Wireless connectivity made easy by design

Part 2: Dual Sub-1GHz and *Bluetooth*® Low Energy with Texas Instruments CC1350 SimpleLink™ Dual Band Wireless MCUs

SECTION 1:
SimpleLink™ Dual-Band Wireless MCU

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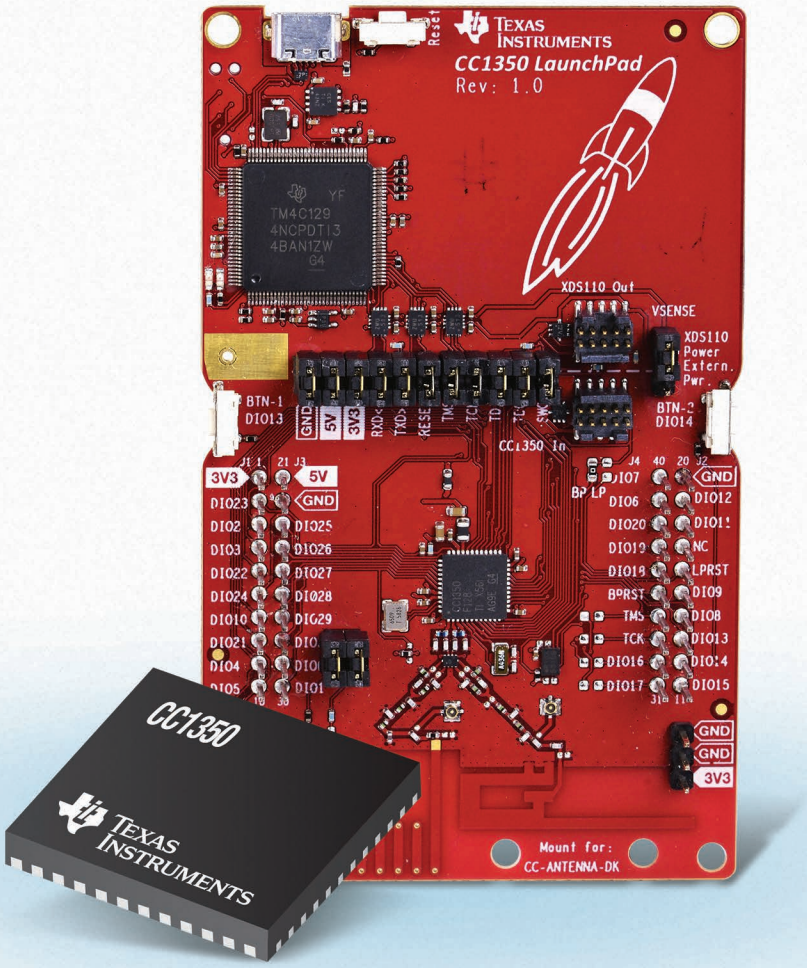

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Abstract

With the explosion of the IoT market, increasingly more devices and applications require wireless connectivity. However, developing an application with wireless connectivity can be a daunting task for engineers who face a variety of choices and constraints when working through their designs. This two-part white paper focuses on making wireless connectivity easier for design engineers. This document will target specific solutions that have been developed to address applications that require both Sub-1GHz and *Bluetooth*® Low Energy. Part one will focus on Sub-1GHz; part two will address the first dual-band solution that incorporates both Sub-1GHz and Bluetooth® Low Energy onto a single chip.

Author

Paul Golata joined Mouser Electronics in 2011. As a Senior Technical Content Specialist, Paul is accountable for contributing to the strategic leadership, tactical execution, and overall product line and marketing direction for advanced technology related products. Paul provides design engineers with the newest and latest information delivered through the creation of unique and valuable technical content that facilitates and enhances Mouser Electronics as the preferred distributor of choice.

Before Mouser Electronics, he served in various Manufacturing, Marketing, and Sales related roles for Hughes Aircraft Company, Melles Griot, Piper Jaffray, Balzers Optics, JDSU, and Arrow Electronics. Mr. Golata holds a BSEET from DeVry Institute of Technology – Chicago, IL; an MBA from Pepperdine University – Malibu, CA; an MDiv w/BL from Southwestern Baptist Theological Seminary – Fort Worth, TX; and a PhD from Southwestern Baptist Theological Seminary – Fort Worth, TX. He may be reached at **paul.golata@mouser.com**.

