



Enabling Simple, Interoperable Wireless Lighting Control

By implementing a lighting control solution using the ZigBee Light Link (ZLL) standard on Silicon Labs' EmberZNet PRO platform, designers can leverage a robust and interoperable network solution to unlock new and exciting consumer-focused lighting applications.

Consumers place a high value on convenience when controlling their appliances, and with the latest advances in color LED technology, the possibilities for choosing and modifying ambient lighting in the home are greater than ever before. Wireless networking further enables new possibilities for lighting control by making it easier and more cost-effective to retrofit modern illumination systems while also making the lighting system's controllers more convenient to use from anywhere in or around the building.

Until now, this emerging wireless lighting control market has been served by a range of solutions, each with its own particular strengths and weaknesses. One particular problem is that consumers have no simple way to ensure that any individual product will work with another, and therefore it has been extremely difficult for users to extend their home lighting system incrementally over time. Additionally, some complex commissioning processes required for such networks often mean that users struggle to add new devices, even when using products from the same manufacturer. Other solutions may require a working with a costly professional installer.

By defining a common standard available to all product designers, the new lighting profile from the ZigBee Alliance addresses all of these issues. Developed in cooperation with major global lighting manufacturers, ZLL not only describes an application messaging protocol for advanced lighting control, but it also includes a mechanism that makes out-of-the-box commissioning as simple for the consumer as pushing a button. In addition to these new features, the ZigBee Light Link profile also leverages the key characteristics common to all ZigBee profiles, enabling robust and secure mesh networks based on low-power, low-cost IEEE 802.15.4 radio technology.

Simple Device Commissioning

As with any new consumer technology, complexity (real or perceived) is a significant barrier to growth. A key principle during the development of the ZLL profile was that the operation of the system should be highly intuitive and certainly no more complex than a traditional wired lighting system. Figure 1 below shows some possible commissioning use cases to demonstrate the ease with which ZigBee Light Link products can be used.

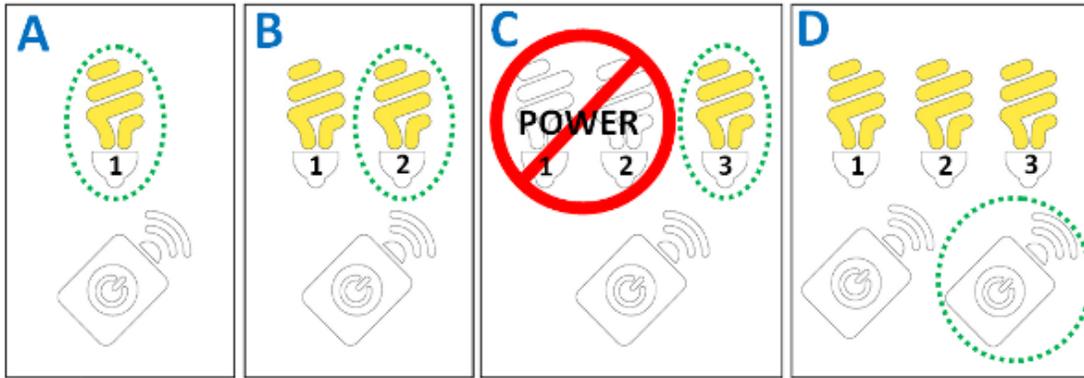


Figure1. ZigBee Light Link Commissioning

In case (A), the user has a factory-fresh starter kit. Creating a network with these devices simply entails powering on the lamp, adding batteries to the remote control and pushing a button. Powering off the lamp or removing the batteries from the remote has no long-term effect on the network, so once power is reapplied, the network can continue functioning as before.

In case (B), a second lamp can be added to the network, again simply by powering it on and pushing a button on the remote control. The new lamp can come from the same manufacturer or from a different source. Each lamp can be addressed independently by the remote, or alternatively both can be controlled simultaneously using multicast messaging depending on the input from the user.

Case (C) shows how additional devices can be added to the same network, even if one or more of the original lamps is temporarily unpowered (or out of RF range). ZLL networks do not rely on a single coordinator node, and therefore there is no single point of failure either for routing messages or when joining additional network devices.

