

Designing a WaveLinx Wireless Connected Lighting System

The WaveLinx Wireless Connected Lighting system from Eaton enables the design and construction community to achieve code compliance and create an IoT-capable infrastructure that runs throughout the building, while saving an extraordinary amount of time and money on installation and commissioning. Today's code-compliant commercial lighting control system often consists of, at a minimum, lighting fixtures, occupancy/vacancy sensors, daylighting sensors, wallstations, and controlled receptacles. In a traditional wired lighting control solution, separate control wires are physically run to connect every light fixture, sensor, wallstation, control panel, and controlled receptacle, creating an expansive and expensive structure of control wiring that must be pulled through the walls and the plenum of the building. New wireless lighting control systems replace the obtrusive and increasingly complex control wiring with a secure and reliable wireless signal. While basic power wiring must be provided to the components that are not battery-powered, the lighting control system communicates wirelessly.

The wireless nature of the WaveLinx system offers incredible flexibility in its design. System layout and device placement is constrained only by the wireless communication range and capacity of the system coordinator and the devices it manages. This application note provides an overview of the various WaveLinx devices and outlines special considerations and best practices to guide the design of this wireless and connected lighting system.

Components of a WaveLinx Wireless Connected Lighting System

The WaveLinx system is comprised of wireless area controllers, WaveLinx-integrated and WaveLinx-enabled luminaires, occupancy and daylight-responsive sensors in various configurations, relay switchpacks, controlled receptacles and wallstations that communicate using a wireless standard, developed by the Institute of Electrical and Electronic Engineers (IEEE), referred to as IEEE 802.15.4. The WaveLinx mobile app dramatically simplifies the set-up and commissioning process by offering default system settings compliant with the latest Title 24 energy code. The app also serves as a maintenance resource and point of individual control, once the system is operational.

WaveLinx Wireless Area Controller

The WaveLinx wireless area controller is the main controller and coordinator of the WaveLinx Wireless Connected Lighting system. This device receives signals from the sensors and wallstations and issues the commands that cause the lighting system to respond in accordance with the control intent of the system. This device also functions like the gateway devices found in other wireless systems, creating a bridge between two or more networks.

Impressive System Capacity and Range

The WaveLinx wireless connected lighting system offers a greater system capacity and a broader system range than most available wireless lighting control systems. Each WaveLinx wireless area controller can manage up to 200 wireless devices, dwarfing many other wireless coordinators and gateways that max out when 50 devices are connected. The wireless area controller also offers a maximum device communication range of up to 300 feet, enabling WaveLinx systems to more easily meet the unique needs of any project when compared with wireless systems that are confined within a much smaller footprint.

Interface with 802.15.4, Wi-Fi and Ethernet

The WaveLinx wireless area controller can serve as an interface between the IEEE 802.15.4 standards-based wireless connected lighting system and other building systems or IT networks via Wi-Fi or Ethernet connections.

Power over Ethernet (PoE) Options

There are two different models of the WaveLinx wireless area controller, each suited for a unique installation scenario. When the wireless area controller will be interfacing with an enterprise network that is PoE-based, and existing PoE ports are available, the wireless area controller (WAC-POE) can be connected to the PoE port and receive its power over the Ethernet. If there is no existing PoE switch or available PoE port, then it is important to select the model that includes a 120V-to-PoE converter (WAC-120). A stand-alone converter is also available (WPOE-120) in case the wrong wireless area controller is ordered and it is discovered that a converter is needed when on the project site.

Product Name	Catalog Number	Product Description
WaveLinx Wireless Area Controller	WAC-POE	Wireless Area Controller, PoE powered
WaveLinx Wireless Area Controller	WAC-120	Wireless Area Controller, 120V powered, includes a 120-PoE converter
Converter	WPOE-120	120-to-PoE Converter



Powering Business Worldwide

WaveLinX-Integrated Luminaires

The WaveLinX-integrated luminaire is an LED fixture that contains a WaveLinX wireless integrated sensor. The integrated sensor operates the fixture in the occupancy and daylight-responsive manner now required by the most stringent energy codes and collects and shares data about the use and performance of the space over a wireless sensor-based network. The specification of WaveLinX-integrated luminaires, over basic LED fixtures, transforms a highly-efficient lighting system into a code-compliant IoT-capable infrastructure that runs throughout the building and provides the foundation for future value-added IoT applications.

