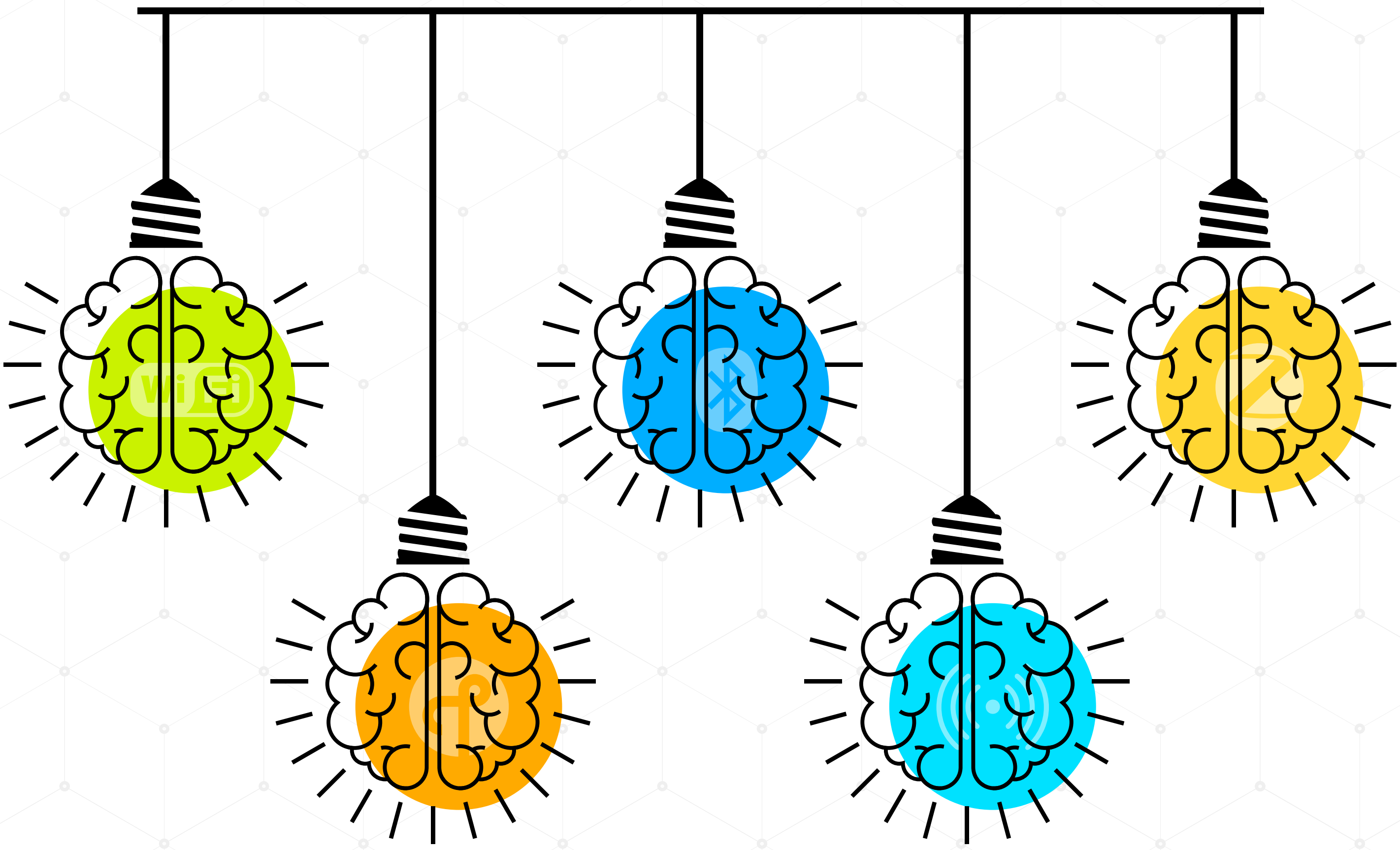
Adding Smart Wireless Connectivity to an LED Lightbulb



Adding Smart Wireless Connectivity to an LED Lightbulb

In this whitepaper we'll take a look at some of the automated and smart lighting solutions entering the consumer market and how bringing the latest low-power MCUs, wireless technologies, and mesh networking standards to your connected home applications can speed up development. We'll also look at what's required to add smart connectivity to an LED bulb.

Contents:

What Hasn’t Smart Lighting Crossed the Chasm?

