

8 Experts on Overcoming Challenges of RF Solution Design

Saving time and simplifying
RF design for wireless devices

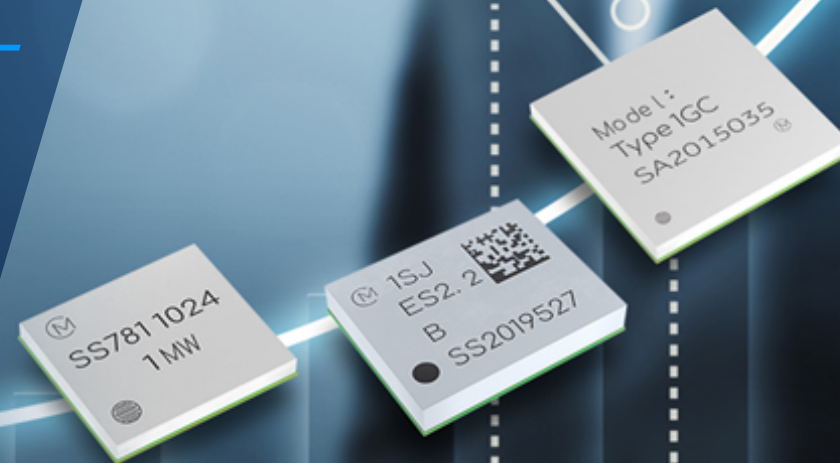


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Introduction

Designing Wireless Solutions

As of 2020, there were approximately seven wirelessly connected devices for every human being on the planet, and that number is growing rapidly. In today's world of remote monitoring and control, it has almost become a requirement that consumer, commercial, industrial, and medical devices have wireless connectivity.

The demand for wireless and Internet of Things devices is on the rise, but the basic physics of wireless engineering remain—things like radio-frequency (RF) interference, power consumption, range, and the daunting task of shrinking more RF power into smaller packages, not to mention regulatory certifications.

How do engineers address these challenges? With the generous support of Murata and Mouser, we explored this question by asking seven RF engineers the following question:

When designing wireless connectivity into a device, which challenges do engineers face in developing an RF solution, and how do you overcome them?

Anyone familiar with RF solution design will not be surprised to hear that a lot of what happens in RF engineering is balancing trade-offs among cost, performance, and development time. In this ebook, engineers talk about the strategies they use to overcome design and economic constraints.

Given the trends toward wireless everything and unlimited bandwidth, this timely ebook provides insights of value to anyone involved in RF solution design.



All the best,
David Rogelberg
Editor
Mighty Guides, Inc.



Mouser Electronics, a Berkshire Hathaway company, is an award-winning, authorized semiconductor and electronic component distributor focused on rapid new product introductions from its manufacturing partners for electronic design engineers and buyers. The global distributor's website, Mouser.com, is available in multiple languages and currencies and features more than 5 million products from over 800 manufacturers. Mouser offers 27 support locations around the world to provide best-in-class customer service and ships globally to over 630,000 customers in more than 223 countries/territories from its 1 million-square-foot state-of-the-art facilities south of Dallas, Texas. For more information, visit www.mouser.com.

Foreword

In today's business climate, achieving wireless connectivity which enables high quality / high speed communication between various devices and the cloud is paramount. Compounding this challenge are the growing number of M2M, multimedia, smart homes, appliances, autonomous robot/sensor networks, health care, telemedicine, mobility, and industrial applications which will require wireless internet of things (IoT) connectivity.

Along with the above, additional considerations regarding how a business is to plan for the inclusion of wireless IoT connectivity into their newest designs in a cost-effective, expedient time-to-market can be a daunting task to many, especially for smaller engineering staffs lacking expertise in this area. Questions such as what communications protocol, operating systems, embedded systems engineering, and technical support will customers require to achieve wireless connectivity must be fully addressed at the onset.

As a pioneer and leading company in the development and manufacturing of innovative, state of the art wireless connectivity modules for consumer, energy, industrial, medical, and mobility applications, Murata Electronics is paving the way for wireless modules for IoT applications and markets. Wireless connectivity makes the IoT possible, and Murata wireless connectivity innovative solutions help make your new IoT product designs a reality.

I sincerely hope you will find the accompanying Mighty Guides e-Book guide to identifying and better understanding the challenges and issues related to achieving wireless connectivity solutions for new designs educational and rewarding.



Regards,
Mehul Udani,
VP of Technology & Innovation
Murata Electronics – Americas



Murata Electronics, Inc.