Although technologically advanced, the WaveLinX lighting system is easier to design and install than typical LED lighting and controls systems. WaveLinX-integrated luminaires are assembled in the factory and arrive onsite preconfigured and ready to be installed. The installation of a WaveLinX-integrated luminaire is identical to the installation process of a standard LED fixture. One advantage of the WaveLinX wireless connected lighting system is that the lighting controls (the sensors, wallstations, controlled receptacles, and relay switchpacks) communicate wirelessly. While power wiring must be run to the fixture, the control of the WaveLinX-integrated luminaire is completely wireless. No additional control wires are necessary.

There are many LED luminaires from Eaton available in WaveLinX-integrated models and the product offering continues to grow. The table below identifies fixtures that can be specified to include the WaveLinX wireless integrated sensor as of May 2017. Please refer to eaton.com/WaveLinX for a complete and updated list. Fixtures not available in a WaveLinX-integrated model can still be included in the WaveLinX wireless connected lighting system. These fixtures become WaveLinX-enabled when they are controlled by the WaveLinX tile-mount daylight sensor or the WaveLinX relay switchpack.

Available as WaveLinX-integrated Luminaires		
Lighting Product Family	Fixture Series	Fixture Type
Metalux	ArcLine™ LED Series	Recessed
		Surface
	ArcLine-R LED Series	Recessed
	Encounter™ LED Series	Recessed
	Encounter™ High Performance (HP) LED Series	Recessed
	SkyRidge™ LED Series	Recessed
Corelite	Bridge WaveStream™ LED Series	Recessed
	Divide WaveStream™ LED Series	Recessed
		Suspended
	Element WaveStream™ LED Series	Suspended
	Iridium i2 WaveStream™ LED Series	Suspended
	JAYLUM LED Series	Suspended
		Wall
		Sconce
	Loft WaveStream™ LED Series	Suspended
	Minigator WaveStream™ LED Series	Suspended
	Vertechs WaveStream™ LED Series	Suspended
RSA	MRZ LED Series* (multi-head recessed integral LED)	Recessed

*Available in 2017

WaveLinX Tile-Mount Daylight Sensor

If a project includes Eaton fixtures that cannot accommodate an integrated sensor, or fixtures from another manufacturer, a WaveLinX tile-mount daylight sensor is available to incorporate these fixtures into the larger WaveLinX system and provide the daylight-responsive controllability and continuous dimming required by the latest energy codes. Each tile-mounted sensor is installed onto a ceiling tile and tethered to a 3A control unit with a low-voltage wire. A 0-10V control wire runs from the control unit to connect all of the fixtures that will respond to the tile-mounted daylighting sensor.

Product Name	Catalog Number	Product Description
WaveLinX Tile Mount Daylight Sensor	TM-SWPD1	Tile-mounted sensor, cable and control unit

The WaveLinx tile-mount daylight sensor is compatible with many luminaires from Eaton and other lighting manufacturers. One sensor can control a LED or non-LED load of up to 3A.

Lighting Product Family	Compatible with the WaveLinx Tile-Mounted Sensor
Portfolio (from Eaton)	All 0-10V LED Downlights and Cylinders
Halo Commercial (from Eaton)	All 0-10V LED Downlights
Other Lighting Manufacturers	Any 0-10V LED Fixture Less than 3A with a 2mA draw

WaveLinx Relay Switchpack with 0-10V

The WaveLinx relay switchpack with 0-10V is installed on the power wire that runs to the lighting fixtures. The relay switchpack receives signals from the wireless area controller that tell it how to modify the power distributed to the attached fixtures. Each WaveLinx relay switchpack can control up to 20A of lighting or receptacle load on a circuit and provides 0-10V dimming control of lighting zones, up to 120 mA, which is typically is enough capacity to control up to twelve fixtures per device.

Product Name	Catalog Number	Product Description
WaveLinx Relay Switchpack	WSP-MV-010	Relay Switchpack with 0-10V Output

WaveLinx Wallstations

The WaveLinx wallstation provides scene-based control that operates individual zones of light or recalls programmed scenes within an area.

Programmed by the WaveLinx mobile app, the wireless wallstation communicates with the WaveLinx lighting system over the IEEE 802.15.4 standards-based wireless network. While power wiring must be run to the wallstation, no physical control wires are needed to carry signals from the wallstation to the lighting.

These wireless wallstations are available in multiple button configurations and color options. Designers can select from large or small button formats and include a raise/lower bar, if desired. Customized engraving is available to precisely match the button text with the programmed settings of the wallstation. Available colors include: white, black, gray and ivory.