In a previous whitepaper, “Flipping the Switch on Smart Connected Lighting,” we took a look at possibly the most familiar electronics devices – the light bulb. From the days of incandescent bulbs to fluorescents to LEDs, the latter might be one of the most significant advancements the common light bulb has undergone in 140 years of existence. More specifically, smart LEDs are opening up uses for light bulbs that Edison never dreamed of.

But connected lighting has been around for a long time, so why hasn’t it taken off the way other consumer-oriented technology has during the Internet age?

One barrier to entry has been the level of effort required to install connected lighting. It simply wasn’t a do-it-yourself proposition. You had to replace a switch, which means cutting electricity to that switch, removing it, then requiring a completely new switch. This level of home improvement is beyond most homeowners. Another thing keeping this market gravity-bound has been cost. Like anything, as the price to consumers comes down, adoption rates increase. New switches, wiring, and the cost of labor for installing hardwired circuits wasn’t cheap, and even with the onset of LEDs, cost remains an obstacle. But that’s changing now.

In 2014 standard LED bulbs were $25 apiece, compared to about $2 today. A typical US home has 40 sockets, so imagine dropping $1,000 on bubs for your house. In the first paper we talked about multiprotocol and it is the flexibility and ease of use of this brings that is becoming a differentiator to provide better user experience and enhanced uses cases. This can be around simply doing Bluetooth commissioning for zigbee, or it can be about running both zigbee or Thread and Bluetooth at the same time.

Besides costs, LED bulbs are truly do-it-yourself solutions. Simply screw it into an existing socket and you have instant connectivity through your smartphone. LEDs also have the advantage of connectivity becoming so ubiquitous. Virtually anyone with a smartphone is familiar with using connectivity as a utility. So LEDs alone deliver on two significant barriers; simple installation and ease of use.

The other barrier we mentioned, the disparate protocol standards out there, is also being solved. Most of today’s connected light bulbs use either zigbee or Bluetooth with low energy functionality. Connected switches may use proprietary protocols as well as ZigBee. Multiprotocol has become important because while each standard has its advantages and disadvantages, manufacturers aren’t interested in betting on one protocol over another at the risk of being left behind. This is why solutions that give developers the flexibility to decide which protocol is the best fit for their application are going to open the market up in ways that until now have been unavailable. Another factor in choosing a single wireless protocol is the regional preferences. For example, zigbee has a strong presence in the United States but it’s not prevalent in Asia. So vendors might be forced to build one version of a product that uses zigbee in North America and another version that uses Bluetooth with low energy functionality in Asia. This is where vendors like Silicon Labs are helping.

The new EFR32 Wireless Gecko simplifies connectivity now and in the future. The new Wireless Gecko has more memory and offers features including over-the-air software updates to support application enhancements and evolving protocol needs in the field. The new Wireless Gecko has more memory and offers features including over-the-air software updates to support application enhancements and evolving protocol needs in the field.

For example, if a customer buys a light that uses zigbee exclusively, they would would need to be sure they were connecting to an existing zigbee network or gateway. But with multiprotocol support, the end user doesn't necessarily have to know what kind of network they're connecting to.

But if that vendor supports zigbee as well as Bluetooth, that changes the landscape. The device will default to Bluetooth and be controlled via a smartphone app. That app could then search for other networks and as to join the zigbee network when it identifies it. Then it's configured, or bootloaded, and appears as a zigbee device. The end user doesn't need to know what's happening or bother with anything other than interfacing with the app.

Similarly, adding a gateway extends the network beyond the local network. By connecting your lighting nework to a router, you can then control and monitor your devices from outside the home.

And all of this happens without the user even being aware of all the connectivity hocus-pocus happening behind the scenes. It just works.

The flexibility and ease of use of multiprotocol compatibility is now a differentiator for better user experiences and enhanced use cases.