Murata is a worldwide leader in the design and manufacture of ceramic passive electronic components, wireless connectivity modules, and power conversion technologies. Since its establishment in Kyoto in 1944, Murata has contributed to the advancement of society and the evolution of the electronics industry. The company's innovations can be found in a wide range of applications: mobile phones, home appliances, automotive electronics, energy management systems, healthcare devices, and more. Today, Murata is a global enterprise with over 100 offices worldwide. Aspiring to the slogan, "Innovator in Electronics®," approximately 48,000 Murata employees strive every day to develop promising new technologies, "world's first" innovations, and products shaping the future of electronics, all toward enabling customers to realize their vision.

Meet Our Experts



Tony Garcia

Senior Manager,
Business Development
Murata Electronics
North America



Tim Cutler

Senior Business
Development Manager,
Connectivity Solutions
Murata Electronics
North America



Gordon W. Hudson

BRF Engineer
Hetronic, Inc., A Division
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Alfred Ip

Senior RF Systems
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Li Ji

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WSAudiology



“The more time it takes to develop a product, the higher its development costs and the longer it will be before that product gets into the market where it can start generating revenue.”

Tony Garcia

Senior Manager, Business Development
at Murata Electronics North America

Tony Garcia is Senior Manager, Business Development, with Murata Americas' Connectivity Solutions Group. He has been at Murata for thirteen years and is currently responsible for promoting wireless modules and supporting customer designs in North America. His experience includes twenty-four years in the wireless industry.



Speeding Time to Market for Wireless IoT Solutions

One of the first considerations in developing any wireless design is choosing the communication protocol appropriate for the application. This choice usually depends on the kind of data the device will send and the transmission range. Range and throughput go hand-in-hand, with lower frequencies typically operating at longer ranges and lower throughput. The communication protocol affects all aspects of the design, including radio-frequency (RF) components, battery requirements, and antenna design.

Major challenges in any design are cost and time to market. These factors relate to each other in that the more time it takes to develop a product, the higher its development costs and the longer it will be before that product gets into the market, where it can start generating revenue. Key factors that contribute to costs and development time include:

- **Software development.** Software manages how the RF section operates in the device to enable wireless communications and data transfer. Depending on the application and data throughput requirements, software development can be complex and time consuming. Software developers need a working prototype with RF and data processing so that they can develop and test software drivers.

- **Hardware development cycle.** This factor includes either building the RF circuit or using a wireless module that supports the communication protocols the solution requires.
- **Regulatory certification.** All wireless devices must go through certification testing to verify that they meet the regulatory requirements of whatever region they will operate in. Certification testing is expensive and time consuming, and if a device fails, testing has to be done again.
- **Component availability.** The inability to reliably source RF components can delay production and time to market, and swapping components after certification will require recertification.

The design and development process must balance many factors to meet cost and time-to-market challenges. If you have the next hot widget, you want to get that to market before anybody else. That means finding the shortest, easiest path to product development, including everything related to RF.

For many designs, using a wireless module that supports the required communication protocol is a smart move because it can shorten development time and lower costs in key ways. For example, if you are planning to use a chip-on-board discrete design, you need the RF front end, but you will also need components for filtering, decoupling, and impedance matching. Putting all that together requires a lot of work on the part of the RF engineer. Plus, all those components must be individually sourced by purchasing, and they need to be assembled during manufacturing.

With a wireless module, the RF front end, filters, decoupling capacitors, and timing crystal are all assembled in a module that has been optimized to operate at a specific impedance. RF engineers can focus on signal integrity, clean power, and a good ground, saving on

“Using a wireless module that supports the required communication protocol is a smart move because it can shorten development time and lower costs in key ways.”

engineering but also simplifying other aspects of design and production. Instead of dealing with all the parts for your RF section, you are now dealing with only one component, which saves on RF engineering and testing time, reduces the burden on purchasing, and simplifies manufacturing. It also simplifies software development because the wireless module just works.

Using a precertified wireless module can greatly reduce overall production and testing time, so that you can get your product to market faster.

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Key Points

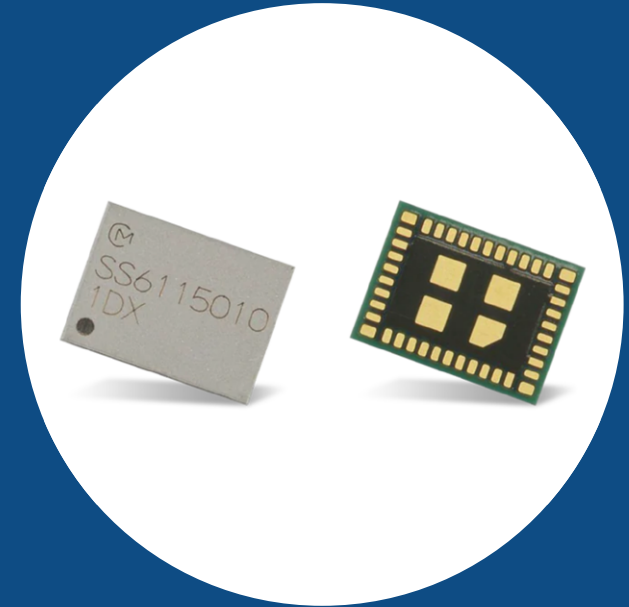
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Tony Garcia

