Electronic Design

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Bluetooth Keeps on Winning in the Short-Range Wireless Race

Sponsored by Texas Instruments: With its growing presence in the connectivity space, companies focusing further on developing Bluetooth building blocks—particularly Low Energy options.

Bluetooth, the oldest short-range wireless technology, continues to be the most widely adopted in wireless products. Emerging around 1998, it has become a popular standard used in Internet of Things (IoT) products. Thanks to ongoing development and improvement of Bluetooth, it's turned into a popular wireless choice, let alone for the fact that it's readily available, easy to design with, low cost, and proven reliable in a wide range of applications. Bluetooth chips and a wide range of systems-on-chip (SoCs) incorporating the technology are some of the highest-volume wireless devices sold.

With such a reputation, you should know more about Bluetooth in case you suddenly need to incorporate wireless in your design. Consider this article to be an introduction to Bluetooth for the uninitiated, a refresher to those planning a new project, and a summary of how to select a Bluetooth device. This coverage focuses on what's become the most popular version, known as Bluetooth Low Energy (BLE).

Bluetooth is Everywhere

Who hasn't heard of or used Bluetooth? Most of us adults and teens probably own a half dozen or more Bluetooth-enabled products. It's inside all smartphones (over a billion sold each year). Virtually all new cars, SUVs, and trucks contain Bluetooth. It's employed to implement hands-free mobile phone use and to connect music sources to the vehicle's sound system. A highly popular wireless product is the Bluetooth speaker, which provides a convenient way to play music from a mobile phone or other source with a greater sound quality without headphones.

Bluetooth is also a major player in the IoT. In consumer/home IoT, Bluetooth is used in wireless thermostats, wireless doorbells, remote control lights, drapes, and ceiling fans. Many kid toys now use Bluetooth. Smart watches leverage Bluetooth for their connectivity.

Industrial IoT (IIoT) is becoming a huge adopter of Bluetooth, too, where it's used in wireless sensor networks that monitor tools and processes. Bluetooth is so versatile it's usually one of the core short-range wireless technologies considered for IoT. Others include Wi-Fi, LoRa, ISM < 1 Gb/s, 802.15.4, Thread, Zigbee, plus a half dozen or more. Bluetooth wins many of these adoptions just because it works reliably. The latest enhancement is Bluetooth mesh, making it even more competitive in the IIoT market.

Look for increasing Bluetooth use in medical devices soon. More about that later.

Bluetooth: Back to Basics

Thousands of articles, blogs, white papers, standard books, eBooks, and manufacturers' product literature have been written about Bluetooth. But a good starting point for learning about and keeping up with Bluetooth is to go to the Bluetooth Special Interest Group (SIG) website. The SIG maintains the Bluetooth standards and does certification testing.

To provide you with a quickie introduction to Bluetooth Low Energy (BLE), here's concise summary of BLE facts and figures:

Bluetooth LE Features

- *Spectrum:* 2.4 to 2.4835 GHz, ISM band.
- *Modulation:* Gaussian frequency-shift keying (GFSK)
- *Access:* Frequency-hopping spread spectrum (FHSS) across forty 2-MHz-wide channels
- *Data rate:* 300 to 800 kb/s
- *Transmission range:* 30 to 100 meters

- *Network topology:* Central/Peripheral with piconets
- *Connection time:* < 3 ms
- *Security and authentication:* AES-128

Without going into a detailed comparison between the standard Bluetooth version and BLE, in summary BLE has a lower data rate since many applications don't require high-speed data transfer. This accomplishes two things: it extends the communications distance and significantly lowers power consumption. BLE is a great choice for battery operated equipment.

