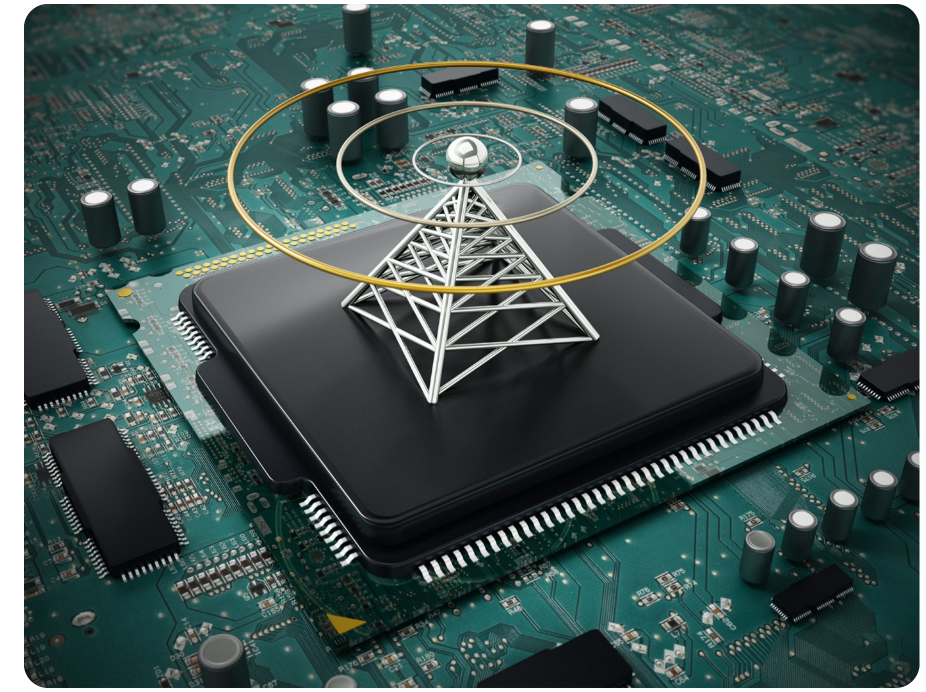
SILICON LABS

Sub-GHz SoC and Module Selector Guide

Selecting the Right SoCs and Transceivers for Your Sub-GHz IoT applications

Introduction to Sub-GHz Networking

To build an advanced wireless system, most developers end up choosing between two industrial, scientific and medical (ISM) radio band options: 2.4 GHz or sub-GHz frequencies. Pairing one or the other with the system's highest priorities will provide the best combination of wireless performance and economy. Sub-GHz networking refers to the use of radio frequencies below 1 GHz for wireless communication between devices. In recent years, there has been a growing interest in this technology due to its many benefits including longer range, lower power consumption, and better penetration through walls and other obstacles.



Wi-Fi, Bluetooth, and Zigbee technologies are heavily marketed 2.4 GHz protocols used extensively in today's markets. However, for low-data-rate applications, such as home security/automation and smart metering, sub-GHz wireless systems offer several advantages, including longer range, reduced power consumption and lower deployment and operating costs.

One common application for sub-GHz is in the field of industrial automation, where sensors and other devices need to communicate with each other over long distances in harsh environments. By using sub-GHz networking, these devices can maintain a reliable connection even in areas with high levels of interference, such as factories and warehouses. Sub-GHz networking can also be used for environmental monitoring and agricultural applications. For example, farmers can use wireless sensors to monitor soil moisture, temperature, and other variables across large fields, allowing them to optimize irrigation and other farming practices.

Two major advantages of sub-GHz networking is its ability to penetrate obstacles such as walls and buildings and its low power consumption.

Signal penetration is useful in environments where line-of-sight communication is not possible, such as inside buildings with thick walls. By using sub-GHz networking, devices can maintain a reliable connection even in these challenging environments. This, coupled with its low power consumption, means sub-GHz networking can be especially useful where devices need to operate on batteries for extended periods of time. By using sub-GHz networking, devices can transmit data over longer distances while consuming less power, allowing them to operate for weeks or even months on a single battery.