Senior Manager, Business Development
Murata Electronics North America



Murata Electronics Type 1DX Wi-Fi® 11b/g/n + BLUETOOTH® 4.2 Module

- 2.4GHz Wi-Fi + Bluetooth module
- AP and STA dual-mode network topology
- Cypress CYW4343W chipset
- No processor
- High performance capabilities for Internet of Things
 - 802.11b/g/n
 - 65Mbps

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“Using a wireless module has several advantages.
For one thing, all the RF engineering is done.”

Tim Cutler

Senior Business Development
Manager, Connectivity Solutions
at Murata Electronics North America

Tim Cutler has more than twenty years of experience helping customers integrate unlicensed wireless—proprietary, Wi-Fi, Bluetooth, 802.15.4/ZigBee, LoRa/Sigfox, and cellular—into their products. He has worked in industrial, commercial, consumer, and medical markets, determining the best technology for his clients’ needs. He holds a bachelor of electrical engineering degree from Georgia Tech and an MBA from Georgia State University.



RF May Not Be Your Product’s Key Selling Feature

The reality for many wireless engineering teams is that the wireless capability of their products is not their key selling feature. The market is pushing products that once functioned as wired devices now to be wireless.

The question for engineering teams with finite development resources is how much time and money they devote to engineering wireless capabilities rather than enhancing the core functionality of their product to make it more competitive. For many products, the answer is to find the fastest, most cost-effective solution to the wireless challenge. But, what are the key challenges, and how do you overcome them so that you can focus on core product functionality?

Start with the following factors:

- **Understanding your requirement.** Sometimes, the wireless requirement comes from a marketing organization that knows little about wireless technology. You must clearly understand the radio-frequency (RF) requirements and the environment in which your device will function. For industrial applications, the requirement includes all the physical aspects of operating in an industrial environment, range and bandwidth, noise immunity, ruggedness, and operational stability. If you are

designing a consumer product, portability, battery power, and power consumption are often key factors. You must understand trade-offs; for instance, if you want a longer run time, you will need to pay more for a larger battery.

- **RF expertise.** It takes expertise to understand RF requirements and create a design that solves them. Many companies do not have an RF engineer on staff. They may be new to wireless or adding wireless capability to an existing product. Using a wireless module has several advantages. For one thing, all the RF engineering is done. Wireless modules are plug-and-play devices that are small and easy to use from a product manufacturing perspective. Still, choosing the right modules, implementing them, and navigating certification testing can be tricky. A good wireless module manufacturer can help by reviewing schematics and layout; providing best-practices information about power, grounding, and filtering; and even preparing for certification testing.
- **Software.** In many cases, software development is the most time-consuming part of creating an RF solution because many wireless devices are software controlled. Wireless modules simplify software development. In fact, many come with a complete software development environment that includes device drivers, libraries, and an operating system. By choosing this option, you can focus on developing the operational logic. Keep in mind that there are two kinds of wireless modules. One is a wireless chip, or RF integrated circuit (RFIC), which includes all the RF functionality and integrates with a microprocessor or microcontroller in your device. The other is a wireless module that includes both the RFIC and an integrated microcontroller or processor in one package. Modules can run both the low-level communications protocols and higher-level application code.

All wireless devices must be certified, and that can be a tricky process. One way to reduce testing costs is to use precertified wireless modules. Certification testing has two parts:

“Many [wireless modules] come with a complete software development environment that includes device drivers, libraries, and an operating system.”

conductive testing, which measures signals coming out of the module, and radiated testing, which measures the signal that comes off the antenna. When you use a precertified module, the conductive testing is already done. You can reuse that certification without further conductive testing, even if you make changes to other parts of your design.

To ensure that you have the components you need to manufacture your device, it's important to plan out your production as far ahead as possible, especially if you are manufacturing in volume. If you are building 50,000 or 100,000 of something in a year, it's not just the RF components you need to worry about. Any component shortage can slow production. Distributors can help source the components you need far in advance.

