# Key Considerations for
# Smart Light Switch Development

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## Introduction

In this whitepaper, co-authored by [Silicon Labs](#) and [Jasco Products](#), we discuss some of the most important considerations to keep in mind when designing a smart light switch, from hardware selection to determining which features to include in the final product. We'll also discuss the size of the device and regulatory requirements because these will influence so many of your design considerations. Finally, we'll explore some of the benefits of choosing a capable technology partner and how this relationship can reduce cost, simplify complex regulatory and supply challenges, and speed up time-to-market.

# Lighting: Yesterday, Today and Tomorrow

One of the questions that tends to get overlooked when designing a smart lighting device – light switches in particular – is to consider what exactly is being replaced in the home. Not just in terms of the technology, but the experience as well. Lighting has been slow to change over the years, with the same basic on/off toggle switches being used for the last century. We've grown so used to the instantaneous accessibility to light that we practically take it for granted. Today's smart switches – in addition to delivering that tried-and-true reliability – can also be controlled wirelessly and perform complicated operations like controlling different light levels in different rooms at the same time.
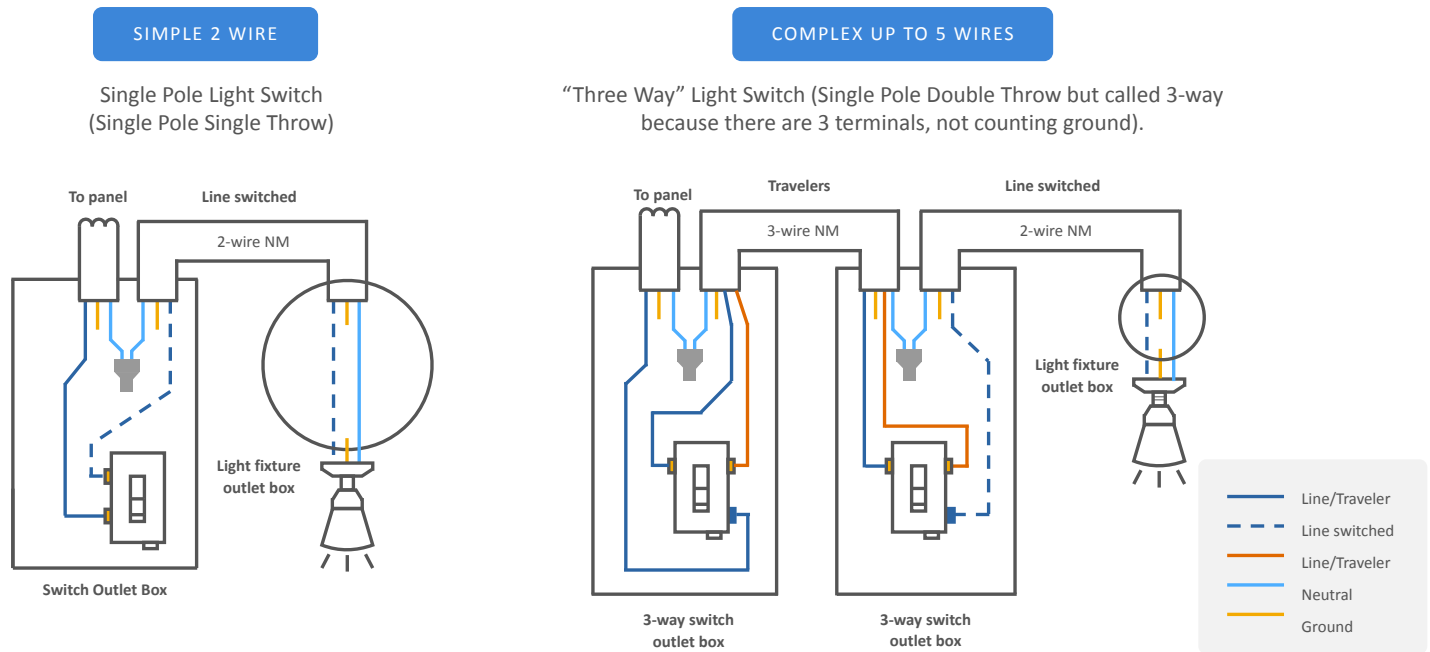
**SIMPLE 2 WIRE**

Single Pole Light Switch
(Single Pole Single Throw)

**COMPLEX UP TO 5 WIRES**

"Three Way" Light Switch (Single Pole Double Throw but called 3-way because there are 3 terminals, not counting ground).

