

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

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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.



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SECTION 1

SimpleLink™ Sub-1GHz CC1310 Wireless Microcontroller

TI's SimpleLink™ Sub-1GHz CC1310 Wireless MCU is specifically designed to yield excellent performance for low-power, robust, long-range connectivity. Additionally, it takes integration to a new level, making it easier to use and incorporate into designs.

CC1310: Long/Robust Range

The CC1310 wireless MCU is optimized for Sub-1GHz frequency operation. To improve co-existence and range, the CC1310 solution also offers very good blocking performance of up to 90dB. The CC1310 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 performance (selectivity and up to 90dB blocking), the CC1310 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 allow full building-wide to city-wide RF coverage.

CC1310: Low Power

The CC1310 wireless MCU is built and designed with low power in mind. It consumes ultra-low power while operating in the Sub-1GHz band and achieves 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 CC1310 solution has very low peak currents, approximately 5.5mA in receive (Rx) and 13mA in transmit (Tx) at +10dBm output power. It achieves a CoreMark score of 142 while consuming only 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 CC1310 wireless MCU uses an ultra-low leakage static random-access memory (SRAM). With full memory retention and the real time clock (RTC) running, the CC1310's standby current is as little as 0.7µA.

CC1310: Highly Integrated

The CC1310 wireless MCU is a highly integrated 315MHz/433MHz/470MHz/500MHz/868MHz/915MHz/920MHz device that offers a true single-chip solution. The device handles sensors through an autonomous, low-power processor called the Sensor Controller. The CC1310 wireless MCU comes in several package sizes, even as small as a 4mm × 4mm QFN package, integrating an MCU plus RF

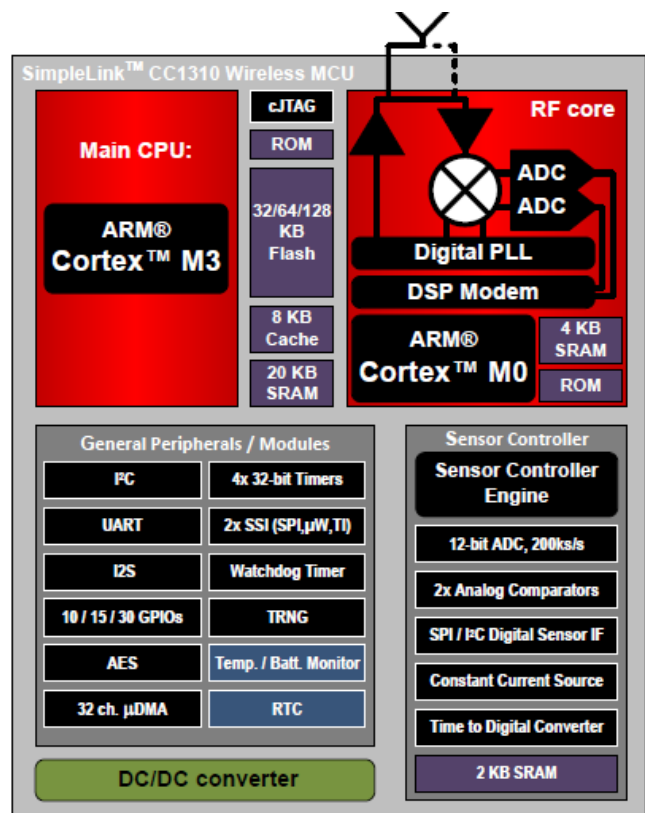


Figure 1. SimpleLink™ CC1310 Wireless Microcontroller Block Diagram

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.

CC1310: Software

TI understands that software is a major challenge in wireless connectivity designs, so they developed the TI 15.4-Stack, an IEEE802.15.4e/g-based software development kit (SDK) that supports a star network topology for Sub-1GHz applications. This saves the time and resources needed for the customer to build their own network protocol from scratch.

The TI 15.4-Stack software offers several key benefits, such as longer range in FCC band and better protection against in-band interference by implementing frequency hopping to increase system robustness. The TI 15.4 Stack software supports ultra-low power and provides customers an accelerated time to market with a complete end-to-end, node-to-gateway solution. The software runs on TI's SimpleLink™ Sub-1GHz CC1310 wireless MCU and CC1310 wireless MCU LaunchPad™ development kit.

CC1310: LaunchPad Kit

TI's SimpleLink™ Sub-1GHz wireless MCU LaunchPad Development Kit (LAUNCHXL-CC1310) is the first LaunchPad kit with a Sub-1GHz radio. It allows users to leverage the existing TI MCU ecosystem. This radio offers long-range connectivity, combined with a 32-bit ARM Cortex-M3 processor on a single chip. This development kit saves time and production cost by helping engineers quickly prototype systems with the LaunchPad kit's I/O connectors. This allows for quick interfacing to a variety of EVMs and BoosterPack™ plug-in modules. Engineers can develop Internet of

TABLE 1 TI 15.4-Stack

Category	Item	TI 15.4-Stack
Network Management	Formation, discovery	TI 15.4–Stack Link Management Layer
Network Management	Joining, leaving	TI 15.4–Stack Link Management Layer
Security	Encryption	AES–128 Encryption
Security	Message integrity	802.15.4 standard CSMA/CA
MAC	Message access	Message Integrity Code
MAC	Addressing	802.15.4 standard addressing
MAC	Packaging	802.15.4 standard packaging
MAC	Frequency hopping	WiSUN™ Alliance based frequency hopping
MAC	Regulatory compliance	Designed for European Telecommunications Standards Institute (ETSI)/ Federal Communications Commission (FCC) compliance

Things (IoT) software applications on the CC1310 LaunchPad kit using the TI-RTOS for CC13xx and CC26xx software development kit (SDK), which features an RF driver, power management driver, and multiple peripheral drivers.