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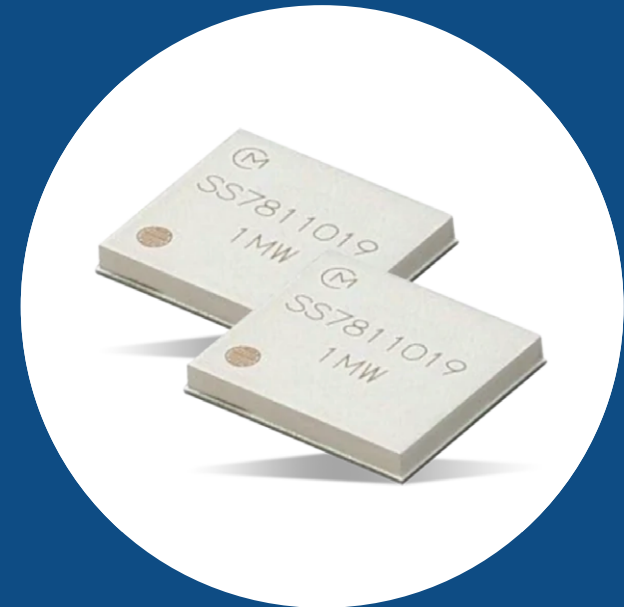
Key Points

- 1** A good wireless module manufacturer can help by reviewing schematics and layout; providing best-practices information about power, grounding, and filtering; and even preparing for certification testing.
- 2** All wireless devices must be certified, and that can be a tricky process. One way to reduce testing costs is to use precertified wireless modules. When you use a precertified module, conductive testing is already done, cutting the testing requirement in half.



Tim Cutler

Senior Business Development
Manager, Connectivity Solutions
at Murata Electronics North America



Murata Type 1MW Bluetooth® WiFi® Module

- Supports WiFi 802.11a/b/g/n/ac with 433Mbps PHY data rate and Bluetooth 4.2 BR/EDR/LE with 3Mbps PHY data rate
- Includes 2.4GHz and 5GHz WiFi frequency with Cypress CYW43455 chipset
- WLAN supports the SDIO v3.0 DDR50 interface
- Bluetooth section supports high-speed 4-wire UART interface

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“Many wireless products have a substantial software development cycle because so much RF hardware is now software driven.”

Gordon W. Hudson

RF Engineer—Hetronic, Inc.,
A Division of Methode Electronics

With a passion for electronics, physics, and radio since his youth, Gordon's professional focus is on low power RF PCB-level design primarily in the HF to UHF range.

Gordon has been involved with several RF module and RF remote control companies, designing and optimizing embedded and modular transmitters, receivers, transceivers, amplifiers, filters, and antennas since 2002. Gordon's interest in RF extends beyond the professional. He holds an FCC extra class ham radio license and operates his own RF consulting firm.



The Most Important Cost Factor Is Time

One of the biggest challenges in developing wireless devices is overall development cost. Many factors can contribute to those costs, the most important of which is time. Product development includes not only the time spent incurring direct development costs but the time that that product is not on the market generating revenue that offsets costs.

During that development cycle, which can often be six months to a year before you have a certified product, you have engineering costs and the costs of certification testing. You also have software development costs. Many wireless products have a substantial software development cycle because so much radio-frequency (RF) hardware is now software driven. For example, using the 900-megahertz (MHz) ISM band in the United States is pretty straightforward, but if you take that device to Europe, where they have the 869-MHz band and you want to use a certain amount of RF power and air time, you have to employ “polite spectrum access,” where software in your device listens for somebody else on that frequency before it transmits. If another device is using that frequency, your device must switch channels before it can transmit. There is a lot of cognitive RF functionality now and a lot of intelligence in the radios based on where they

are in the world, due to the increasing number of wireless devices in a given frequency band.

The easiest way to address many of these challenges is to use a wireless module. Wireless modules are often ready-made, functional, complete RF transceivers that require only connections to the antenna, power, ground, and data. Organizations that are not conversant with RF technology or do not have an RF engineering team may prefer to use a wireless module. Another advantage of wireless modules and chips is that many manufacturers provide a development kit that supports several module types. These kits often come with a common microcontroller on a board and an example program so that you can get started quickly, saving software development time. Many wireless modules today come pre-certified for many countries and regions, allowing the developer of the product to skip costly certification testing and inherit the certification that comes with the wireless module.

In addition to wireless modules, highly integrated wireless chips are also available for designers who want to design their own basic RF hardware. These integrated circuits generally need power, ground, data, and antenna connections within your own printed circuit board (PCB) design. They will be controlled via your own application within a microcontroller on your PCB. Alternatively, many wireless chips are integrated into a system-on-chip (SoC) that includes the RF section and a microcontroller in one package. You simply put the chip on the board and it performs all the processing, control, and RF functions.

When using wireless modules, you must make a few important decisions. First, you must select the right frequency for your application. The frequency you choose depends on factors such as range requirements, data, and where the device will be operating. Second, you must decide whether you want licensed or license-free operations. Finally, for some products, component longevity is an important consideration.