SECTION 1

CC1350: SimpleLink™ Dual–Band Wireless MCU

TI's SimpleLink™ dual-band CC1350 Wireless MCU is specifically designed to yield excellent performance for low-power, robust, long-range connectivity for applications that require both Sub-1GHz and Bluetooth low energy. The dual-band CC1350 wireless MCU's Sub-1GHz technology provides long-range communication and its Bluetooth low energy technology enables easy connectivity to smart devices—all while operating for years on a single coin cell battery.

By incorporating dual-band functionality into a 4mm × 4mm package, TI has taken integration and design flexibility to a new level, making it easy to design with both Sub-1GHz and Bluetooth low energy. The CC1350 wireless MCU offers excellent sensitivity and strong coexistence to provide reliable communication. The device's dual-band operation allows easy access to the cloud through smart devices.

CC1350: Long/Robust Range

The CC1350 wireless MCU is optimized for Sub-1GHz frequency operation. To improve co-existence and range, the CC1350 device offers very good blocking performance of up to 90dB. The CC1350 device is designed for +14dBm output power which is more than most 2.4GHz solutions. Due to its excellent sensitivity (110dBm @ 50kbps; -124dBm @ 0.625kbps) and robust (selectivity and up to 90 dB blocking) performance, the CC1350 wireless MCU provides engineers with a higher link budget and longer range. With good antennas, the CC1310 device can offer a range up to 20km using just a coin cell battery, making it a robust and long-range solution. The CC1310 solution provides best-in-class selectivity, TI 15.4-Stack software with frequency hopping (private), or SIGFOX (public) to allows for full building-wide to citywide RF coverage. In addition, its Bluetooth low energy mode provides +9dBm output power and -87dBm sensitivity, yielding a range of up to 100m for smart device connection.

CC1350: Low Power

The CC1350 wireless MCU was built and designed with low power in mind. It consumes ultra-low power while operating in the Sub-1GHz band and achieves

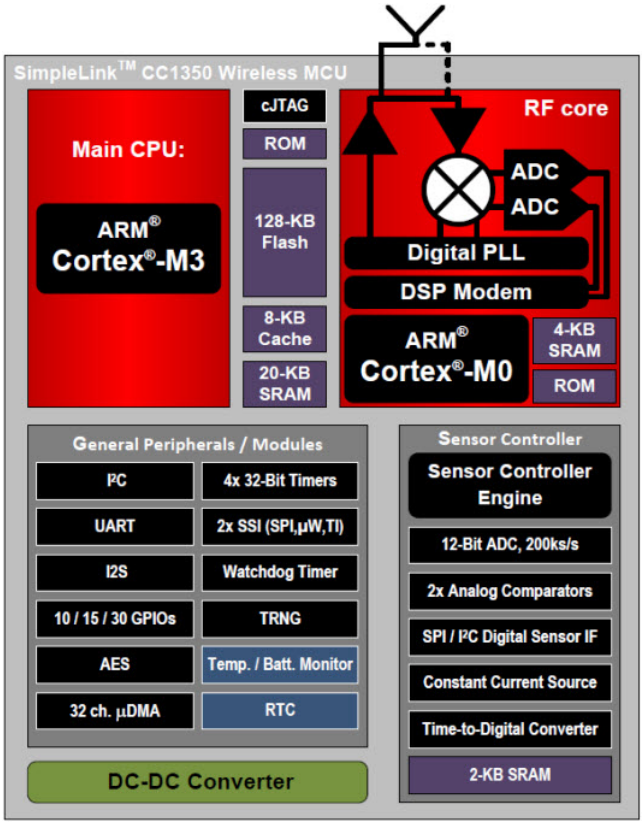


Figure 1. SimpleLink™ CC1350 Wireless Microcontroller Block Diagram

the lowest sleep, RF and wireless MCU current consumption levels in the industry. To eliminate the battery, and make the unit virtually maintenance-free, engineers can design the MCU to incorporate energy harvesting.