**Figure 1:** Common Residential Light Switch Configurations

The next generation of smart switches incorporates light, motion and temperature sensors, as well as microphones for operation with digital assistants that will be much better integrated into their surroundings. The two most common residential lighting configurations are illustrated in the diagram below. On the right is a standard single pulse switch with two physical connections on the switch, and a three-way switch that has three connections. These can present problems for DIY installation because it can be difficult to distinguish between line and load wires.

In the image below you can see a tear down of a standard toggle switch. UL, the regulatory body responsible for compliance, requires these devices pass a battery of tests including overload testing, temperature rise testing and endurance testing. This means anything that goes into a wall to replace a standard toggle switch also needs to pass the same basic requirements. This puts pressure on smart switch manufacturers to be sure the suppliers they use are building their components based on the original specs sent to UL. It's not uncommon to discover small changes made during the process have resulted in performance to slip.
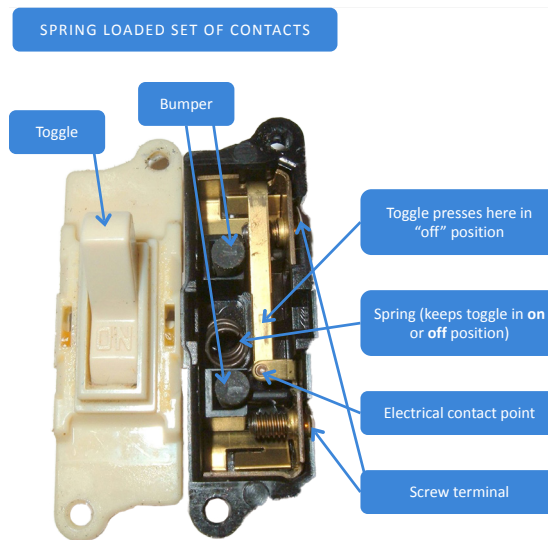


**Figure 2:** Manual Switch Teardown

## Anatomy of a Smart Light Switch and the Importance of Knowing Your Components

In the image below you can see a standard Zigbee-based Jasco switch. This as a single PCB with a high level of integration of surface-mount components. That integration allows Jasco to reduce the housing size by 20 percent from previous models. UL requires 6K or 10K cycles for overload and reliability testing and Jasco aims for at least 40K cycles. One of the ways they do that is to monitor the zero crossing of the sine wave, then switch the relay as close to a mil-load operation as possible. One way to ensure high wireless performance is by using pre-certified modules (keep reading to find out more). For this example, three-way switching and dimming are two of the requirements, so we made sure to have at least a three-hundred-foot loop distance from the main power device to the auxiliary switch. Because it is a dimmer, the user should also be able to dim the light from a remote location. We achieve that by using Jasco proprietary auxiliary switches.
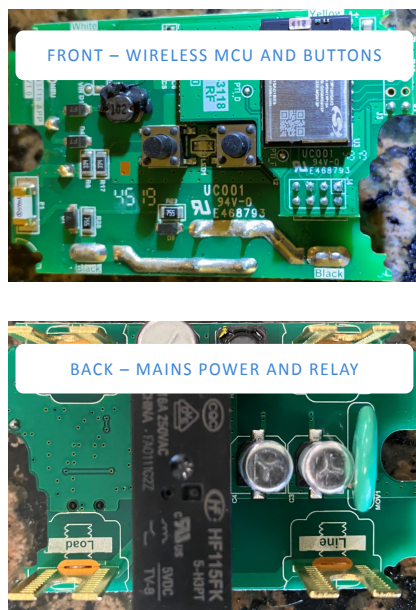


| Design Requirements | Target | Method |
| --- | --- | --- |
| Size of switch | Smallest chassis design | Proprietary |
| Reliability | 40000 ON/OFF Cycles | Switch at zero crossing |
| Wireless Capability | Z-Wave, Zigbee, Wi-Fi | Star or Mesh |
| Switch Type | 2-Way/3-Way | Primary/Secondary Node |
| RF Distance | 300ft (Line of Sight) | Based on RF design |
| 3-Way Wire Length | 300ft Loop | Proprietary (can dim from secondary node) |