“Organizations that are not conversant with RF technology or do not have an RF engineering team may prefer to use a wireless module.”

When you use any RF component, ensure that those components will be available for the life of your product. Any component changes will require a recertification of the device if the component is within the RF path, which is time consuming and costly. Wireless modules are lower risk than an RF circuit you build yourself because the wireless module is just one component, whereas the RF circuit contains many components, any one of which could become unavailable. Wireless chips and modules can become obsolete, too, and then you not only need to replace the part but update the software. Your choices depend on the product and the market. In our case, we like to ensure that RF components will be available for a minimum of ten years.

“Wireless modules are lower risk than an RF circuit you build yourself because the wireless module is just one component, whereas the RF circuit contains many components, any one of which could become unavailable.”

Key Points

1 A lot of wireless chips are integrated into a system on a chip that includes the RF section and a microcontroller in one package. You simply put the chip on the board and it performs all the processing, control, and RF functions.

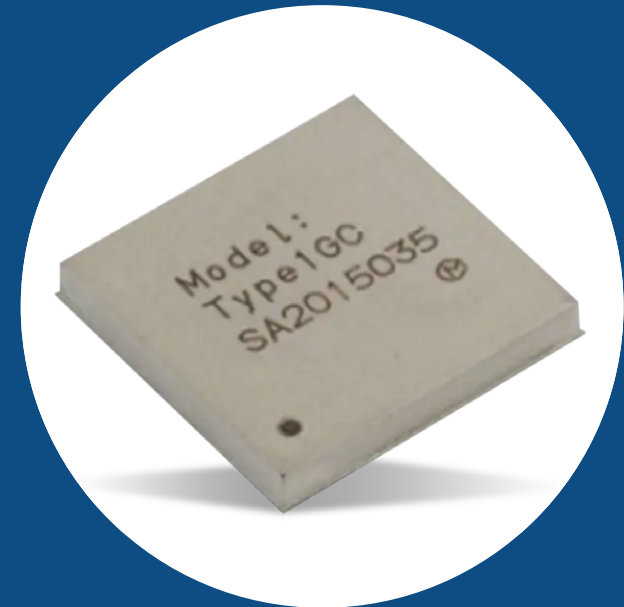
2 Wireless development kits typically include a wireless module, a board with a common microcontroller on it, and a sample program so that you can get started quickly, saving software development time.



Gordon W. Hudson

RF Engineer

Hetronic, Inc., A Division of Methode Electronics



Murata Type 1GC Wireless Module

- Shielded ultra small dual-band WiFi 11a/b/g/n +Ethernet+MCU module
- 2.4GHz and 5GHz WiFi+Ethernet MCU module
- AP and STA dual-mode network topology
- Cypress (CYW43907) chipset
- ARM Cortex-R4 processor

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“The goal is to solve the problem by achieving the requirement with minimum effort and at the lowest cost.”

Alfred Ip

Senior RF Systems Engineer
Amazon Lab126

Alfred Ip is the Wireless Systems department lead engineer at Amazon Lab126. He has more than twenty years of experience in multiple RF hardware disciplines, including RF circuit, RF systems, and antenna designs, and has worked in multiple wireless industries, including RFIC, consumer electronics, industrial equipment, and medical devices. He has a passion for creating wireless devices that can change or enhance customers' life experiences.



Gain Wireless Connectivity with Less Engineering Effort, Cost, and Time

To address the challenges of developing a wireless solution, you must first understand what the wireless solution needs to do. This in turn means understanding basic performance requirements. Those requirements are embedded in customer expectations about how the solution will operate in its intended use case environment. Only by knowing exactly what the solution must do can you translate that information into engineering requirements, and then make decisions that balance competing aspects of the design.

Every engineering team must make decisions about the look of a product, how much innovation it will include, its communication range and speed, and power consumption, each of which influences the others. For example, if you want longer-range communications, you may need a higher milliampere-hour (mA-h) battery, which would determine battery size and selection. These factors affect two other key considerations: cost and time to market. We want more features and a better-looking, more innovative product that we can produce at low cost and get to market quickly. Designing a wireless solution is always a balancing act.

The goal is to solve the problem by achieving the requirement with minimum effort and at the lowest cost. The question is, how do we prioritize these competing factors within the design?

The answer depends on many factors, including the complexity of the wireless requirement, reliability, and the product life cycle. If you have a highly specialized requirement, you may need to design your own wireless section, but that takes a lot of time. In contrast, if you can find a module that satisfies all your wireless requirements, it will save a lot of engineering time.