Sub-GHz wireless networks can provide an extremely cost-effective solution in any low-data-rate system, from simple point-to-point connections to much larger mesh networks, where long range, robust radio links and extended battery life are leading priorities. Higher regulatory output power, reduced absorption, less spectral pollution and narrowband operation increase transmission range. Better circuit efficiency, improved signal propagation and a smaller memory footprint reduce overall power consumption, which can result in years of battery-powered operation.

Sub-GHz Wireless critical for Smart Infrastructure

Sub-GHz provides a low-power, long-range solution for infrastructure where connectivity needs to be immune to the growing amount of 2.4 GHz noise. Applications can vary widely including utility metering, asset tracking to street lighting, stop lights, and even parking meters. The long range, mesh capabilities of some sub-GHz technologies enable the robust connectivity needed for these applications. Sub-GHz technologies have formed the backbone of these critical networks and the emergence of new standards-based protocols further strengthen its foothold in this space.

Opening Doors in the Smart Home

Though known for targeting smart cities and industrial, several kilometers (miles) connectivity use cases, sub-GHz frequencies are incredibly useful for low data transmission rate smart home IoT device development. How? They enable a range of features and capabilities that cannot be obtained through other communication protocols.

Sub-GHz is particularly effective in smart home applications due to several key advantages it offers over higher frequency wireless technologies.

Key Considerations for Sub-GHz Wireless Deployment

There are key priorities to consider when deploying this type of technology. Let's explore what those priorities are and how they can help you maximize the potential of your sub-GHz wireless deployment.

Range

The range of a sub-GHz system can vary greatly depending on the operating environment, so it's important to identify any obstacles that might affect the signal strength or interfere with the transmission of data. For example, if you are using an outdoor antenna, you will need to consider how nearby buildings or other metal objects may impact the signal strength. Additionally, if you plan on using multiple antennas in an area with high radio interference levels, such as cities or urban areas, you should make sure that each antenna is properly spaced out to avoid interference between them.

Sub-GHz radios can provide superior range performance over 2.4 GHz applications due to attenuation rates, fading, and diffraction advantages. Sub-GHz frequencies are broken down into two main categories—UHF (Ultra High Frequency) and VHF (Very High Frequency). UHF bands have higher frequencies than VHF bands, which means they are more efficient and provide better range than VHF bands. However, UHF bands also require more power to operate and may not be suitable for all applications. Therefore, it's important to carefully consider your application requirements before selecting a frequency band.

Power Consumption

Sub-GHz radios can help reduce power consumption due to their lower bandwidth requirements and increased receiver sensitivity. Additionally, interference from other 2.4 GHz signals is reduced, resulting in fewer retries and more efficient operation.

This type of technology requires relatively low power consumption compared to other communication technologies such as Wi-Fi or cellular networks, but this does not mean that power consumption should be overlooked entirely. When designing your system architecture, it is important to consider energy efficiency by using components with low standby power consumption and optimizing data packet sizes so that only necessary information is transmitted over the airwaves – minimizing latency and battery drain in devices using sub-GHz radios for communication purposes.

Data Rates

Sub-GHz radios are ideal for low-data-rate applications due to their narrowband operation, allowing efficient transmission of small amounts of data.

Antenna Size

Although sub-GHz antennas can be larger than those used in 2.4 GHz networks, antenna size and frequency are inversely proportional. The optimal antenna size for 433 MHz applications can be up to seven inches.

Key Considerations for Sub-GHz Wireless Deployment

Interoperability

Sub-GHz wireless systems offer greater interoperability than 2.4 GHz systems due to their wider range of supported standards. IEEE802.15.4g and IEEE802.15.4e are two commonly used standards. A number of standard solutions for the radio PHY, MAC, and stack layers are available for 2.4 GHz and sub-GHz applications. 802.15.4 (PHY/MAC), Zigbee, Bluetooth, Wi-Fi, and RF4CE are widely used 2.4 GHz solutions. Sub-GHz standards-based solutions include Zigbee, EnOcean, io-homecontrol®, ONE-NET, INSTEON®, and Z-Wave. While standard solutions offer the advantage of vendor-independent interoperable nodes, they normally will increase each node's cost and footprint.