Adding Smarts to a Dumb LED Light Bulb

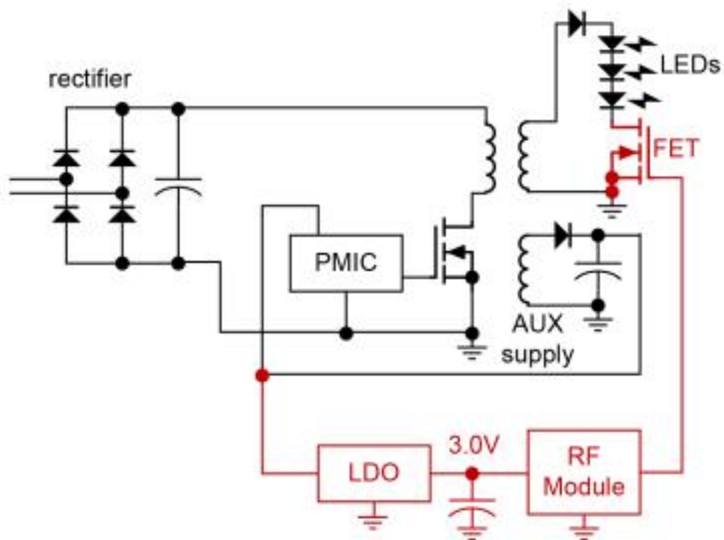
LED light bulbs have now gone through many generations and have better color balance, improved reliability, and lower cost. There are many LED light bulb manufactures and they are looking at how they can create a more innovative, smart connected light bulb.

Adding smart wireless connectivity to a LED light bulb presents some design challenges. RF modules for ZigBee and Bluetooth Smart are readily available. From a high level, it seems like it might be easy to just add a RF module to an existing design.

LED light bulbs have an electronic ballast which typically includes a PMIC and some high voltage discrete components. The electronic ballast typically drives the LEDs with a constant current to achieve a constant brightness that does not vary with input voltage or temperature. The electronics also provide good power factor and work with conventional wall mounted dimmers.

The PMICs typically include an auxiliary power supply to power the PMIC itself. The PMIC auxiliary supply can also power an MCU, wireless SoC, or RF module. The auxiliary supply is typically a poorly regulated supply of 10 to 15 volts. Therefore, a linear regulator is required to lower this voltage and provide a well-regulated 3V or 1.8V supply.

The second challenge is how to switch the LED off or dim the LED. One method is to add a MOSFET between the LED cathode are ground for the MCU to switch off or PWM the LED. This presents some issues if the PMIC was originally designed for a constant load. Disabling the PMIC would also disable the auxiliary supply and is not an option.



The diagram above illustrates the circuitry needed to add smart connectivity to an LED bulb

The first few generations of smart connected LED bulbs will leverage the basic LED bulb designs with modifications. The next generation of smart LED bulbs will incorporate ballast electronics with PMIC that were designed from the ground up for smart bulbs. These designs will include an always on well-regulated low voltage supply and the ability to control LED intensity without requiring extra MOSFETs.

Energy efficiency standards such as the EPAs Energy Star program and California Energy Commission's Title 20 Appliance Efficiency program have strict requirements for standby or vampire current. ENERGY STAR's Product Specification for Lamps Version 2.0 requires a standby power of less than 500 mW. The CEC's Title 20 is even more stringent and requires less than 200 mW in standby mode. While the wireless transceiver power consumption is well below the limit, it is still a challenge to convert the AC line voltage down to the RF transceiver voltage. The auxiliary supply needs to provide about 50 mW to the RF module with an efficiency of better than 50 % and a quiescent current of less than 100 mW.

RF module and antenna placement presents some physical design challenges. Basic LED bulbs often have a metal shield around the ballast board to minimize electromagnetic interference from the switching converter. Smart LED bulb designs need to shield the ballast and also provide a good antenna for the RF. A simple PCB antenna on the RF module might work if the module is positioned vertically near the top of the bulb. However, this might interfere with the light transmission and will put the smart semiconductors close to the LED heat source. Designers need to carefully consider how RF performance will impact the usability of their bulbs. It is important to consumers to have a reliable connection.

Last but not least, the temperature environment of the RF module is also a consideration. Ideally the RF module should be placed far from the heat generating LEDs and ballast electronics. However, this is not always practical. The reliability of the LEDs and also the reliability of the wireless SoC can be extended by monitoring the temperature of both the LEDs and the wireless SoC and dimming the LED to limit the heat generation. A thermistor placed near the LEDs can monitor the LED temperature, while the wireless SoC might have an on chip temperature sensor.

Over-the-Air Updates

Finally, future-proofing existing devices is one of the chief advantages of over-the-air capabilities. Transferring a new image to a wireless device without requiring external memory means vendors will be able to teach existing devices new tricks. As we discussed earlier, it's not uncommon for a home to have 40 light bulbs. When the latest Bluetooth standard comes out it would be quite a hassle to manually convert each bulb, but now you don't have to. By using a common bootloader for all wireless standards, you're no longer limited to just updating to the latest version of zigbee or Bluetooth, etc. You will be able to move from zigbee to Bluetooth and back again as needed.