Software development is another consideration. Many wireless devices have two levels of software development: lower-level software that works on the data link and network layer and higher-level software that is the device's application layer. When you use a wireless module, the lower-level software is already developed. So, you can focus all your efforts on developing and debugging the higher-level software, a potentially complex process in itself that can involve multiple teams. Not having to develop and debug the lower-level software saves a lot of time.

A wireless module can reduce development time—if you can find the right module. This module must satisfy your wireless requirements. Reference regulatory certification is a valuable proposition because it is a proven, compliant component—and it is available.

Quality and availability are important, as well. A module that is unreliable can have a high failure rate, high service costs, and result in brand damage. If the module is unavailable, you don't even have a product. The solution is to choose a prestigious manufacturer that has a track record of delivering quality components at high volumes, even in the hundreds of millions of units.

Second sourcing is also an option to ensure availability, but that is not always possible because of the different performance characteristics of wireless modules. Also, you must

“A wireless module can reduce development time—if you can find the right module. This module must satisfy your wireless requirements. Reference regulatory certification . . . is a proven, compliant component—and it is available.”

consider whether it's worth the extra certification testing you will have to do on another version of the product and maintaining an extra bill of materials. The question is whether it makes sense to do all that work for the particular wireless solution you are developing, and that's just one more factor to consider in the balancing act that is wireless solution design.

“Choose a prestigious manufacturer that has a track record of delivering quality components at high volumes, even in the hundreds of millions of units.”

Key Points

- 1 Every engineering team must make decisions about the look of a product, how much innovation to include, its communication range and speed, and power consumption. These factors affect two other key considerations: cost and time to market.
- 2 If a module is unreliable, it could have a high failure rate and service costs, which could result in brand damage. If the module is unavailable, you don't even have a product. The solution is to choose a prestigious manufacturer that has a track record of delivering quality components at high volumes.



Alfred Ip

Senior RF Systems Engineer
Amazon Lab126



Murata Electronics MBN52832 BLUETOOTH® Low Energy 5.0 Module

- Bluetooth v5
- ANT, NFC Tag
- Nordic nRF52832 Bluetooth Smart
- Built-in Arm Cortex M4 core with 64KB RAM and 512KB flash
- Bluetooth/ANT On-Board Antenna

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Jay Kruse

Head of Hardware
eero

Jay Kruse leads hardware engineering and program management at eero LLC, where his teams are developing the next generation of wireless mesh hardware. An industry veteran who thrives on solving difficult problems, Jay has worked on projects from GaAs IC design to MacBook computers with some of the best teams in Silicon Valley. He holds a PhD and a master's degree from the University of Illinois.



“Consider how much radio-frequency (RF) performance you are getting for the money you are putting in, the number of watts you are putting in, and the area or size of the device.”

When Making Engineering Trade-Offs, Remember to Leverage Vendor Support

When designing a wireless device, you must first understand what you need to achieve with that device. Then, within that framework of requirements, consider how much radio-frequency (RF) performance you are getting for the money you are putting in, the number of watts you are putting in, and the area or size of the device. When designing a wireless system, you need a feel for the numbers:

- **RF Performance.** This measure is the total RF performance, including frequency, range, output power, and throughput. You need RF technology that delivers on bandwidth and range requirements, but you must balance that delivery against power consumption. Increasing the range requires more power.
- **Input watts.** This measure is the power consumption of your device. It dictates power supply, battery size, and how long the device will operate on a single battery charge. Input watts combined with device size dictates power efficiency requirements, another factor that influences RF technology choices.
- **Area.** This measure is the physical size of your device, which determines the components it can contain, component types and configuration, and battery size. Think about the area, how much power the device will consume, and how it affects

system thermals. As devices become smaller, the importance of power efficiency increases.

- **Money.** This measure is the costs that go into product development: engineering time, components, software development, certification testing, and time to market. For example, how quickly you want to get a product out helps you choose the path you take. If you need to get a product out faster, you may choose an existing device, chip, or circuitry that can reduce engineering costs and time to market. Software development takes time and money. Testing is expensive and time consuming, especially if your device is intended for a global market. In addition, you may need to design different versions of a product for different markets.

When designing wireless systems, you need a feel for these numbers and the trade-offs to know if you are going in the right direction.

Unless you are working in uncharted territory, the right wireless module can save a lot of time and help with power consumption and RF performance. A key factor is availability, and availability depends on the supplier's ability to guarantee delivery at the quantities you need so that you can deliver your product. The worst-case scenario is having to shut down the factory because you can't get a critical component.

Another important consideration in selecting wireless modules is vendor support. Does the vendor take into account customer and industry needs? Does it follow up on support services? Factors such as firmware support, software support, and e-support become fundamental considerations when choosing a wireless module or chip.