Sub–1GHz Wireless Connectivity Made Easy

Texas Instruments has the largest selection of low-power, robust, easy-to-use wireless connectivity parts in the market. Make your Sub-1GHz design easy by using the SimpleLink CC1310 wireless MCU in your next wireless connectivity design.

SECTION 2 (Read Part 2 of this White Paper series for *Bluetooth 2.4GHz*)

Sub-1GHz Technology

Given the variety of technologies and spectrums available for wireless connectivity, why would an engineer consider Sub-1GHz products instead of designing wireless connectivity at another common frequency, such as the very popular 2.4GHz? Primarily, long-range applications, robustness, and low power consumption.

Long Range Applications

Sub-1GHz technology can help engineers obtain long-range connectivity. Technologies like near field communication (NFC) and radio-frequency identification (RFID) work well for extremely short distances characteristically measured in centimeters, while Bluetooth® and Bluetooth® Low Energy are well-suited for ranges of hundreds of meters. Sub-1GHz goes well beyond these ranges, enabling connectivity into the multi-kilometer range. 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.

Robustness

In addition to achieving long range transmissions, Sub-1GHz is generally more robust than technologies that employ higher frequencies. The Sub-1GHz spectrum is less crowded when compared to other spectrums and can better penetrate through objects such as trees, walls, ceilings, and equipment. This means that Sub-1GHz has better performance characteristics in environments that will be considered

to be crowded relative to human lines of sight (LoS). In addition, the lower frequencies of the Sub-1GHz spectrum can bend around objects with less attenuation and provide better coverage than comparable level 2.4GHz signals.

Low Power Consumption

Sub-1GHz also consumes little power, which allows applications to operate off a coin cell battery for up to 20 years. Sub-1GHz technology's low power consumption makes it ideal for applications including home automation, smart grid, alarm and security, retail, logistics, factory automation, and agriculture, among others. Sub-1GHz technology can also be configured into star networks to maximize performance for the intended application. For example, in home automation a star network will help to achieve full house coverage, while building automation systems should employ star networks using multiple gateways.

Summary

Sub-1GHz wireless connectivity products are excellent for battery-powered applications that need to operate within a long range and require very robust connectivity that can be difficult to achieve on current 2.4GHz technologies. To further investigate Sub-1GHz technology, start with the market leader, Texas Instruments.

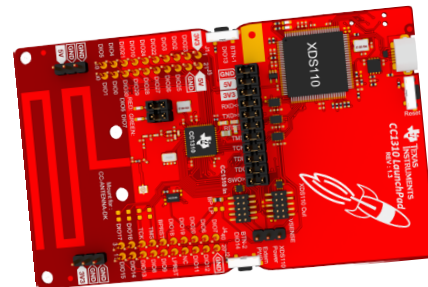


TABLE 2. The Operating Range of Key Wireless Connectivity Technologies

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

SECTION 3

Texas Instruments Wireless Connectivity

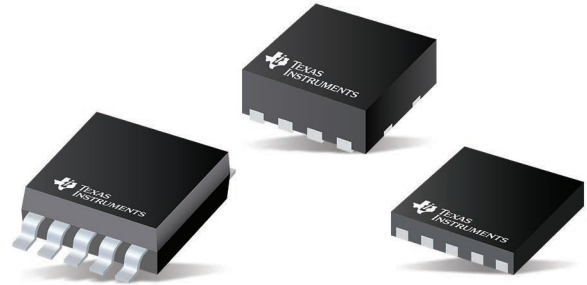
Texas Instruments (TI) is a leading designer and manufacturer of analog and embedded processor semiconductors with sales of \$13 billion (2015). TI's embedded processing segment generated revenue of \$2.8 billion, representing approximately 15 percent market share, putting TI among the leaders in this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

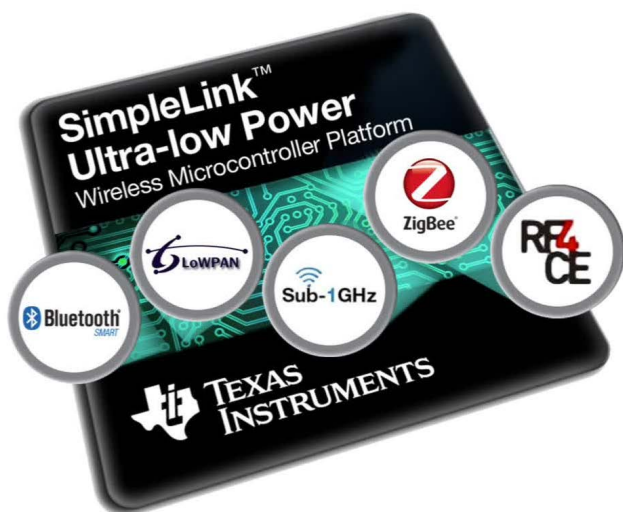
TI's SimpleLink™ wireless microcontroller (MCU) portfolio incorporates an ultra-low power (ULP) design built for multiple standards, including Bluetooth Low Energy, Sub-1GHz, 6LoWPAN, ZigBee, or ZigBee RF4CE. The SimpleLink™ ULP platform has an integrated low-power ARM® Cortex®-M3, the industry-leading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



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, I²C/I²S, DMA

Application MCU: ARM Cortex-M3 MCU, application, profiles/services, TI RTOS, peripheral drivers and libraries, royalty-free protocol stacks

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		•	•	•	•

Golata, Paul. *Wireless Connectivity Made Easy by Design: Sub-1GHz with Texas Instruments CC1310 SimpleLink™ Ultra-Low Power Wireless Microcontrollers*. Mansfield, TX: Mouser Electronics. 2017.



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