**Figure 3:** Smart Switch Teardown and Design Considerations

The image below shows an exploded bill of materials (BOM) for this particular switch, and as you can see there are a lot more components than would come with a simple toggle switch. Being familiar with every element in the BOM is important because you'll need to be confident in the subcomponents that are coming from other manufacturers. Being particular about the use of high-quality materials is critical because it will help ensure these devices are UL-recognized or UL-listed, and everything needs to meet the strength and flammability requirements set by the local electrical code, as well.
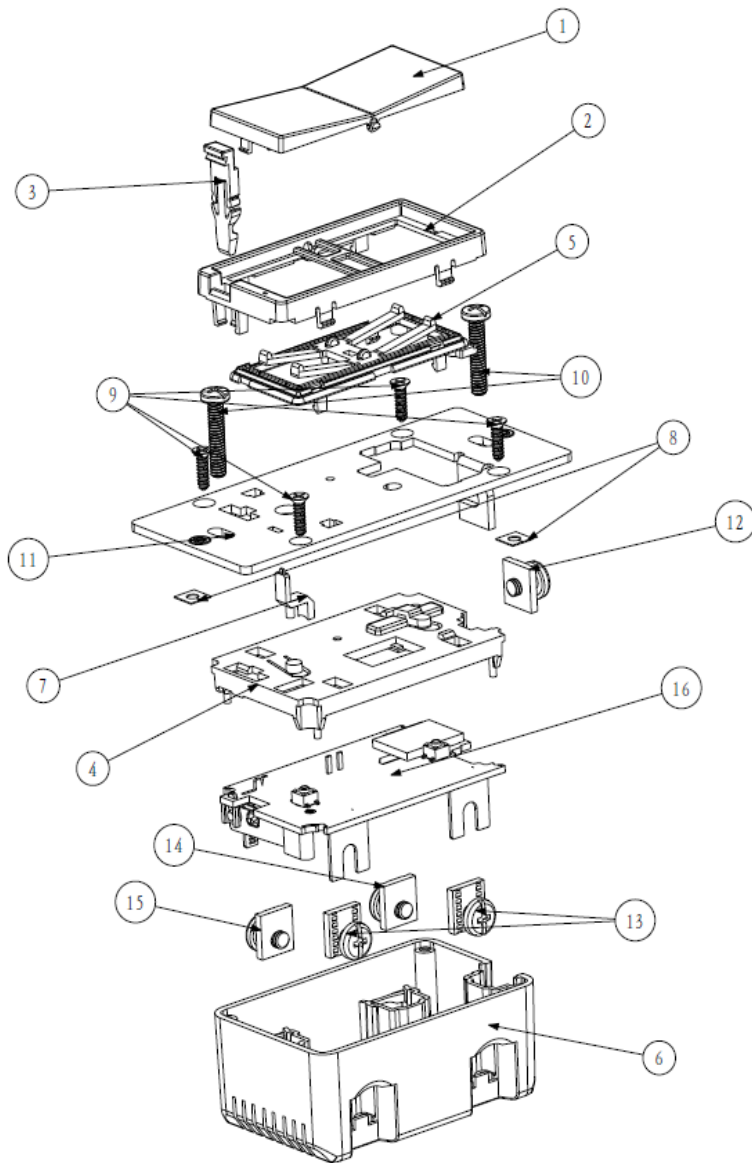


| Number | Description | Quantity |
|---|---|---|
| 1 | Paddle Cover | 1 |
| 2 | Top Frame | 1 |
| 3 | Air Switch Actuator | 1 |
| 4 | Middle Cover | 1 |
| 5 | Antenna Cover | 1 |
| 6 | Bottom Cover | 1 |
| 7 | Light Guide | 1 |
| 8 | Mylay Film | 2 |
| 9 | Screw KA2.6X10 Ni | 4 |
| 10 | Screw UNC #6-32*3/4 | 2 |
| 11 | Yoke | 1 |
| 12 | Green Screw | 1 |
| 13 | Black Screw | 2 |
| 14 | Yellow Screw | 1 |
| 15 | White Screw | 1 |
| 16 | PCBA Assembly | 1 |