For example, some vendors can help with pre-certification testing, especially when software is involved. They can set up a module so that it transmits appropriately for compliance testing. Because of the time and cost of compliance testing, do everything you can to avoid problems. You want to go in certain that you have covered everything, but even then there will be surprises.

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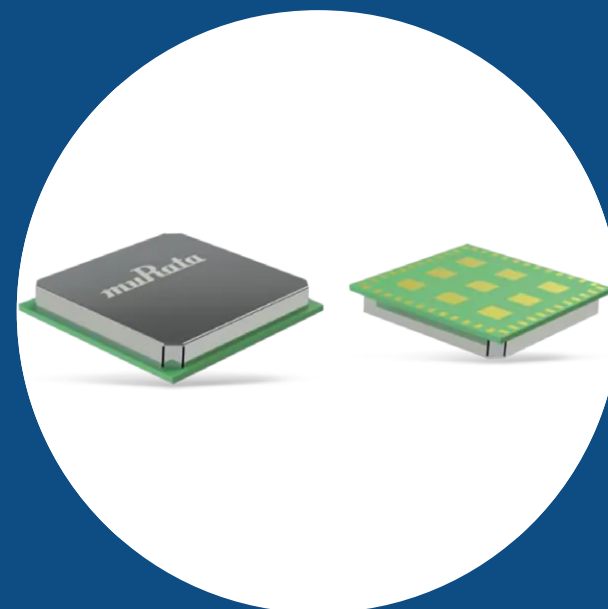
Key Points

- 1** How quickly you want to get a product out helps you choose the path you take. If you need to get a product out faster, choose an existing device, chip, or circuitry that can reduce engineering costs and time to market.
- 2** Choosing the right wireless module can save a lot of time and help with power consumption and RF performance. A key factor, however, is availability, which depends on the supplier's ability to guarantee delivery at the quantities you need for production.



Jay Kruse

Head of Hardware
eero



Murata Electronics Type ABZ LoRa Modules

- Pre-loaded firmware from the factory
- Integrated TCXO with robust low drift thermal characteristics provides an accurate clock source for the RF transceiver
- ADC and up to 18 GPIOs offer flexibility for connecting sensors, switches, and status LEDs
- Pre-certified radio regulatory approvals for operating in the 868MHz and 915MHz industrial, scientific, and medical (ISM) spectrum in most geographical regions of the world

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Li Ji

Senior Hardware Engineer
Avanos Medical

Li Ji has twenty years of experience as a hardware engineer. He is proficient with analog and digital circuits as well as embedded system design. He holds master's degrees in electrical engineering and computer science. For the past few years, his design interest has focused on wearable medical devices and the Internet of Medical Things.



“The trick is finding the best balance among the physical characteristics of the device . . . , power consumption, and RF performance to meet your design requirement.”

Look for Component Vendors That Have a Good Support Plan

In wirelessly connected medical devices, you have multiple choices for wireless technology. The trick is finding the best balance among the physical characteristics of the device (such as wearables), power consumption, and radio-frequency (RF) performance to meet your design requirement.

For example, the short-range connectivity that Bluetooth Low Energy (BLE) provides may be good enough if the device connects to an application on a smartphone. If the device is in a hospital, however, and needs to connect over a long range, maybe from a patient room to a nursing center, you need architecture to support that scenario. You could build a Wi-Fi module into your device to connect to an information center directly, or you could build a gateway that goes into a room and connects to your BLE device. Then, you have Wi-Fi inside that gateway that connects to the information center. Or, you could build a cellular module into your device that connects directly to a cellular network.

Power consumption is a big consideration. If you are designing a wearable device and you want to build Wi-Fi into it, you cannot have a wire connected to it because that would require a large battery—and would not be practical for a wearable device. With BLE that connects to a smartphone app, you can build a much lighter device with a

smaller battery. Such a configuration is ideal for collecting patient data that goes through a smartphone app to the cloud, where remote doctors can see it for medical diagnosis. Part of product development, then, involves creating the smartphone app and the RF data interface.

Another challenge is finding a wireless module that meets RF and data processing requirements but also comes in the right physical package. For wearable medical devices, package size is important. In some wearables, comfort, such as an ultrathin design, is a key consideration. Such a device may also require a flexible design so that as the person moves, the device can bend without damaging components. Often, smaller and more compact packages must be more power efficient because small packages do not dissipate heat as well as a large packages.

We use wireless modules instead of designing our own RF circuit because doing so simplifies the engineering. A module contains everything: the RF section, chip antenna, and matching circuit. You just need to connect it to a few external components. For some designs, such as those that can flex without damaging components, we use just the wireless chip, which is in a very small package. In such cases, we use a vendor-provided reference design for the matching circuit.

