's, controls and interfaces.

C. Grouping
1. System groups and subgroups can be reconfigured at the point of control without rewiring or access to the Electronic Drive Unit
2. System keypads can control any Electronic Drive Unit, group, or subgroup without requiring Group Controls.

D. Limits and Intermediate Presets
   2. Limits shall be programmable and adjustable from the Electronic Drive Units, wall-mounted keypads, or hand-held infrared transmitters as applicable.
   3. Open and Close limits may be recalled at the Electronic Drive Unit. Preset positions may be recalled by contact closure inputs, keypads, infrared receivers, and lighting control system interfaces.
   4. Preset positions shall be user adjustable with a 5-second button "press and hold" from keypads, infrared transmitters, or contact closure boards. The user adjustment feature can be disabled at the keypad location
E. Protection
   1. System components shall provide appropriate (spike and brownout) overcurrent protection (± 10% of line voltage) for all devices in the system.
   2. The Electronic Drive Unit shall be powered via a UL Listed or UL Recognized Class 2 Power Supply.
F. Integration
   1. The Electronic Drive Unit(s) shall seamlessly integrate with Lutron lighting control systems.
   2. System shall integrate with A/V equipment such as timeclocks and security systems through contact closure inputs
   3. Electronic Drive Unit shall be capable of receiving Infrared (IR) from hand-held transmitters through infrared receivers on a keypad, contact closure interface, or through an IR receiver wired directly to the Electronic Drive Unit.
G. Roller Shades
   1. Mounting
      a. Roller shade brackets shall allow for symmetrical light gaps as small as ¾" on each side of shade.
      b. System shall have a roller shade leveling adjustment that allows level adjustment while the roller shades are mounted to the brackets.
      c. System shall allow a side-to-side adjustment of up to ±3/8" on each side while the shade is mounted to the bracket to properly center shade over the window.
      d. System shall have a projection adjustment of up to 1/2" allowing the shade to clear the trim or move the shade closer to the window in order to have a tighter seal between the fabric and the window.
      e. System dual brackets shall be provided to permit two shades rollers to be mounted in the same opening
   2. Coupling
      a. A single EDU shall be capable of driving multiple shades with a coupling pin. This pin shall allow the adjustment of

the hem bar levels without removing the roller from its installed point or removing fabric from the roller tube.

3. Shade Tube
   a. 2.5" aluminium extrusion
   b. Fabric shall be connected to the tube with double-sided adhesive strip applied for exact and firm mounting of the fabric and for easy adjustment of fabric to prevent telescoping.
   c. A minimum of one turn of fabric will be placed on the roller before the working section of fabric starts, to protect the fabric and smooth out the starting seam.

3. Fabrics
   a. Qualifications
      i. Fire – Provide shade fabrics tested in accordance with: 1989 NFPA 701 small scale Vertical Burn Test and rated "PASS" and 1996 NFPA 701 small scale Vertical Burn (telephone booth test) and rated "PASS."
   b. Manufacturing
      i. Where applicable, shade fabric will be ultrasonically cut and friction sealed to minimize fraying.
      ii. Woven yarn fabrics will be interlocking and heat-treated so that all material is securely bonded.
      iii. Shade Fabric panels shall be 100% visually inspected for defects using a light box integrated into the manufacturing line.
      iv. 100% visual inspections shall be performed on each shade seam and hem bar welds and compared to strict aesthetic standards.
      v. Shade seam weld strength process shall be tested on a daily basis to ensure controlled consistency of weld quality.
      vi. Shade panels shall be 100% checked for squareness (±1/16")
      vii. Shade panels shall be 100% visually inspected to ensure there are no frayed edges or defects in the cut.
   b. Fabric Selection
      i. Light filtering fabrics
      ii. Total blackout fabrics
      iii. Translucent fabrics
      iv. Room darkening fabrics

4. Custom printing
   a. Shade fabric shall be printed with Frank Lloyd Wright prints on white fabric.
   b. Shade fabric shall be printed with Ancient Celtic designs on white fabric.

  c. Shade fabric shall be printed with Toile designs on white fabric.

  d. Shade fabric shall be printed with Abstract Expressionism designs on white fabric.

  e. Shade fabric shall be printed with artwork specified by building end user. Design to be provided in digital (tiff) format.

  f. Shade panels shall be 100% visually inspected to ensure there are no frayed edges or defects in the cut.

5. Light filtering fabrics

6. Total blackout fabrics

7. Hem bar

  a. Standard Sealed Hem Bar shall be a 1" wide by .1875" thick extruded aluminum bar enclosed on all sides in a thermally sealed pocket across the bottom of the shading fabric.

  b. Exposed Hem Bar shall be a 1.375" high by .375" wide aluminum extrusion containing a spline groove at the top to receive and secure the fabric and a "T" slot at the bottom for wool-pile light seal, if desired. Black end caps will be furnished.

8. Control

  a. Shade system shall interface to the lighting system to provide single system control of the natural and artificial light in the space.

  b. Control shall provide two-way communication between Electronic Drive Unit and lighting control system so that system software shall display actual shade position.

  c. System groups and subgroups can be setup or changed without rewiring the system.

H. Tranformers

1. Power Panels

  a. Panels shall be UL Listed Class 2 power supply

  b. Panels shall accept 120VAC hardwired connections and provide centralized, power and communication landing terminals for up to 10 Electronic Drive Units.

  c. Panels shall provide protection to each Electronic Drive Unit with an independent circuit breaker.

  d. Panels shall provide diagnostic LED status indicators to indicate that power and control wiring for Electronic Drive Unit is correct and functioning.

2. J Box mounted transformer

  a. Transformer shall be UL Listed

  b. Transformer shall accept 120VAC hardwired connections and provide power for one Electronic Drive unit

  c. Transformer Shall Provide circuit breaker for each EDU

3. Plug in transformer 100VA

          a. Transformer shall be UL Listed
          b. Transformer shall provide line cord to connect directly to standard 120VAC grounded outlets
    4. Plug in transformer 50VA
          a. Transformer shall be UL Listed
          b. Transformer shall provide integral 3 prong connector to mount directly to a standard 120VAC outlet

PART 3 – EXECUTION

3.01 INSTALLATION

3.02 SYSTEM COMMISSIONING

3.03 WARRANTY AND WARRANTY SERVICE

A. Unless otherwise noted, Manufacturer shall provide an eight-year limited warranty on all equipment supplied. Manufacturer will, at its option, repair or replace any Unit that is defective in materials or manufacturing which, in Manufacturers opinion, has been properly installed, wired, insulated, used, and maintained, within a period of eight years after installation. Credit will be granted against the purchase price for replacement parts according to the following schedule:
    For the first 2 years from the date of installation 100%
    For years 3, 4, and 5 from the date of installation 50%
    For years 6, 7, and 8 from the date of installation 25%

B. Warranty coverage shall begin from the date of final system commissioning or three months from date of delivery, which ever comes first.