The CC1350 solution has very low peak currents, approximately 5.5mA in Rx and 13 mA in Tx at +10dBm output power. It achieves a CoreMark score of 142 while only consuming 51µA/MHz, resulting in a very low average power consumption during active use. Its internal MCU consumes approximately 2.5mA at maximum speed (48MHz), and outperforms any wireless MCU on the market. In addition, the Sensor Control Engine (SCE) monitors sensors in a low power manner, allowing the rest of the system to sleep until an event occurs.

In any battery-operated application, the RF (receive/transmit) duty-cycle and its parameters determine the battery lifetime; that is, standby currents should remain as low as possible between transmissions. To

achieve this, the CC1350 wireless MCU uses an ultra-low leakage static random-access memory (SRAM). With full memory retention and the real time clock (RTC) running, the CC1350's standby current is as little as 0.7µA.

In Bluetooth low energy mode, the CC1350 wireless MCU radio consumes 6.5mA Rx and 10.2mA Tx @ +0dBm, which enables ultra-low-power smart device connections.

CC1350: Highly Integrated

The CC1350 wireless MCU is a highly integrated device that offers a true single-chip solution for both Sub-1GHz and Bluetooth low energy technologies. The device handles sensors through an autonomous, low-power processor called the Sensor Controller. The CC1350 wireless MCU comes in several package sizes, even as small as a 4mm × 4mm QFN package, integrating an MCU plus RF with a built-in DC/DC converter that supports efficient battery use.

All clock and power management is implemented in TI-RTOS, a real-time operating system for TI microcontrollers. TI-RTOS, offered in source code free of charge, enables faster development by eliminating the need for developers to write and maintain system software such as schedulers, protocol stacks, and drivers.

All the Rest

TI recognizes that hardware is only the start. Without supporting software, evaluation modules (EVMs), LaunchPads, and other resources, getting started requires significant work. TI makes it easy.

CC1350: SensorTag Demo Kit

The CC1350 SensorTag (CC1350STK) expands the SensorTag ecosystem with a device that combines Bluetooth low energy radio, a Sub-1GHz radio, and a 32-bit ARM Cortex-M3 processor on a single-chip for the ultimate combination of easy smart device integration with long-range connectivity that can run for years on a single coin cell battery. The CC1350 SensorTag kit allows for direct connection with to smart devices via Bluetooth low energy combined with a range of up to 2,000 m utilizing the Sub-1GHz radio. It contains a small, sensor-based kit that includes 10 low-power MEMS sensors and can connect to the cloud in less than three minutes.

CC1350: LaunchPad

The Texas Instruments SimpleLink™ CC1350 Wireless MCU LaunchPad™ Development Kit (LAUNCHXL-CC1350) combines a Sub-1GHz radio with a Bluetooth low energy radio. This allows for the ultimate combination of easy smart device integration with long-range connectivity including a 32-bit ARM Cortex-M3 processor on a single chip. These LaunchPad Kit includes an integrated PCB trace antenna and provide access to all I/O signals with the BoosterPack™ plug-in module connectors. The built-in onboard emulator helps designers to get started with instant code development in TI's CCS Cloud ecosystem.

Dual–Band Wireless Connectivity Made Easy

Texas Instruments has the largest selection of low-power, robust, easy-to-use wireless connectivity products in the market. Make your next wireless design easier by designing with the SimpleLink™ Dual-Band CC1350 Wireless Microcontroller.

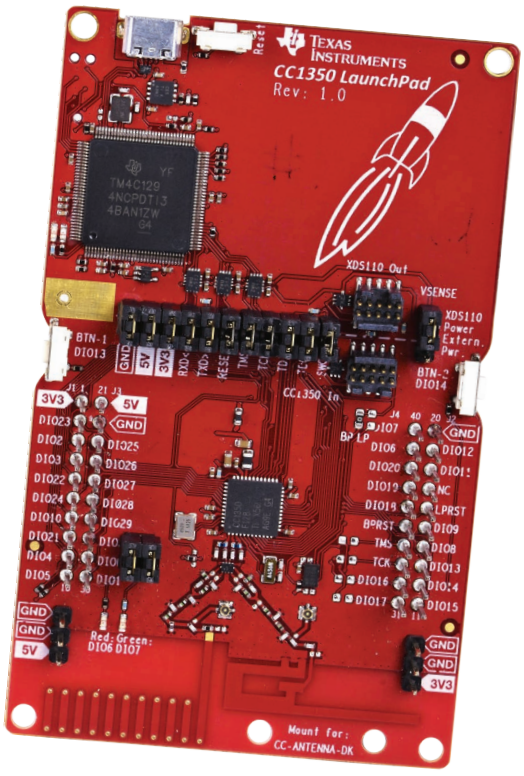


Figure 2. CC1350 Launchpad

SECTION 2

(Read Part 1 of this White Paper series for Sub–1GHz)