With specialized functions and small software stacks, proprietary solutions can achieve smaller die sizes and reduced memory footprints. Less complex stacks also simplify deployments and lower maintenance costs. Therefore, proprietary sub-GHz solutions can offer less expensive point-to-point localized networks like a garage door opener or home automation system.

Worldwide Deployment

Sub-GHz wireless systems are globally available, with different countries and regions using different sets of sub-GHz frequencies. It is important to ensure that the system is compliant with the regulations of the region in which it is to be deployed. For instance, video game manufacturers who market their products worldwide can use 2.4 GHz radios for all their consoles because it is a global ISM allocation. Similarly, wireless applications using the 433 MHz band share a global sub-GHz ISM allocation, with Japan being the sole major market exception. In addition, 915 MHz is used extensively in North America and Australia, 868 MHz is deployed across all of Europe and 315 MHz is available in North America, Asia and Japan.

Sub-GHz wireless deployment has many advantages over traditional communication technologies like Wi-Fi or cellular networks; however, there are certain key priorities that must be taken into consideration when deploying this type of technology in order to maximize its potential benefits and ensure successful operation in various environments and conditions. By choosing the right frequency band, maximizing range through proper antenna placement and spacing out elements within an area with high radio interference levels and optimizing power consumption through careful design considerations, you can ensure successful deployment of your wireless network and reap all the rewards associated with it.

Sub-GHz Networking Protocols Snapshot

There are various types of sub-GHz protocols available for use in low-power wireless communication. The most common implementations are Amazon Sidewalk, Wi-SUN, and Z-Wave, each with their own advantages and disadvantages.

amazon sidewalk

Amazon Sidewalk is a shared wireless network that uses compatible devices to extend connectivity.

Z WAVE

Z-Wave is a sub-GHz protocol that uses low-energy RF for device-to-device communication.

Wi SUN

Wi-SUN is based on IEEE 802.15.4g/e and supports star, mesh, and hybrid topologies.

mioty alliance

Mioty is an LPWAN protocol that uses telegram splitting in the license-free spectrum.

LoRa

LoRa is a proprietary radio technique based on spread spectrum modulation.

802.11ah

IEEE 802.11ah uses 900 MHz license-exempt bands extend the range of Wi-FI networks.

Silicon Labs' Sub-GHz Hardware Portfolio

Our portfolio of sub-GHz products ranges from transceivers to multi-band wireless SoCs for IoT applications offering ultra-low power, the longest range available, and up to 20 dBm output power while covering major frequency bands.

Proprietary Software Development with the Flex SDK

The Flex SDK is a complete software development suite for proprietary wireless applications that provides two paths for development. The first path begins with Silicon Labs RAIL (Radio Abstraction Interface Layer), which is an intuitive and easily customizable radio interface layer designed to support proprietary or standards-based wireless protocols. The second path uses Silicon Labs Connect, an IEEE 802.15.4-based networking stack designed for creating easily customizable broad-based proprietary wireless networking solutions optimized for devices that require low power consumption for both sub-GHz and 2.4 GHz frequency bands and targeted for simple network topologies.

The Flex SDK includes extensive documentation and sample applications, the popular range test, functionality for lab evaluation, wake-on-radio as well as bi-directional packet transmission and reception. All these examples are provided in source code within the Flex SDK sample applications. Using the supporting Simplicity Studio tools suite, developers can take advantage of the graphical user interface to quickly generate wireless applications, perform energy profiling, and various system optimizations.