**Figure 4:** Switch/Dimmer Assembly and BOM

## Navigating Regulatory Requirements

Below is a typical block diagram that illustrates the regulatory requirements for each component. All devices will have an AC-DC power supply, which is typically going to be a simple switch mode device that will need to meet regulatory requirements for spurious emissions. And as we mentioned earlier, it's going to need components that are UL-recognized. This example is a Z-Wave device with a pre-certified Silicon Labs 700-series Z-Wave module.
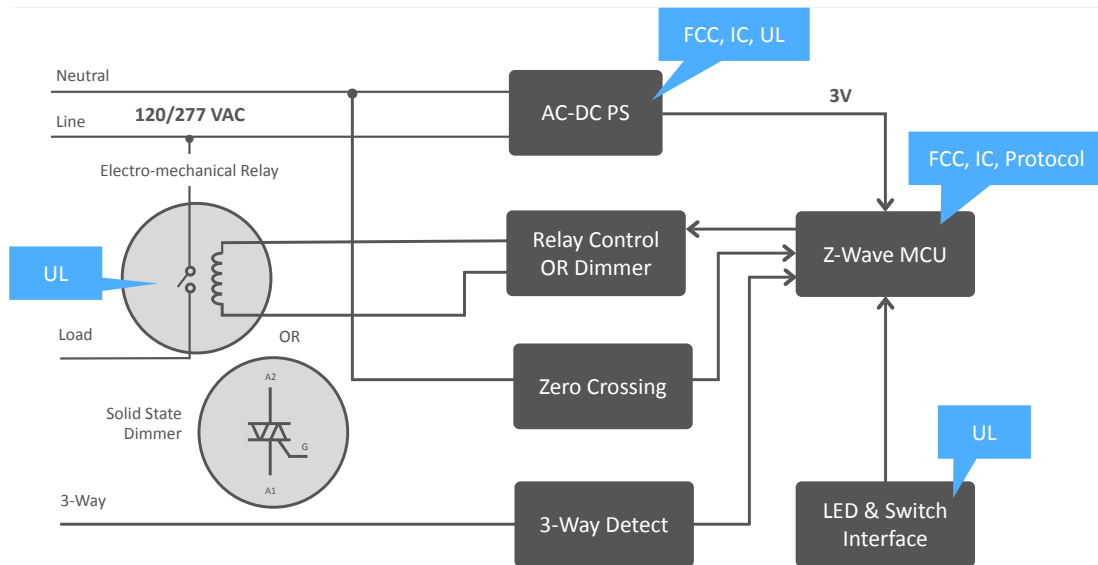


**Figure 5:** Block Diagram – Smart Switch or Dimmer

One design consideration that will impact regulatory qualification and user experience is the placement of the LED and switch interface. It's important to position these components so that they are accessible to the consumer and can also pass an impact test. The switch device, or whatever component is handling the power, will need to be UL recognized. If your design includes a TRIAC dimmer, the filtering of the dimmer is going to also require testing by the FCC. As you can see, this is a regulatory-intensive process. Regulatory is one of the most overlooked aspects of the design process, yet it is critical. No matter how useful a product may be, if it doesn't meet regulatory requirements then it's not going to make it to market.