Bluetooth® 2.4GHz

Bluetooth® wireless technology is one of the most prominent short-to-medium range communication standards, offering data rates up to 3Mbps. Due to its excellent performance and reliable connections—at distances up to roughly 100m—Bluetooth technology has proven to be both flexible and reliable for wireless connectivity solutions, as well as an excellent solution for connections to personal area networks (PANs).

With the explosion of portable devices, Bluetooth low energy has established itself as the way to connect low-power applications to smart devices such as phones or tablets. It offers the advantage of consuming much less power than Bluetooth while maintaining ease-of-use. In addition, Bluetooth low energy technology is not limited by harsh environments, offering the ability to be automotive qualified and operating in extreme temperatures up to 125°C.

Range

Bluetooth and Bluetooth low energy are well-suited for ranges of hundreds of meters, but designs require Sub-1GHz to go into the multi-kilometer range. This low-frequency transmission allows for longer distance at a given output power, meaning that a Sub-1GHz transmission can travel farther than its 2.4GHz counterpart for the same output power.

Robust

This Bluetooth 2.4GHz spectrum is robust and proven but generally more crowded and susceptible to interference when compared to Sub-1GHz.

Power

Bluetooth employs a low-power transmit (Tx) and receive (Rx) radio to minimize power consumption.

Throughput

Typical Bluetooth applications achieve a high throughput in Mbps while typical Sub-1GHz applications achieve a lower throughput in Kbps. This makes Bluetooth advantageous for applications that require a higher throughput than Sub-1GHz can offer, such as over-the-air firmware updates.

Summary

Bluetooth 2.4GHz wireless connectivity products are an excellent medium-range, high-throughput, low-power, and low-cost way to transmit data. They are interoperable with other Bluetooth devices and have a very large install base in smart mobile devices.

TI Products

Texas Instruments offers the industry's largest selection of Bluetooth and Bluetooth low energy solutions devices. These devices are also the easiest to use and consume the lowest power.

Which Spectrum?

When designing wireless connectivity applications, what is the primary differentiating factor when considering whether to employ Bluetooth 2.4GHz or Sub-1GHz? It turns out that many of today's applications can employ either a Bluetooth or a Sub-1GHz design and be successful. However, applications that need to transfer large amounts of data over a short distance, such as a building security camera, will require Bluetooth technology's higher data rate capabilities. If a longer range is needed, then Sub-1GHz has the advantage. Additionally, Sub-1GHz

TABLE 2. The Operating Range of Key Wireless Connectivity Technologies

Wireless Connectivity Technology	Range (m)
Sub-1GHz	20,000
ZigBee® and Bluetooth® Low Energy	400
Wi-Fi®	100

is preferred if longer battery life is key to the design. The following table shows which frequency spectrum has advantages for particular design features.

HAVE IT BOTH WAYS: Dual–Band: Sub–1GHz + Bluetooth Low Energy

The preceding table shows that designers must often decide between having high data rates or maximizing battery life and long-range connectivity. Until now, there has been no easy way to get both simultaneously. But what if both technologies were integrated into a single part that could operate in both spectrums? With such a part, engineers could have high data rates at their fingertips by utilizing Bluetooth low energy and achieve low power and long range by leveraging Sub-1GHz technology. The following example designs demonstrate ways that companies can use mobile devices equipped with Sub-1GHz and Bluetooth Low Energy technologies in daily operations.

Role Switching: Wireless Firmware Update (Sub–1GHz or Bluetooth Low Energy)

Maintenance workers use mobile devices to ensure that all of the lights in the building have received the latest firmware update. The workers use the devices' high-throughput Bluetooth low energy capabilities to quickly transmit the correct version of the firmware, thereby reducing the power consumption by shortening the time of the update. The devices then return to Sub-1GHz operation to achieve complete building coverage at very low power.