The final image, case (D), first shows that if lamps one and two are powered back on, then all four devices will automatically form a single mesh network without any additional user intervention. The picture is also intended to demonstrate how the system enables additional remote devices on the same network, as well as multiple lamps.

Advanced Lighting Control Features

Unlike other ZigBee profiles such as Home Automation (HA), ZigBee Light Link was designed specifically for lighting applications. This optimized approach allows ZLL products to easily implement different color settings, dimming levels and brightness, store atmosphere settings, or automate lighting control for maximum convenience and energy efficiency. The extent to which these features are implemented is a choice entirely for the product designer, and systems can be as simple as a single on/off light and switch, or as complex as a fully featured home lighting solution.

These features are all based on the ZigBee cluster library concept, which provides a suite of application-level, over-the-air messaging protocols. ZLL incorporates and extends those clusters that are most appropriate to home lighting applications and uses these to define a range of standard devices on which designers can base real-world products. In this way, a new ZigBee Light Link product can implement advanced features like color controls, color loop and scene storing/setting quickly and easily, and in a way that operates seamlessly with existing devices on the market.

Assured Interoperability

Since the entire system is based on open standards, product designers and consumers can be confident that certified ZigBee Light Link devices will all work together without problems. The first step to ensuring device interoperability is to certify products through the ZigBee Alliance. The best route to achieving trouble-free ZigBee certification is to select a ZigBee-compliant platform on which to base the product. Each of Silicon Labs' EmberZNet PRO stack releases is independently certified to guarantee interoperability at the networking level, and a comprehensive list of certified stack platforms from all vendors can be found on the ZigBee Alliance website at: <http://zigbee.org/Products/CompliantPlatforms/Overview.aspx>.

Once a suitable platform has been selected, the next stage is to make sure that the application-level features are compliant with the ZLL specification. Here again, Silicon Labs provides an off-the-shelf, certifiable software implementation of the ZigBee Light Link cluster specification to enable designers to quickly and easily deploy lighting solutions. Using the Application Builder tool available from Silicon Labs, any standard ZLL device can be configured, and a ready-to-compile software project can be produced. The only task remaining is to configure the code to interact with the specific product hardware – for example, physically turning the light on and off when the appropriate message is received.

One extra benefit of using the ZigBee standard is that ZLL devices are also interoperable on the network level with devices based on other application profiles, such as HA. This allows end users to integrate different devices in the home, providing a larger and more robust wireless infrastructure within the Connected Home.