Below is the flowchart that UL provides to explain the certification process in more detail. As you can see, it's a thorough process with a lot of interaction between the developer, the customer and UL. It can be overwhelming and frustrating but knowing the standards that are going to apply to your product ahead of time and writing your UL submission in advance can make a big difference in getting the product listed quickly. The typical UL estimate for project completion is listed at 8-10 week, but if you haven't designed the product to pass the testing up front, it's likely to take a lot longer.
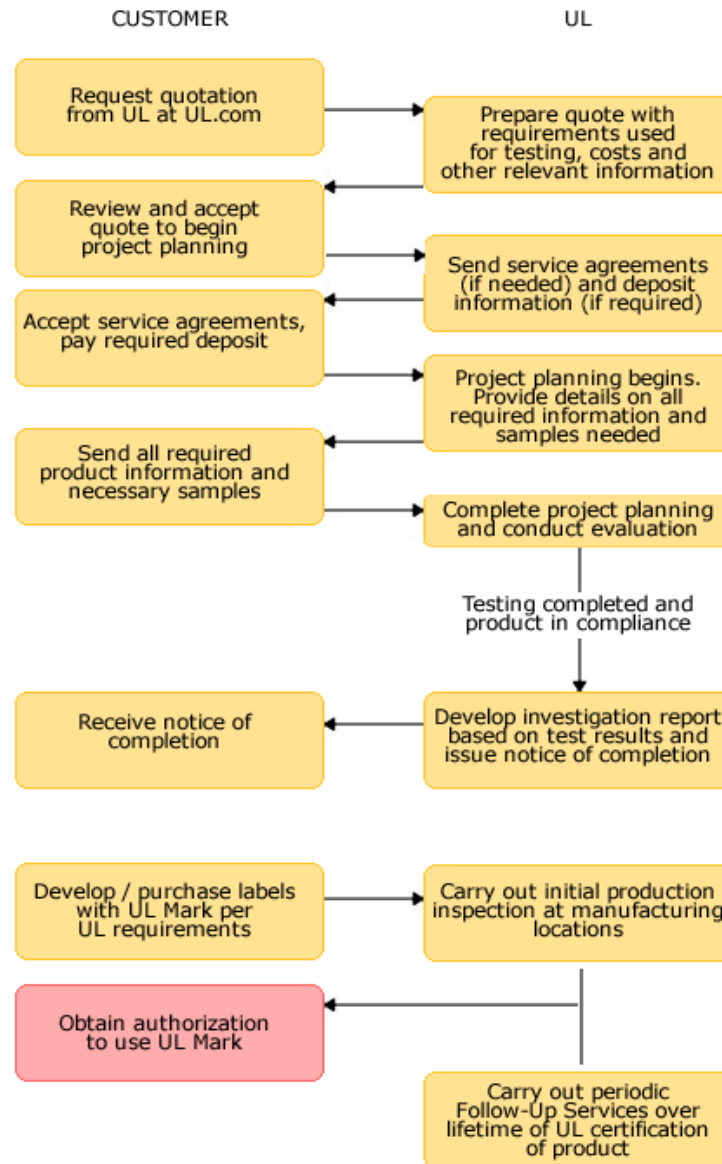


**Figure 6:** UL Testing Requirements

While the requirements for certification are quite complex, they can be grouped into two main categories: RF Regulatory Certification and Standards Certification. RF Regulatory requirements are driven by the market where the product is being sold. For example, if you're building a device in the US to sell to UK markets, you need CE certification. The second part of this, Standards Certification, is driven by the standards bodies responsible for those specifications such as the Zigbee Alliance and the Bluetooth Special Interest Group, or SIG. Silicon Labs' pre-certified modules have the RF regulatory certifications, and the software stacks are also certified to the respective standard. Pre-certified modules reduce time-to-market and reduce the required BOM such as crystals, inductors, and caps, enabling you go to fast through standards certification.
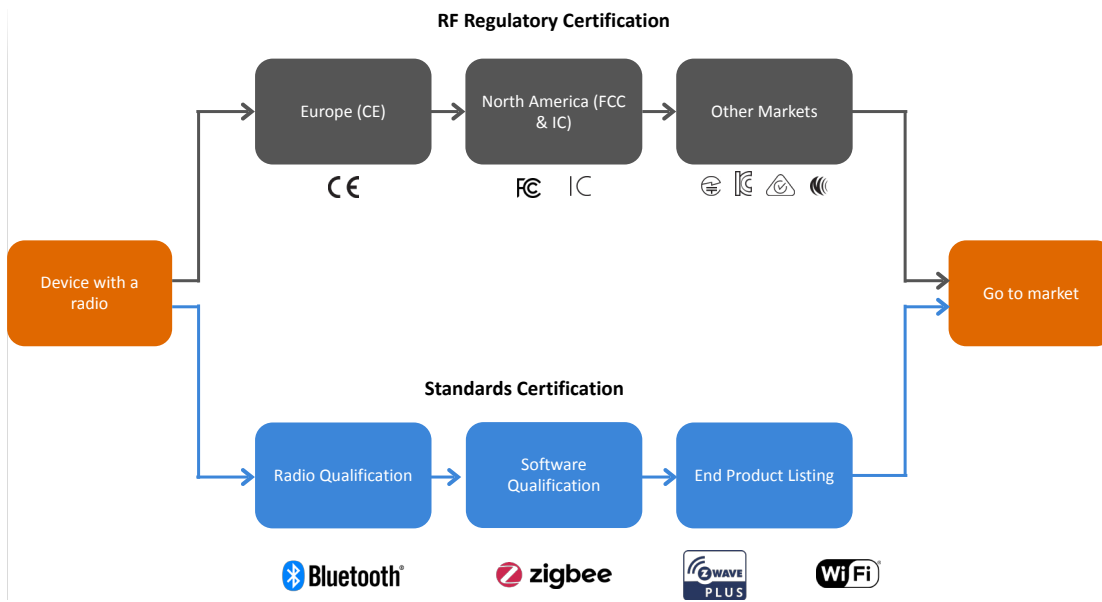
**Figure 7:** Process for Wireless Certification