Beacons: Remote Display Collection (Sub–1GHz and Bluetooth Low Energy)

A technician uses a mobile device to collect industrial information from all of the buildings on the company's campus. The technician's device uses the long-range properties of Sub-1GHz technology to send that information to the company's central system. Other technicians can then access the information and create a remote display on their devices using Bluetooth low energy.

Duty Cycle: Inventory Tracking (Sub–1GHz and Bluetooth Low Energy)

A company uses RFID tags to track its vehicles and inventory, sending the data over long distances to cloud servers using Sub-1GHz technology. When the company's inventory control specialists are in close proximity to the tags, the data is wirelessly transmitted from the cloud to their mobile devices using Bluetooth low energy technology.

These designs are possibile with the new Texas Instruments SimpleLink™ dual-band CC1350 wireless MCU.

TABLE 2 The Advantages of Key Wireless Connectivity Technologies

Issue	Advantage
Battery Life	Sub-1GHz
Data Rate	Bluetooth 2.4GHz
Range	Sub-1GHz

SECTION 3

Texas Instruments Wireless Connectivity

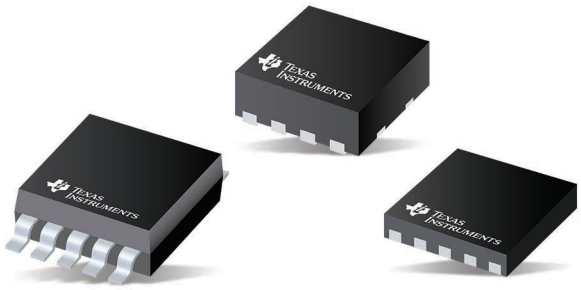
Texas Instruments (TI) is a leading designer and manufacturer of analog and embedded processor semiconductors with sales of $13 billion (2015). TI's embedded processing segment generated revenue of $2.8 billion, representing approximately 15 percent market share, putting TI among the leaders in this business segment (2015).

Embedded processing consists of products that function as the "brains" of many electronic devices. Embedded processing products are designed to handle specific tasks and can be optimized for various combinations of performance, power and cost, depending on the application. TI's embedded processing is further broken down into three major product lines: Microcontrollers, Processors, and Wireless Connectivity.

Wireless Connectivity Made Easy by Design

Wireless connectivity products enable electronic devices to seamlessly connect and transfer data. However, the requirements for speed, data capability, distance, power and security vary depending on the application. TI's wireless connectivity products support many wireless technologies—including Bluetooth, Wi-Fi, Sub-1GHz, 6LoWPAN, ZigBee, ZigBee RF4CE™, and NFC—in order to meet these various requirements. TI's wireless connectivity products are typically designed into customer devices alongside TI's processor and microcontroller products, enabling data to be collected, transmitted and acted upon. Engineers can design applications to bypass the separate processor or microcontroller by selecting one of TI's wireless microcontrollers for an all-in-one package. Wireless connectivity is driving new designs in many applications, including automotive, motor drive and remote control, building automation, smart grid, factory automation, wearables, audio, home electronics, and smart peripherals.

TI distinguishes its wireless connectivity product line from its competitors' lines by three main factors that make TI the most attractive supplier to engage with: large selection, low power consumption, and ease-of-use.



Large Selection

First, TI wireless connectivity offers the largest selection of products in the marketplace that work with a variety of connectivity standards. TI has been investing in wireless connectivity products for almost two decades and has a customer base that includes millions of designed-in parts and products. This large and well-established designed-in component base allows engineers to easily integrate into TI's offering of the industry's broadest wireless connectivity portfolio. TI's wireless connectivity portfolio is a fit for any system topology, whether designed for short ranges measured in centimeters or long ranges measured in kilometers. TI has wireless connectivity products that cover proximity, personal area networks (PAN), local area networks (LAN), and neighborhood area networks (NAN). Currently, TI wireless connectivity offers 14 standards and technologies, which allows customers to leverage their investment and future-proof their designs by working with a single, proven supplier.

Need Bluetooth? TI has it. Need Wi-Fi? TI has the parts. Want Sub-1GHz? Look to TI. Considering 6LoWPAN, ZigBee, ZigBee RF4CE, or NFC/RFID? Check, check, check, and check. In addition to supporting so many standards and technologies, TI also offers the option of designing with integrated circuits (ICs) or with TI-certified modules.