Please refer to WaveLinx wallstation data sheets for detailed ordering information.

Product Name	Number of Buttons	Button Size	- Raise/Lower	- Color
WaveLinx Wallstation Wireless (W)	1 Button (1)	Large (L)	Raise/Lower	White (W)
	2 Button (2)	Small (S)	(RL)	Black (B)
	3 Button (3)			Gray (G)
	4 Button (4)			Ivory (V)
	5 Button (5)			
	6 Button (6)			

WaveLinx Receptacle

The WaveLinx receptacle provides the automatic receptacle control now required by many energy codes. The duplex receptacle is designed to turn the top outlet on and off in response to occupancy, saving plug load energy when the room is unoccupied. The lower outlet remains constantly on. The controlled outlet is clearly labeled and communicates wirelessly with the WaveLinx connected lighting system. While the receptacle must be wired for power, no control wiring is necessary.

Product Name	Catalog Number	Product Description
WaveLinx Receptacle	WR-15	Receptacle 15A
*WaveLinx Receptacle	WR-20	Receptacle 20A

*Available in 2017

WaveLinx Ceiling Sensor

The WaveLinx ceiling sensor is a completely wireless PIR occupancy sensor that can be affixed to any surface and provides occupancy-based control for multiple fixtures in a room. The sensor has a 1500 square foot coverage area and is battery powered. These features allow the WaveLinx ceiling sensor to be placed where needed and associated with the appropriate WaveLinx devices using the WaveLinx mobile app. Equipping a space for code-mandated occupancy response has never been faster or more efficient.

Product Name	Catalog Number	Product Description
WaveLinx Ceiling Sensor	CWPD-1500	Wireless Ceiling Sensor, 1500 sq. ft.

WaveLinx Mobile App

The WaveLinx mobile app is used to commission, control, and view the power consumption of the WaveLinx connected lighting system from smartphones and tablets. This mobile app enables contractors to ensure the WaveLinx system components have been installed correctly and streamlines the process of defining and programming the functionality of the system into a few simple steps, allowing a code-compliant lighting system to be commissioned quickly with drag-and-drop ease. Once operational, lights can be controlled directly through the mobile app, enabling users to turn lights on and off, select lighting scenes, or change lighting schedules from a personal mobile device. The real-time power consumption of the lighting system can also be viewed. The WaveLinx mobile app is compatible with devices running on an iOS 9+ or Android 5+ operating system.

Construction Grouping

The patent-pending Construction Grouping capability eliminates guesswork during installation by enabling contractors to prove that the WaveLinx system works. The quick system start-up provides a visual confirmation verifying that the different system components have been installed correctly and are functioning as expected. Basic occupancy sensing and wallstation control functionalities are also initiated during this process that can save lighting energy during the construction phase of the project.

Automatic Code Commissioning

During the commissioning phase of a project, the sequence of operations for the lighting system must be defined, so that the system will function in a code-compliant manner. Then the system must be programmed to perform as defined. Regardless of whether a lighting system must comply with ANSI/ASHRAE/IES Standard 90.1, IECC, or the most stringent Title 24 energy code, commissioning the system is one of the most challenging, time-consuming, and costly aspects of a lighting project. The WaveLinx system eliminates the cost and complexity of lighting system commissioning with the Automatic Code Commissioning feature on the WaveLinx mobile app.

Automatic Code Commissioning streamlines the process of defining code-compliant performance and the subsequent programming of the system into two easy steps. Using the WaveLinx mobile app, on a mobile device, create the different areas of the project. Then drag and drop the icons that correspond to the installed WaveLinx devices into the appropriate areas. Once the WaveLinx devices have been laid out in the app, the Automatic Code Commissioning feature automatically programs the devices to function in compliance with the latest Title 24 energy code. Defaulting system settings to comply with the most stringent energy code ensures that the system will perform in compliance with whichever standard has jurisdiction over the project.

Multi-Tiered Security in a WaveLinx Wireless Connected Lighting System

Security was a key consideration in the design of the WaveLinx Wireless Connected Lighting system. Input from Eaton's specialized Product Cybersecurity Center of Excellence, industry best practices, and measures recommended by the Department of Homeland Security (DHS), National Institute of Standards and Technology (NIST), and the Federal Information Processing Standard (FIPS) formed the tenets used in the development of this secure and reliable wireless solution. The system features a multi-tiered approach to security aimed at preventing unauthorized users and devices from gaining system access, minimizing the potential impact that an attack could have on the system, if a breach does occur, and allocating dedicated talent and resources to the ongoing pursuit of making and maintaining products that provide a robust defense against the ever-evolving landscape of cyber attacks.