	FG22	xGM230S	FG25	xG28	xG23	Si44xx
Family		ZGM, FGM		ZG28, FG28, SG23	ZG23, FG23, SG23	
Protocols	• Proprietary	• WM-BUS • Proprietary • Connect	• Wi-Sun • Proprietary	• Proprietary • CONNECT • Amazon Sidewalk • Wireless M-BUS • Wi-SUN • Bluetooth 5.4 • Z-Wave	• Wi-SUN (RCP Only) • Wireless M-BUS • Proprietary, • Amazon Sidewalk • Connect • Z-Wave	• Wireless M-Bus • Proprietary • SigFox
Freq. Bands	2.4 GHz	Sub-GHz	Sub-GHz	Sub-GHz + 2.4 GHz Bluetooth LE	Sub-GHz	Sub-GHz
Modulation Schemes	• 2 (G)FSK with fully configu- rable shaping • OQPSK DSSS • (G)MSK	• 2/4 (G)FSK with fully configurable shaping • OQPSK DSSS	• Wi-SUN MR OFDM MCS 0-6 (all 4 Options) • 802.15.4 SUN MR OQPSK with DSSS • Wi-SUN FSK • 2(G)FSK with fully configurable shaping • (G)MSK	• 2/4 (G)FSK with fully configurable shaping • OQPSK DSSS • (G)MSK • OOK	• 2/4 (G)FSK with fully configurable shaping • OQPSK DSSS • (G)MSK • OOK	• 2/4 (G)FSK • (G)MSK • OOK
Core	Cortex-M33 (38.4 MHz) Cortex M0+ (Radio)	Cortex-M33 (39 MHz) Cortex M0+ (Radio)	Cortex-M33 (97.5 MHz) Cortex M0+ (Radio)	Cortex-M33 @78 MHz Cortex M0+ (Radio)	Cortex-M33 (78 MHz) Cortex M0+ (Radio)	–
Max Flash	512 kB	512 kB	1920 kB	1024 kB	512 kB	–
Max RAM	32 kB	64 kB	512 kB	256 kB	64 kB	–
Security	Secure Vault- Mid	Secure Vault- Mid Secure Vault-High	Secure Vault- Mid Secure Vault-High	Secure Vault- Mid Secure Vault-High	Secure Vault- Mid Secure Vault-High	–
Trustzone	Yes	Yes	Yes	Yes	Yes	–
Max TX Power	+6 dBm	+14 dBm	+16 dBm	+20 dBm	+20 dBm	+20 dBm
RX Sensitivity (50 Kbps GFSK@915 Mhz)	-102.3 dBm @250 kbps O-QPSK DSSS	-109.7 @40 Kbps	-109.9 dBm	-111.5 dBm	-110 dBm	-109 dBm
Active Current (CoreMark)	26 µA /MHz	26 µA /MHz	30 µA /MHz	36 µA /MHz	26 µA /MHz	–
Sleep Current	1.2 µA/MHz (8 kb ret)	1.5 µA/MHz (64 kb ret)	2.6 µA/MHz (32 kb ret)	2.8 µA/MHz (256 kb ret) /1.3 µA/MHz (16 kb ret)	1.5 µA/MHz (64 kb ret	740 nA
TX Current @+14 dBm	8.2 mA @+6 dBm	30 mA @+14 dBm	58.6 mA @+13 dBm	26.2 mA @+14 dBm	25 mA @+14 dBm	44.5 mA @+14 dBm
Serial Peripherals	USART, PDM, I2C, EUART	USART, I2C, EUSART	USB 2.0, I2C, EUSART	USART, EUSART, I2C	USART, I2C, EUSART	SPI
Analog Peripherals	16-bit ADC,12-bit ADC, Temperature sensor	16-bit ADC,12-bit ADC, 12- bit VDAC, ACMP, LCD, Temperature sensor	16-bit ADC,12-bit ADC, 12- bit VDAC, ACMP, IADC, Tem- perature sensor	16-bit ADC,12-bit ADC, 12-bit VDAC, ACMP, IADC, temperature Sensor	16-bit ADC,12-bit ADC, 12- bit VDAC, ACMP, LCD, Temperature sensor	11-bit ADC, Aux ADC, Voltage sensor
Supply Voltage	1.71 V to 3.8 V	1.8 V to 3.8 V	1.71 V to 3.8 V	1.71 V to 3.8 V	1.71 V to 3.8 V	1.8 V to 3.8 V
Operating Temperature Range	-40 to +85 °C	-40 to +85 °C	-40 to +125 °C	-40 to +125 °C	-40 to +125 °C	–40 to +85 °C
GPIO	26	34	37	49	31	4
Package	• 5× 5 QFN40 • 4× 4 QFN32	• 6.5 mm x 6.5 mm SIP	• 7× 7 QFN56	• 8 × 8 QFN68 • 6 mm × 6 mm QFN48	• 5× 5 mm QFN40	• 3 × 3mm QFN20