

Designing Next Gen Bluetooth Low Energy System for the Internet of Things

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KEY TAKEAWAYS

- Bluetooth technology provides wireless communication necessary for the Internet of Things.
- IOT product design can be challenging and costly.
- PSoC 4 BLE offers simplification and integration to address common design challenges.
- PSoC 4 BLE offers best in-class low-power modes to enable low-power wireless systems.
- Cypress offers end-to-end BLE expertise, including a fully certified and prequalified BLE module.

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OVERVIEW

Most IOT (Internet of Things) products—like fitness monitors and thermostats—connect to external devices like smartphones and PCs through a wireless Bluetooth connection. Development of wireless sensor-based systems using Bluetooth technology can be complicated and costly. Additionally, power consumption and battery life is a concern for these portable devices.

The PSoC (Programmable System-on-Chip) 4 BLE (Bluetooth Low Energy) chip from Cypress enables engineers to easily design low-power, wireless systems with an integrated one-chip solution. Potential applications for the PSoC 4 BLE chip include sports and fitness monitors, wearable electronics, medical devices, home automation solutions, game controllers, and other sensor-based low-power systems for IOT.

CONTEXT

Gagan Luthra discussed the rise of the IOT and Bluetooth's role in today's devices. He shared the challenges IOT product designers often face and discussed how Cypress products can provide solutions for these often complex and costly problems.

KEY TAKEAWAYS

Bluetooth technology provides wireless communication necessary for the Internet of Things.

From fitness and heart rate monitors to electronic deadbolts and thermostats, IOT devices are composed of three main building blocks:

1. **Sensors** allow a device to sense the environment around it.

2. **A computing component**, like a central processing unit, allows a device to act autonomously and make decisions based on the data it receives.

3. **Communication technology** enables a device to share information and interact with other devices, like cellphones or internet servers.

Not only is it nice for IOT products to be wireless; it's very important for them to be low-power consumption so they can last for a long time on batteries.

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Most IOT devices communicate wirelessly using Bluetooth technology. This wireless communication protocol has become ubiquitous in the cellphones, laptops, tablets, and TVs with which IOT devices communicate. Because these small and portable devices run on battery power, BLE has become the standard wireless communications technology (see figure 1).

IOT product design can be challenging and costly.

Designing wireless sensor-based systems typically means engineers must work with design tools from multiple chips and IC (integrated circuit) vendors, which can make designing IOT products both complicated and pricey. The stringent wireless specifications, including those for BLE, add to the complexity of firmware development. RF (radio frequency) communication over the Bluetooth antenna can be tricky to design as well.

Designing Next Gen Bluetooth Low Energy System for the Internet of Things

Size and cost become a challenge in this very competitive market.

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Using multiple chips also makes it difficult to keep product size down to a minimum, because the more chips on the PCB (printed circuit board), the larger and more complicated the board.

Power consumption is a significant design challenge for IOT product developers. Most IOT products run off batteries, which often don't last as long as consumers want.

Figure 1

Bluetooth Terms

Bluetooth Classic	A legacy standard for personal area networks made popular by audio streaming to cell phone headsets. Operates in the 2.4-GHz (gigahertz) ISM (Industrial, Scientific, Medical RF frequency) Band with GFSK (Gaussian frequency shift keying) modulation and supports up to 3-Mbps (megabits per second) data rate.
Bluetooth Low Energy (BLE)	A standard for short-range, low-power wireless applications that communicates state or control information. Operates in the 2.4-GHz ISM Band with GFSK modulation and supports a 1-Mbps data rate. Not backward-compatible with Bluetooth Classic.
Bluetooth 4.0/4.1/4.2	- Bluetooth 4.0 [2010] is an upgraded Bluetooth Classic specification that adds BLE. - Bluetooth 4.1 [2013] improves security, at lower power, with higher throughput. - Bluetooth 4.2 [2014] increases packet length, improves privacy, and security
Bluetooth Smart	A brand for Bluetooth 4.0/4.1 products that support only BLE.
Bluetooth Smart Ready	A brand for Bluetooth 4.0/4.1 products that support both Bluetooth Classic and BLE.
Bluetooth SIG (Special Interest Group)	The organization that oversees the development and licensing of Bluetooth standards.

PSoC 4 BLE offers simplification and integration to address common design challenges.

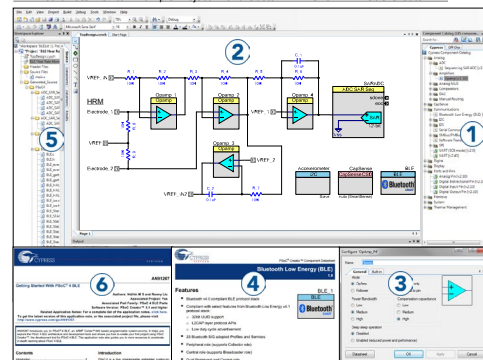
PSoC 4 BLE is a single-chip solution that offers simplification and integration in creating low-power, sensor-based IOT systems.

PSoC Creator is the chip's software front end, which enables complete system design. It offers prebuilt components in a graphical, drag-and-drop interface that provides developers with the power to design the chip to best fit their needs. Once the design is complete, the tool generates a set of APIs (application programming interfaces) for each component in the schematic, enabling immediate use of the APIs in the system and application.