In total, the WaveLinx Wireless Connected Lighting solution protects the integrity of its system and the other building systems with which it interfaces with seven layers of cyber defense. They are:

- Physical security
- Customer security
- Device security
- Network security
- Network segmentation
- OTA update security
- Security updates and information from Eaton's Product Cybersecurity Center of Excellence

A Note about Physical Security

One potential threat outside the scope of what the WaveLinx system can actively prevent is physical access to the system once it has been installed on a project. While the wireless area controllers have been designed to be installed in the plenum areas or wire-tied in a suspended ceiling, making the components hard to find and difficult to access, implementing additional on-site access control policies intended to prevent unauthorized users from accessing these devices is an important step in securing the integrity of the WaveLinx lighting system and the enterprise systems with which it interfaces.

Achieving Code Compliance with a WaveLinx Lighting System

The WaveLinx Wireless Connected Lighting system provides the functionality required by the latest ANSI/ASHRAE/IES Standard 90.1-2016, the International Energy Conservation Code (IECC) 2015, and California's Title 24 2016. This system is equipped to provide code-mandated and high-efficiency lighting control functionalities that include: occupancy-based/vacancy control, daylight-responsive control, partial on, partial off, automatic receptacle control, continuous dimming, multi-level lighting, high end tuning, scheduling, energy metering, personal control, UL 924 emergency control, demand response, and HVAC integration.

Designing a WaveLinx Wireless Connected Lighting System

The most critical consideration when designing a WaveLinx Wireless Connected Lighting system is the placement of the various WaveLinx devices in the network. Designers must ensure that devices are placed within communication range of the other devices and that a sufficient device density is achieved to maintain the integrity of the wireless structure.

Device Placement and Range Best Practices

Here are some general guidelines on the optimal and maximum spacing that is recommended between WaveLinx devices.

Placement Considerations	Best Practice	Maximum
Wireless Area Controller Range	150 feet-250 feet line-of-sight	300 feet line-of-sight
Number of Interior Walls	2 walls	3 walls
Distance from Wireless Area Controller to 1st WaveLinx Device	150 feet	200 feet
Distance between WaveLinx Devices	75 feet	150 feet
Number of Areas per Wireless Area Controller	16	16
Number of Zones per Area	3	16
Number of Scenes per Area	6	6

An area: A unique space within the system where the lighting control strategy and lighting settings can be defined. Private office, open office space, bathroom, etc.

A zone: An individual light or group of lights that are controlled together. For example, a private office with two overhead lights, where one will be daylight-responsive, and a controlled receptacle has three zones.

A scene: Specific settings for each zone within an area that contribute toward creating a certain scene or ambience.

Wireless Area Controller Placement and Density

Each wireless area controller has a recommended communication radius of 150 feet line-of-sight (LOS), a maximum range of 300 feet LOS, and a system capacity of 200 devices. This generally means that all wireless devices that will be paired with a wireless area controller must be within 300 feet of the unit and located on the same floor.

The wireless area controller can be mounted in many locations. It can be mounted on a wall, mounted on a DIN rail, wire-tied in a suspended ceiling, or installed in the plenum. The PoE nature of this device makes it a good practice to place the wireless area controller near available PoE ports, if they are available. Avoid placing the wireless area controller near a large, metal surface or inside a NEMA enclosure, as it may disrupt the transmission of the wireless signal. The wireless area controller may be placed inside a plastic or fiberglass enclosure.

It is also important to note that the wireless area controller should be located on a separate branch circuit from the devices it controls.

WaveLinx Device Placement

The physical placement of a WaveLinx device in the wireless network is limited primarily by the communications range of the WaveLinx wireless area controller and the other devices in the network. In a best practice scenario, it is generally recommended that the distance between the wireless area controller and the WaveLinx devices it manages not exceed 150 feet and that the distance from WaveLinx device to WaveLinx device not exceed 75 feet. The wireless area controller can manage up to 200 devices placed within its communication range.

Mobile Device Planning

The use of the WaveLinx mobile app is constrained only by the Wi-Fi available in the building to connect the personal mobile device to the wireless area controller. Users expecting to use the WaveLinx mobile app to commission or control the WaveLinx system should ensure the appropriate functionality and range of their personal mobile device to connect with the wireless area controller.