Low Power

TI wireless connectivity products are designed to consume the lowest power to enable multi-year operation on coin cell batteries. TI empowers

customers to easily adapt their designs to work with energy-harvesting technology so that batteries may be completely eliminated from the design.

Easy

Finally, TI wireless connectivity products are the easiest to use. How can TI make this claim? They have made designing easy by making sure that engineers have everything they require with a full broad-market ecosystem that includes software, tools, the TI E2E™ community, certified modules, TI Designs (a robust reference design library), online training, and technical sales support.

SimpleLink™ Solutions

TI has two key wireless connectivity solution portfolios: WiLink™ and SimpleLink™. WiLink™ is an RF transceiver (radio) that contains both high-performance Wi-Fi and Bluetooth/Bluetooth Low Energy connectivity in a single chip. SimpleLink™ is a broad device offering for all technologies and system partitioning that represents the industry's first multi-wireless microcontroller platform that can execute Bluetooth Low Energy, Sub-1GHz, 6LoWPAN, ZigBee and ZigBee RF4CE.

SimpleLink™ solutions' uniqueness lies in its ability to be easily scaled across various wireless connectivity technologies. Different wireless connectivity technologies are supported by a single product platform by means of a common pin-to-pin layout, common peripheral support, and common software coding. This allows design engineers a great deal of flexibility to solve all of their wireless connectivity challenges with one simple product platform.

TI offers SimpleLink™ solutions in three product categories:

- Smart RF transceiver (radio)
- Wireless Network Processor (WNP), which combines an RF transceiver (radio) and a wireless stack
- Wireless microcontroller (MCU), which incorporates an RF transceiver (radio), a wireless stack, and application MCU

SimpleLink™ Wireless Microcontroller (MCU)

TI's SimpleLink™ wireless microcontroller (MCU) portfolio incorporates an ultra-low power (ULP) design built for multiple standards, including Bluetooth Low Energy, Sub-1GHz, 6LoWPAN, ZigBee, or ZigBee RF4CE. The SimpleLink™ ULP platform has an integrated low-power ARM® Cortex®-M3, the industry-leading 32-bit processor for low-power, cost-sensitive, and highly deterministic real-time embedded applications.

The SimpleLink™ ULP platform is easy to use because it has common software and royalty-free network stacks. TI provides support through comprehensive documentation, the TI E2E™ community, available training, TI Design reference designs, and support from TI's IoT cloud ecosystem members including IBM, and the fact that silicon and kits are available through the TI Store.

One Architecture, Several Technologies

For the SimpleLink™ Wireless MCU products, specifically the CC26xx and CC13xx series, TI has employed a common architecture to accommodate a variety of specific wireless connectivity technologies, including Sub-1GHz, Bluetooth Low Energy, and ZigBee.

The following table lists some of the SimpleLink™ Wireless MCUs that help designers enable commonly employed wireless connectivity technology.

TABLE 3. Connectivity Technology and Frequency Spectrums

Connectivity Technology						
Spectrum	Part	Sub-1GHz	Bluetooth® Low Energy	ZigBee	6LoWPAN	ZigBee RF4CE
Sub-1GHz	CC1310	●			●	
Dual Band, Sub-1GHz + BLE	CC1350	●	●		●	
2.4GHz	CC2620					●
2.4GHz	CC2630			●	●	
2.4GHz	CC2640		●			
2.4GHz	CC2650		●	●	●	●

This common architecture provides the following elements:

Radio: Dedicated radio controller utilizing an ARM Cortex-M0 MCU, flexible, software defined, that support multiple protocols
Sensor Control Engine: Analog-to-digital converters (ADCs) and comparators, digital sensor readings, capacitive sensing
Memory: 128KB Flash, 8KB cache, 2KB SRAM
Peripherals and Modules: DC/DC converter, temperature and battery monitor, advanced encryption standard (AES), GPIO, timers, UART/SPI, I^2C/I^2S, DMA
Application MCU: ARM Cortex-M3 MCU, application, profiles/services, TI RTOS, peripheral drivers and libraries, royalty-free protocol stacks

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