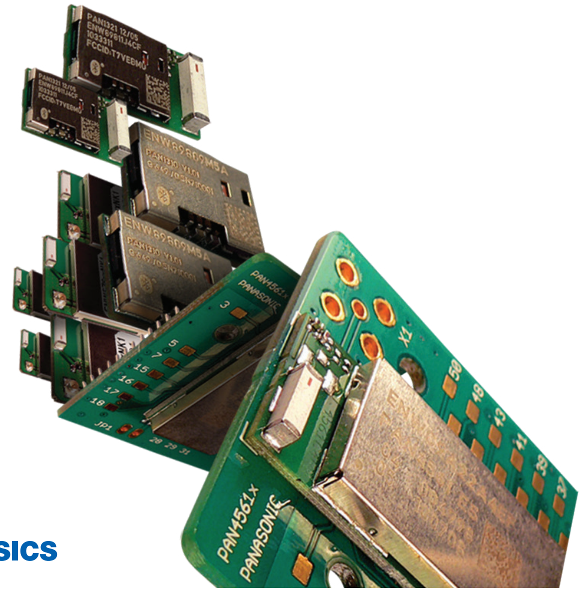
Moving Forward With Bluetooth Low Energy

An update to the Bluetooth core specification and chip advances will increase the impact of this ultra-low-power RF technology.



Bluetooth® Low Energy (BLE) may not be part of your electronic designs just yet, but chances are it will be soon. This wireless connectivity technology has experienced explosive growth over the last three years. And it now provides low-power connectivity to millions of electronic devices, such as smart watches, fitness trackers, smart phone accessories and medical monitors. Thanks to upcoming technical enhancements, BLE is poised to become even more pervasive in the next generation of consumer electronics and the emerging Internet of Things.

Many of the enhancements have been incorporated in *Bluetooth* 4.1, a recent update to the core specification. Among them are support for more efficient bulk data transfers, greater flexibility in communications between devices, simultaneous dual-mode roles and the first steps toward IP-based communications. Taken together, these technical improvements make BLE even more attractive from power consumption, performance and cost standpoints.

In addition to the enhancements outlined in *Bluetooth* 4.1, the BLE chips themselves have been continuously improving as well. Thanks to efficiency improvements, transmission power consumption in the second generation of BLE will fall by about 66 percent with no loss of range or performance.

With all the recent changes BLE and with more to come soon, it's a good time to take a look at where the technology stands today and where it's heading.

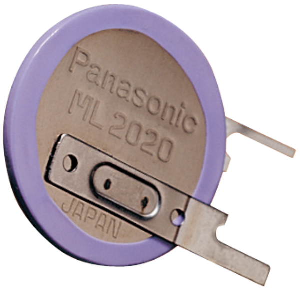
BLE BASICS

For wireless communication devices that have been optimized for low power consumption rather than maximum data transfer rates, BLE fits the bill perfectly. It consumes as little as one-hundredth the average power required by *Bluetooth* Classic. And BLE's peak current draw is a low as 15 mA, compared to 40 mA or more for *Bluetooth* Classic. With such thrifty current consumption, BLE can run on a single coin-cell battery for months or even years, depending on the application.

BLE achieves its low power consumption primarily by keeping its radio turned off most of the time. BLE scans only three advertising channels, and its radio awakens only to send or receive short bursts of data, with small packet sizes from 8 to 27 octets. BLE also sets up connections very quickly, which further minimizes the radio's on time. BLE can transmit authenticated data in as little as 3 ms, versus the 1000 ms typical for Bluetooth Classic.

As for data rates, BLE's maximum practical data rate is typically well under 100 kbs. So it's not intended for the continuous data streaming applications possible with *Bluetooth* Classic, which offers data rates up to 3 Mbps.

BLE also has other technology differences with *Bluetooth* Classic. Chief among them, BLE uses a star network topology and 32-bit access address on every packet for each slave, which in theory allows billions of devices to be connected at a given time. *Bluetooth* Classic's piconet topology, by contrast, allows only up to 8 devices at a time.



Bluetooth Low Energy devices can run for years on a single coin-size battery.

Other BLE technical features include:

- **Optimized GSFK modulation.** Like *Bluetooth* Classic, BLE makes use of a GSFK modulation scheme. BLE, however, uses a higher modulation index and 2MHz channels—for lower bit error rates that translate to greater range.
- **Adaptive frequency hopping.** BLE technology uses the same adaptive frequency hopping scheme as *Bluetooth* Classic when devices are connected. Adaptive frequency hopping minimizes interference from other technologies in the 2.4 GHz ISM Band shared by the multitude of wireless devices operating in this spectrum.
- **Robustness.** BLE uses single 24-bit cyclic redundancy check (CRC) on each packet, allowing the header and data fields to detect odd number bit errors as well as 2- and 4-bit errors. The 24-bit CRC, versus 16- or 32-bit CRC, is optimized for BLE's data payload.
- **Tight security.** BLE encryption and authentication is implemented using 128-bit Advanced Encryption System (AES-128), an encryption system developed by the U.S. government to safeguard data.