Recommended Approach to WaveLinx System Design

1. Select and layout system fixtures.
2. Place wallstations and receptacles.
3. Add relays, ceiling sensors, tile-mount daylight sensors
4. Identify location of the WaveLinx wireless area controller.
5. Confirm devices are within 150 ft. communication radius of the wireless area controller.

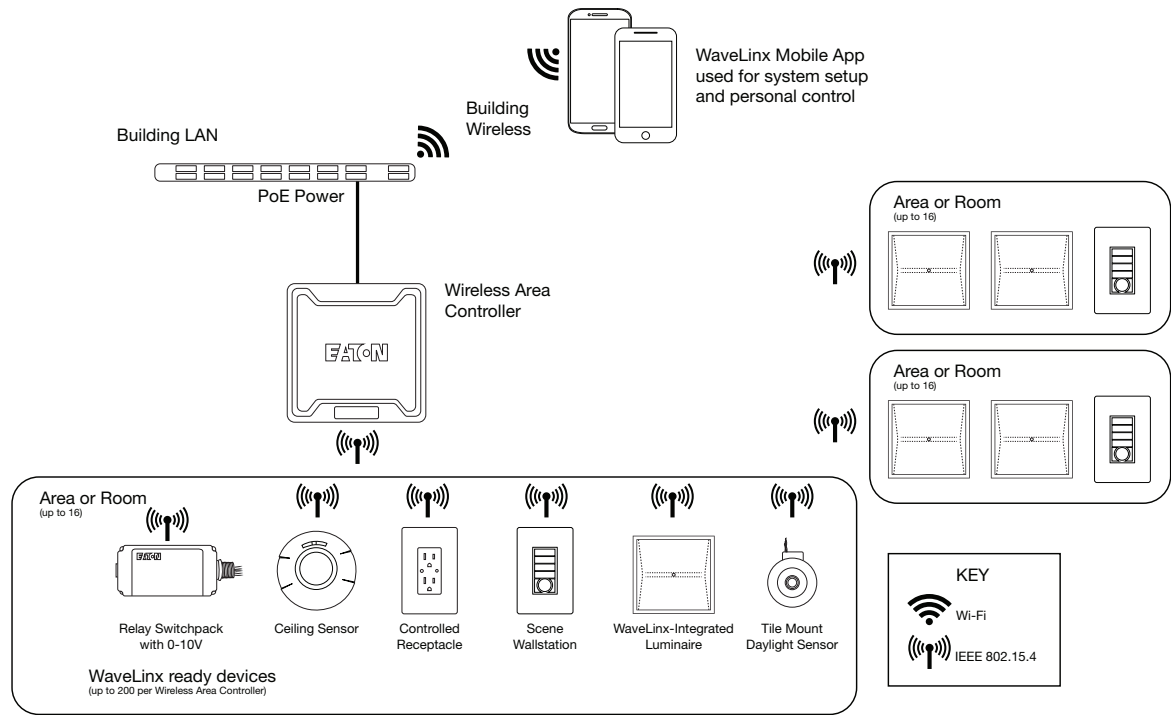
General WaveLinx Design Example

Here are a few questions to guide the selection of WaveLinx devices necessary to deliver the desired lighting performance in an area. The answers to these questions will help to identify the type of fixtures and number of devices that should be included on the bill of materials (BOM).

1. Does the area need daylighting control?
 - a. If yes, choose WaveLinx-integrated luminaires or fixtures that connect to a tile-mount daylight sensor.
 - I. If WaveLinx-integrated luminaires were selected, specify the number of fixtures. No additional relay switchpacks with 0-10V are needed.
 - II. If tile-mounted sensors were selected, specify one tile-mounted sensor for every 3A of lighting.
 - b. If no: move to question 2.

- 2. Does the area require occupancy control?
 - a. If yes, choose WaveLinx-integrated luminaires or a WaveLinx ceiling sensor.
 - I. If WaveLinx-integrated luminaires were selected, specify necessary number of fixtures.
 - II. If WaveLinx ceiling sensors were selected, specify 1 ceiling sensor for each room or for 1500 square feet in an open area. Also, specify 1 relay switchpack with 0-10V for every 20A of fixtures that will be controlled by the sensor.
 - b. If no: move to question 3.
- 3. Does the area have at least one WaveLinx receptacle?
 - a. If yes, the room will need WaveLinx-integrated luminaires or a WaveLinx ceiling sensor.
 - b. If no, move to question 4.
- 4. Does the area require manual control?
 - a. If yes, a WaveLinx wallstation must be specified.

System Architecture



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