There are two primary approaches to get your product certified: First, the classic certification approach is used in countries such as the US, Canada, Japan, and Korea, and the end product will inherit the module approval. OEM's need to test their end device. Full testing is not required. Spot checking is generally sufficient.

The second approach named Decoration of Conformity (DoC) or self-certification applies to countries in the EU, Australia and New Zealand. OEM will test internally and at an accredited lab and file a DOC. Silicon Labs provides its own DoC and test There There are two primary approaches to get your product certified: First, the classic certification approach is used in countries such as the US, Canada, Japan, and Korea, and the end product will inherit the module approval. OEM's need to test their end device. Full testing is not required. Spot checking is generally sufficient.



**Figure 8:** Global RF Regulatory Bodies

The second approach named Decoration of Conformity (DoC) or self-certification applies to countries in the EU, Australia and New Zealand. OEM will test internally and at an accredited lab and file a DOC. Silicon Labs provides its own DoC and test reports for the modules. However, the OEM has full legal responsibility for the product, so we recommend the OEM test the end products to prove compliance.

There are also elements beside certification to a smart light switch that aren't regulated but are worth incorporating for customer satisfaction. For example, customers like being able to customize the dimming rates or having indicator lights that can be configured as always off. Button feedback is also important to the user experience. There's a maximum time that someone wants to wait for a response - if it's too long it will seem like it's not working properly.

# The Advantages of a Mesh Networking Topology

A mesh networking topology presents several advantages when developing smart lighting devices, including reliability, low power, and its ability to enable other smart applications. Limited or discrete mesh sensors also offer extensibility as more sensors join the network. In the diagram below, the top portion indicates how a single switch can enable a custom scene to run or when a manual 'on' event occurs. The bottom portion indicates how smart sensors such as an occupancy sensor can automatically initiate the custom scene and also automatically turn it off, helping to save energy when the system is not in use. This is a simple but powerful example of the power of automation to add comfort while also enabling energy savings.
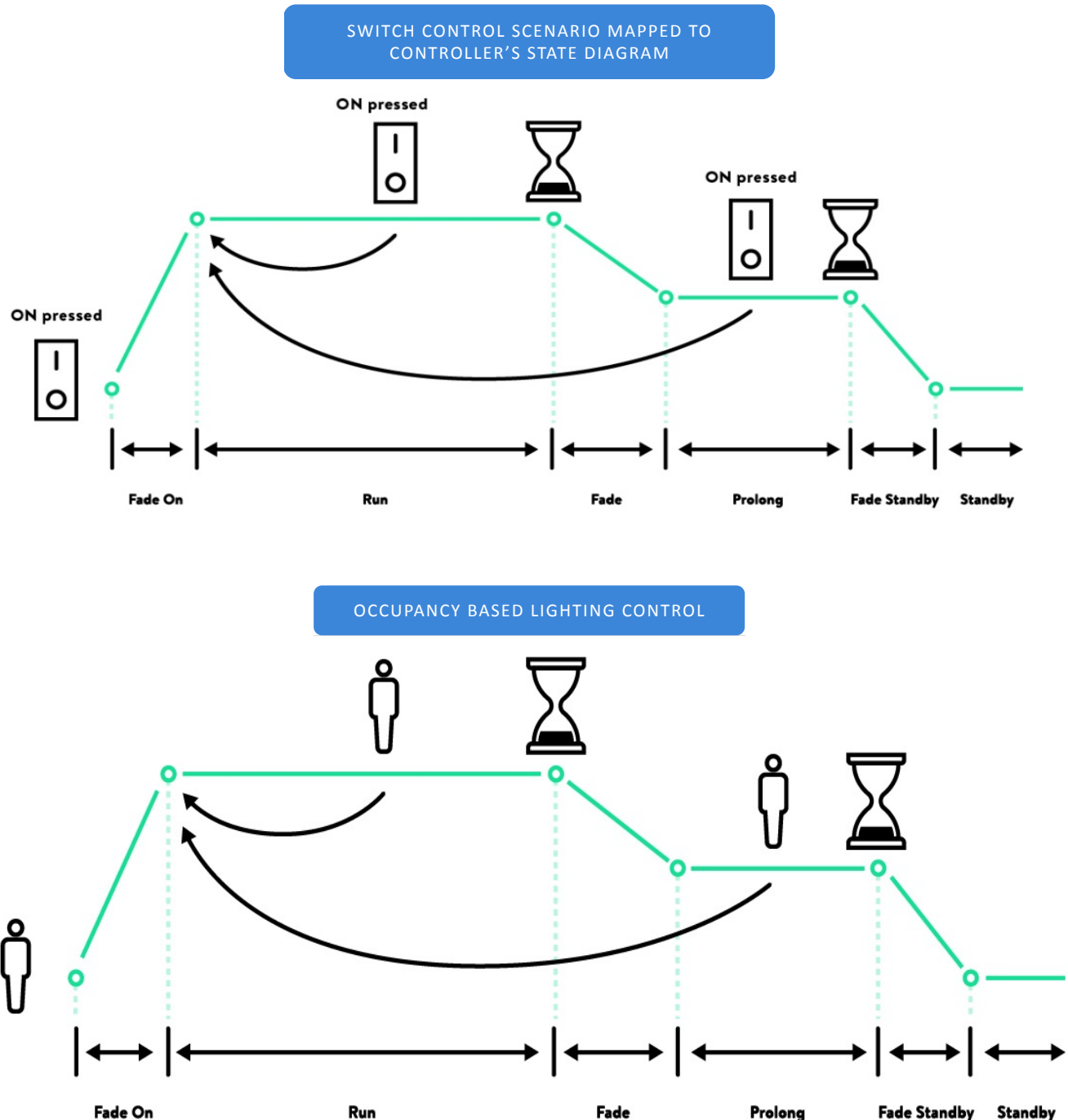