As of DEC, 2016	Bluetooth™		
Specifications	**Classic Bluetooth**	**Bluetooth Low Energy (V 4.2)**	**Bluetooth 5**
Range	100 m	Greater than 100 m	Greater than 400 m
Data Rate	1-3 Mbps	1 Mbps	2 Mbps
Application Throughput	0.7 -2.1 Mbps	0.27 Mbps	—
Frequency	2.4 GHz	2.4 GHz	—
Security	56/128-bit	128-bit AES with Counter Mode CBC-MAC	—
Robustness	Adaptive fast frequency hopping, FEC, fast ASK	24-bit CRC, 32-bit Message Integrity Check	—
Latency	100 ms	6 ms	—
Time Lag	100 ms	3 ms	—
Voice Capable	Yes	No	—
Network Topology	Star	Star	—
Power Consumption	1 W	0.01 to 0.5 W	—
Peak Current Consumption	less than 30 mA	less than 15 mA	—

A Better MCU for BLE

Many if not most BLE radios are integrated onto a microcontroller (MCU) chip. You can get individual Bluetooth transceiver, receiver, and transmitter chips, but more often Bluetooth/BLE's entire functionality is part of an MCU. After all, Bluetooth is just a wireless interface to some MCU, integrated or not. For that reason, the MCU must meet your needs as well as the Bluetooth version selected.

The big design question is: Do you choose the Bluetooth vendor first and hope that an appropriate MCU is available, or do you select the MCU first and then seek out a suitable version of Bluetooth? The availability of the software that supports your design should be a major selection factor.

One of the more popular and capable MCUs is the popular Arm series. Many Bluetooth products use Arm MCUs incorporated into the chip. The M3 and M4F versions of the company's 32-bit processor are popular in this role.

An example of this is Texas Instruments' SimpleLInk MCU family. TI has been supplying SimpleLink devices for several

BLUETOOTH VERSION CONFUSION

Over the years, Bluetooth has undergone many changes. New versions and enhancements occur on a regular basis. I don't know about you, but I'm often confused about the difference between the different versions and where enhancements fit. Let me see if I can boil all this down to a few simple points.

- The original version of Bluetooth standard 1.0 happened in 1999. It was also standardized by IEEE as 802.15.1
- Versions 2.0/2.1 introduced extended data rate (EDR) that can send and receive at 2.1 Mb/s
- Version 3.0 was a high-speed version that never became popular.
- Version 4.0 introduced the Low Energy (LE) feature.
- Versions 4.1 and 4.2 added features that make BLE increasingly useful in IoT applications.
- Version 5.0 increased data rate to 2 Mb/s, extended the communications range, added better security, increased message capacity, and improved (lowered) energy consumption.
- Bluetooth mesh capability was later added. It can work with versions 4.0-4.2 as well as with version 5.0. Mesh increases the number of external slave nodes that Bluetooth can handle from seven to hundreds. This greatly extends the range and reliability of a network for IoT applications, making it more competitive with Zigbee, Thread, ANT+, and other mesh technologies.

Hope that helps.

years. The product line includes ISM band 802.15.4 standard devices and software for < 1-GHz rates, Wi-Fi devices, as well as the Bluetooth standard and BLE. The Bluetooth family—the CC2640—has a wide range of devices that are pin-compatible QFN packages. The family includes the CC2640R2E in a 2.7- × 2.7-mm wafer chip-scale package (WCSP). A larger 4- × 4-mm WCSP is also part of the product line.

Among other competitive features offered is greater flash memory (up to 352 kB). One new version, the CC2640R2F, is now AEC-Q100-qualified for automotive applications. Also offered is Bluetooth 5 software that will aid in developing higher-speed, longer-range products.

The CC2640R2F is an interesting BLE chip that employs a special coded PHY feature in which serial data processing (coding) is used to add to the available performance for some outdoor long-range applications. The data rate is reduced to 125 kb/s with the coding. In addition to improved receiver sensitivity from the usual –93 to –105 dBm and its 5 dBm output power, the overall link budget permits exceptional long-range communications. One recent test demo produced excellent connectivity over a range of 1.6 km. Adding gain antennas can extend that range farther.

BLE Improves Healthcare Products

Medical instruments have long incorporated the latest electronic technology. Presently some hospitals use Bluetooth, or Wi-Fi, for patient monitoring. It helps minimize the patient wiring problem. Now, with short-range wireless like BLE, patient monitors are more convenient and more reliable—and making that wireless gear more portable with longer range.

Doctors wanting to monitor patient vitals prefer to send patients home to avoid the cost and physical hazards of the hospital. BLE makes real remote patient monitoring possible. Patients can wear sensors like temperature patches that transmit the data via BLE to a smartphone and then on to remote monitoring point by way of the cloud. With tiny 2.7- × 2.7-mm chips, patches are more practical than ever.