Figure 2

PSoC Creator Enables Complete System Design

BLE Heart Rate Monitor Example Project With a Custom AFE Shown in PSoC Creator IDE



1. Explore the library of 75+ Components
2. Drag and drop Component icons to complete your hardware system design in the main design workspace (e.g., use the BLE Component for Bluetooth Smart designs)
3. Configure Components using the Component Configuration Tools
4. Access Component datasheets directly from the Component Configuration Tools
5. Codesign your application firmware and hardware in the PSoC Creator IDE
6. Use the [Getting Started with PSoC 4 BLE App Note](#) for complete system design guidelines

The BLE Component simplifies stack and profile configuration, saving developers the time and effort of going through hundreds of lines of code for implementation. The tool uses drag-and-drop user interface to add components to a schematic and includes all hardware controllers that reside within the chip as well as a Bluetooth 4.2 version of the BLE Protocol Stack,

Designing Next Gen Bluetooth Low Energy System for the Internet of Things

including all BLE Profiles. Just as with the PSoC Creator, the tool generates simple APIs that can be used to exercise the stack or perform communication between Bluetooth devices.

PSoC 4 BLE includes an integrated balun. This component is necessary for the AMN (antenna matching network) to convert signals between balanced and unbalanced. Providing the integrated balun decreases the time and effort that may be spent building one and the increased BOM (bill of materials) cost and decreased board space associated with purchasing a balun chip.

PSoC 4 BLE offers you a highly integrated solution that allows you to create entire IOT systems with a single chip.

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PSoC 4 BLE enables the development of entire IOT systems on a single chip by offering integrated programmable AFEs (analog front ends), and digital logic, as well as CapSense, which is a capacitive sensor. The integration not only reduces BOM costs, but it allows the chip to be re-designed and re-programmed at the touch of a button in PSoC Creator.

PSoC 4 BLE offers best in-class low-power modes to enable low-power wireless systems.

In addition to providing a tightly integrated system that provides sensing, computation, and communication capabilities, PSoC 4 BLE also offers low power consumption. The chip has five available power modes that can be called via API to meet specific needs at specific times: Active, Sleep, Deep Sleep, Hibernate, and Stop.

Figure 3: PSoC 4 BLE Power Modes

Power Mode	Current Consumption
Active	22 mA (milliamps) @ 6 MHz (megahertz)
Sleep	1.3 mA
Deep Sleep	1.3 μ A (microamps)
Hibernate	150 nA (nanoamps)
Stop	60 nA

IOT battery life is driven not by how much current is consumed in active-power mode, but by how little current is consumed in low-power modes.

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Most products spend approximately one-tenth of their time in active-power mode, and the remaining time in low-power modes. Because the current drawn during these low-power modes can significantly impact battery life, Luthra discussed Deep Sleep, Hibernate, and Stop modes in detail.

In Deep Sleep mode, the CPU is turned off, but the BLE is kept active; the connection with the cellphone or other external device is not broken. No data is sent during this mode, but the device periodically returns to an Active state to send the data back to the external device, returning to Deep Sleep when it is complete. This mode is useful for devices that routinely send information every few minutes, like a heart rate monitor.

Hibernate and Stop modes both break the Bluetooth connection between the two devices, allowing the chip to consume nanoamps of current to preserve battery life. These modes are used when data is sent after longer intervals, such as with a thermostat that doesn't need to check the temperature every minute.

Designing Next Gen Bluetooth Low Energy System for the Internet of Things

These modes also allow products to sit on retail shelves for a long time without worrying about battery drain; the system is essentially shut off, but the battery is plugged in and the device is ready to come back to life once purchased.

Cypress offers end-to-end BLE expertise, including a fully certified and prequalified BLE module.

Cypress is the only semiconductor supplier today that offers a true end-to-end BLE solution, from silicon to software stack to module manufacturing. Most module manufacturers use silicon from different companies, and most silicon companies rely on third-party module makers to create modules for them, which can cause both development and support issues.

Cypress offers a fully certified and prequalified BLE module—the EZ-BLE PSoC (Programmable Radio-on-Chip) module—which includes the chip, an antenna, crystals, and all of the passives necessary to deploy a plug-and-play solution. This saves the development time that would be needed to take a chip and add the additional components.

Modules also save a development team time and money in the qualification and regulatory compliance processes.

- **Bluetooth SIG:** The EZ-BLE PSoC Module and its components have already qualified by the Bluetooth SIG as Bluetooth Smart. This allows companies using the module or chips to reference Cypress' qualification IDs to receive certification, which saves both time and money.
- **Regulatory Compliance:** The EZ-BLE PSoC Module complies with wireless regulations for the United States, Canada, Japan, Korea, and Europe. Because the module is pre-certified with regulatory authorities in these countries, companies can bring BLE products to market faster, without the hassle of regulatory and qualification processes.

ADDITIONAL INFORMATION

- **Getting started.** To get started with PSoC 4 BLE:
 - Download the [PSoC Creator IDE](#) (integrated development environment).
 - Buy the [BLE Pioneer Kit](#), which includes the PSoC 4 BLE module and the PSoC BLE module.
 - Download the Getting Started with [PSoC 4 BLE App Note](#).
- **More information.** For more information on PSoC 4 BLE, visit the product webpage: www.cypress.com/PSoC4BLE.

BIOGRAPHY

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Gagan Luthra is a Product Marketing Manager at Cypress Semiconductor Corporation, working on the PSoC platform of programmable System-on-Chips. He started working with Cypress as an intern in 2005 while studying Electrical Engineering at Washington State University. He's passionate about embedded solutions, the engineering hobbyist community, small form-factor and real-time computing, DIY projects, the maker community, digital audio-visual art, and more.