**Figure 9:** Energy Savings Need Sensors: Occupancy and Ambient Light, RHT

## How to Approach Your Specific Lighting Applications

As we've discussed, there are some fundamental decisions that need to be made during this process. Which technology to use? Which ecosystem best suits the application? What is the use case, the range, power requirements, and should you consider an open or closed ecosystem? What are the market opportunities and segments? What is the sales channel? And most importantly, what is the cost? A partner can help you answer these questions.

Today's IoT ecosystem landscape is evolving rapidly. Having multiple ecosystems to choose from is similar to the multiple wireless protocols available. No single ecosystem or protocol will be suitable for all scenarios. Companies are making big investments in order to consolidate the market and unify on one network stack and one application layer. However, there is still a need for 2.4 GHz and sub-GHZ, and Silicon Labs strongly believes that both are required. Managing this transition is important for Silicon Labs so we can help our customers avoid having to wait for new standards before committing to a new product design.

## The Cost of Developing a Lighting Application

Fixed costs can be relatively easy to compile but may present an artificially inexpensive product design.  Reality starts to set in when it comes to engineering costs of headcount and equipment, as well as the costs associated with marketing and ongoing product support. This is another area in which partnering with experienced product development companies like Jasco can bring big benefits. They have the experience working with the key software stacks and protocols as well as getting products through the certification process. They also have low cost due to their high volumes and being able to leverage design reuse.

Additionally, ecosystem and product support from a single supplier is a bonus. There are many players looking to create embedded development environments for the IoT. But just as there will not be just one connectivity protocol for the IoT, there will be many hardware and software environments that shape and enable the IoT market. The winners will be those that cracked the code on the tight integration required between the hardware and software for the IoT-constrained environment. We believe market success will require intimate knowledge and control of an integrated hardware platform, coupled with best-in-breed software that includes protocol stacks built and optimized for that hardware platform. We also believe that winners in IoT will approach the market and deliver ecosystem solutions collaboratively.

## The Z-Wave 700-Series

Fully integrated Z-Wave modules ideally suited for smart home and hospitality applications including sensors, door locks, light switches, security networks, and IoT gateways.

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