Another crucial aspect of *Bluetooth* 4.1 is its dual-mode capability. While devices such as sensors or phone accessories often use BLE by itself, smart phones and tablets frequently act as wireless hubs that communicate via both BLE and *Bluetooth* Classic. The *Bluetooth* core specification makes this dual-mode implementation possible. In essence, dual-mode modules combine the Classic and BLE communication stacks and permit a shared antenna. Single-mode and dual-mode devices are respectively designated as *Bluetooth Smart* and *Bluetooth Smart Ready*.

Low-Power Wireless Alternatives

Bluetooth Low Energy (BLE) isn't the only game in town when it comes to low power wireless communications. ANT and Zigbee have capabilities that overlap with BLE, and both wireless standards have their place. But BLE does have significant advantages when you consider technical capabilities and the fact that it is an open protocol.

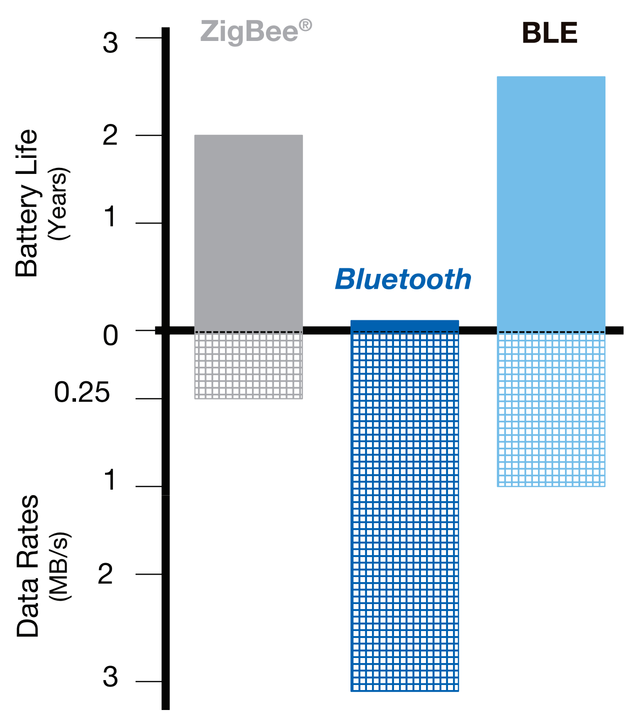
WHAT'S NEXT FOR BLE

Even as it stands today, BLE technology already provides an exceptional solution for devices that require low-power wireless connectivity. But BLE is about to become even more power efficient, and the enhancements contained in *Bluetooth* 4.1 will make it easier to design the next generation of wireless devices and the smart objects that will make up the Internet of Things.

These enhancements to *Bluetooth* 4.1, which remains backwards compatible to legacy devices, include:

- **Multiple role support.** Changes to the link layer and dual-mode topology will allow dual-mode devices will be able to act simultaneously as Smart Ready hubs and Smart Devices.
- **Data exchange efficiency.** The addition of connection oriented channels to the logical link control and adaptation protocol (L2CAP) allows more efficient transfer of bulk data between BLE devices while minimizing overhead.

Battery Life and Data Rates

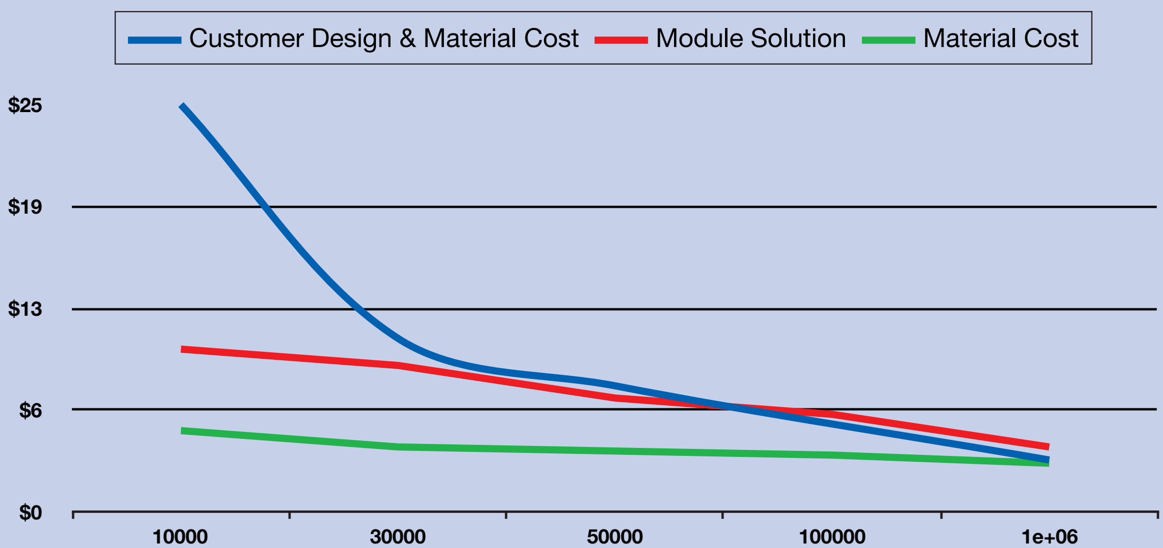


Bluetooth Low Energy Implementation Strategies

After deciding your applications protocol, the next question to answer is how to implement it—buy a BLE module or build your own discrete solution. Both approaches are viable, but there are three scenarios that clearly favor modules:

- **Low production volumes.** At production volumes under 100,000 units, modules have a clear cost advantage over discrete components. Tally up the development, manufacturing, RF certification and testing costs of a chip-based BLE implementation, you will find that the cost typically falls between $150,000 and $200,000. Amortize those costs over volumes under 100,000 and the cost of RF can be prohibitively expensive. At volumes from 100,000 to 150,000, either the module or chip solution can make sense from a total cost standpoint. Over 150,000 units, the balance swings back to discrete solutions.
- **Fast time-to-market objectives.** Modules also have an advantage when time-to-market considerations come into play. Discrete RF applications typically take three to six months to develop—and that time frame applies to experienced engineering teams. By replacing much of the custom programming with an API and text string command set, modules dramatically streamline the development process. Modules are also pre-certified, which eliminates the time and cost of the certification process. Bottom line: modules can be dropped into a new product design in a matter of weeks, creating a significant time-to-market advantage.
- **Long lifecycles.** Modules can fight obsolescence in products that have lifecycles that may outlast their integrated circuits. Module designs can incorporate new chips when needed without changes to the legacy pinouts, functionality, size or firmware interface.

Module Versus Chip Cost

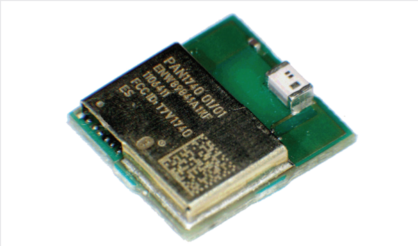


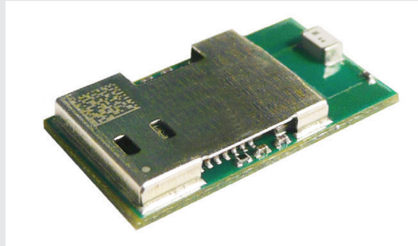
- **Connection improvements.** Engineers will have more flexibility in creating and maintaining *Bluetooth* connections, including automated reconnections.
- **IP-based connections.** Paving the way for the Internet of Things, the new core specification builds the technical foundation for IPv6 communications by adding dedicated L2CAP channels.

Look for the enhancements contained in *Bluetooth* 4.1 to start appearing in BLE and dual-mode chips and modules early in 2014. And looking further down the road, expect an ongoing BLE revolution that positively affect power budgets for battery powered applications.

The beginning of this revolution can be seen in the new BLE discrete ICs and modules that are hitting the market. These

Bluetooth Low Energy Modules





PAN1740 Single Mode *Bluetooth* Low Energy Module — "nanoPower"

- Tx current @ 0dBm: 5mA
- Small Footprint: 9 x 9.5 x 1.9 mm
- High sensitivity (-93 dBm typ.)
- Tx power control up to a maximum of 0 dBm
- Place and play
- Autonomous, Stand Alone Operation
- *Bluetooth* Smart® module
- Embedded BLE stack and GATT profile
- Industrial Temperature Range: -40ºC to 85ºC
- Two internal crystal oscillators
- Integrated shielding to resist EMI
- No external components needed

PAN1720 and PAN1721 Single-Mode *Bluetooth* Low Energy Module

- Surface mount package, measuring 15.6 x 8.7 x 1.9 mm
- Typical Tx power up to 4.0 dBm with transmit power control
- High sensitivity, typically-94 dBm
- Based on Texas Instrument's CC2540 Single Chip BLE Solution.
- High performance, low power 8051 microcontroller core
- No external components needed
- Fast connection setup
- Internal crystal oscillator, 26 MHz
- Internal 32 kHz crystal oscillator for Sleep Timer
- Two powerful USARTs
- Battery monitor and temperature sensor
- PAN1720 offers USB interface
- PAN1721 offers I2C interface

PAN1316 and PAN1326 Dual-Mode BLE and Classic Modules

- Best-in-class *Bluetooth* RF performance for Tx power, Rx sensitivity and blocking
- Fully Qualified *Bluetooth* v4.0 + EDR
- Dimensions: 6.5mm x 9mm x 1.7mm (PAN1316)
- Certifications: *Bluetooth*, FCC, CE, IC
- Operating temperature range: -40ºC to 85ºC
- Profiles: All profiles are supported
- Based on TI's CC2564
- Integrates with nearly all microcontrollers
- Very fast algorithm for both ACL and eSCO
- Supports extended range, Tx power 10.5 dBm typical output

devices are commonly known as ultra-low power BLE, although individual manufactures have already adopted trade names such as Panasonic's *nanoPower* family. Nanopower devices reduce transmit and receive current consumption by more than 66% when compared to the current generation of BLE devices and by nearly 90% when compared to *Bluetooth* Classic devices. Moreover, these current reductions have been achieved without range reduction, without transmit power reduction and without manipulation of the *Bluetooth* specification.