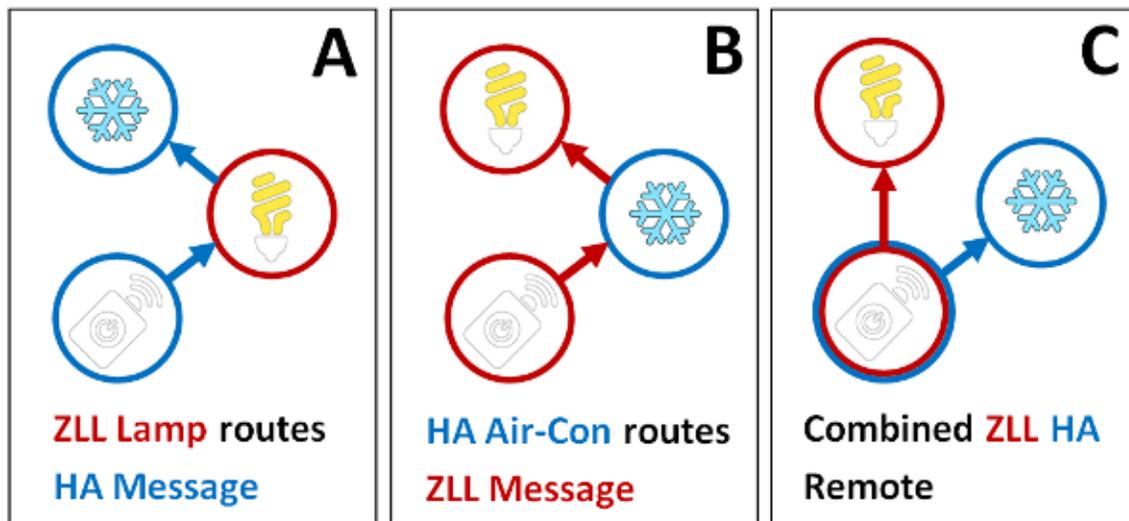


Figure 2. Network Interoperability

Figure 2 demonstrates the flexibility of adding devices from different profiles into a single ZigBee network. One possible use case shown in (A) is that the lighting network provides the backbone to the mesh network, since lights are likely to be distributed throughout the home. This would allow devices from other profiles to use this network, thus extending the usable range between the two nodes. The reverse case is also possible, where an existing Home Automation network could route messages on behalf of ZigBee Light Link devices, as shown in (B). Another interesting product possibility is a combined remote control implementing both profiles. Such a controller is not only able to share the same network, but it is also capable of sending and receiving application messages to/from the different device types. Image (C) shows the remote

control as a handheld device, but this could be implemented easily on an Internet-enabled gateway, allowing end users to control their lighting and home automation devices through a PC or smart phone.

Under the Hood

From a hardware perspective, competition in the semiconductor market has led to the availability of cost-effective silicon solutions ideally suited to the demands of lighting control applications. Low sleep current is a key parameter for battery-driven devices, but features such as on-chip RF power amplifiers and advanced 32-bit microcontrollers also mean that cost-effective system-on-chip solutions are now a possibility for the mass consumer market. Because the standard is based on the globally available 2.4 GHz ISM band, manufacturers are able to market ZigBee Light Link products to the widest possible audience.

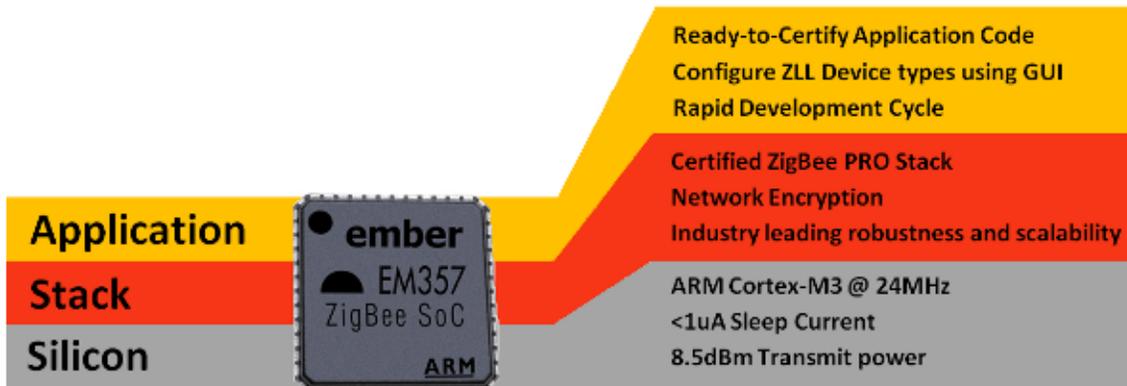


Figure 3. Silicon Labs' Ember ZigBee Light Link Platform

The existing ZigBee PRO networking standard also offers several key benefits to wireless lighting control applications in addition to those already mentioned. The existing AES encryption mechanisms designed for machine-to-machine (M2M) applications are well suited to consumer lighting because they provide protection against both neighboring network traffic and malicious intrusion without adding to system complexity for the end user. In addition, since the mesh network is scalable to thousands of nodes, there is almost an unlimited scope to extend the solution to incorporate a large number of lights, controllers and sensors into a single integrated system. Finally, many wireless systems suffer from link reliability problems. ZigBee Light Link uses layered acknowledgement and retry mechanisms designed into the ZigBee stack to ensure that application messages are received reliably and with an acceptable latency.

ZigBee Light Link Summary

- Cost-effective and convenient wireless control solution for consumer lighting applications
- Simple and intuitive installation; no extra tools, no wires and no specialist knowledge
- System is expandable incrementally with components of different supporting brands
- Worldwide ecosystem of key lighting manufacturers, creating end user value
- Reliable, proven networking technology compatible with devices from other ZigBee profiles
- Supported by a wide range of global vendors – cost-effective, high-performance silicon
- Off-the-shelf, certifiable software solutions available

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