Component sourcing is critical. You have many vendor choices for BLE and other wireless modules and chips. Using precertified components helps streamline certification testing, which takes a lot of time and money. Cost is an important criterion for us because some of our products are disposable or semidisposable, but all our devices have a long market life—between five and ten years. That means that we need parts from sustainable chip vendors that can support manufacturing for many years. We also look for vendors based in the United States, with good facilities and a good reputation, and we want vendors with a good support plan. It's important to build the vendor relationship. You can get a feeling about a vendor by the way it responds to your questions.



**“We need parts
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Key Points

- 1 There are a lot of vendor choices for BLE and other wireless modules and chips. Using precertified components helps streamline certification testing, which takes a lot of time and money.
- 2 With BLE that connects to a smartphone app, you can build a much lighter device with a smaller battery, but part of the product development involves creating the smartphone app and the RF data interface.



Li Ji

Senior Hardware Engineer
Avanos Medical



“Choosing a radio technology is the first and most important aspect of a wireless design because that decision has a huge impact on the characteristics of the device you are building.”

Sabin Banuleasa

IoT Software Engineer
Oerlikon Metco AG

Sabin Banuleasa is an IoT software engineer at Oerlikon Metco in Switzerland, where he works in the Equipment Business Line organization. He is responsible for the digitalization of Oerlikon's products and services. Sabin is a pioneer and has co-founded four startup initiatives. A former Microsoft employee, he also publishes PhD research articles about IoT wearable medical devices.



Optimizing IoT Devices for Maximum Performance at the Lowest Cost

Choosing a radio technology is the first and most important aspect of a wireless design because that decision has a huge impact on the characteristics of the device you are building. You must choose between licensed technologies, such as narrowband Internet of Things and Long-Term Evolution for Machines, or unlicensed technologies, such as LoRaWAN, Sigfox, and Bluetooth Low Energy (BLE). The technology you choose depends mostly on the use case and on the operational requirements of the device you are designing, coverage requirements, the regions in which it will operate, and data transmission specifics.

BLE is a popular choice, benefiting from low power consumption and offerings from a variety of component providers. Because it has a range limitation of tens of meters, it must rely on a gateway to relay information to a server over the internet, which is why many BLE devices leverage smartphone connectivity. That is the reason we see a lot of wearable devices using this wireless technology.

Once you settle on a radio technology, the next challenge is antenna design. The antenna must provide the best signal while having the smallest form factor and lowest price. For instance, some industrial devices cannot have external antennas because they break

off in industrial environments, so the antenna must be inside the enclosure, which creates problems if, for example, the enclosure is entirely made of metal. Some wireless modules are now available with innovative features to tackle these challenges, which can greatly simplify antenna design, reduce costs and improve performance.

Other factors also contribute to the difficulty and costs of a design. Software development is one, and although you can consider it a fixed, one-time investment in the design process, you have to plan for continuous development and software security updates. Depending on whether the device has its own operating system, you may need to create device driver code.

There are great opportunities in optimizing power consumption and implementing power management at the hardware and software levels. The radio-frequency (RF) section is where most energy is drawn in an IoT device. Many microcontrollers and integrated circuits consume relatively very little energy, which is great for small devices, but the RF section remains a big challenge, and there is a lot of room for improvement. Several factors influence power usage, including temperature, antenna, how frequently you synchronize data, how much data you send, and signal strength. In some cases, innovative algorithms and artificial intelligence as cloud services can make real-time adjustments to a device's data transmission strategy, based on its location and RF connectivity parameters, which can result in dramatic power savings. Having the right tools, knowledge and a reliable electronics component supplier is the key to success to building the best in-class IoT device.

Using the latest integrated circuit wireless modules rather than designing a custom RF section on the printed circuit board is essential for managing design costs. Coming up with your own design is a huge investment that makes sense only if you have a special requirement and a large budget. A wireless module makes things easier: you buy the modem chip and design minimal RF circuitry that connects the antenna. Some chips come

“A wireless module makes things easier: you buy the modem chip and design some minimal RF circuitry that connects to the antenna. Some chips come with great documentation and guidelines, which speeds that part of the design process and reduces design risks”

with great documentation and guidelines, which speeds that part of the design process and reduces design risks. Using certified modules not only makes your preparation for laboratory testing easier, but ensures that you increase your chances of passing the regulatory certifications faster. Companies sometimes underestimate this aspect of compliance and adherence to standards, but too often certification increases development costs.

It's really important to use the best components from reliable suppliers. A lot of work goes into a design, and changing even a single small part later is costly. When you're in a rush to finish a project, you don't always have time to perform a thorough component search. I've had the experience of finding other suppliers with better components only after completing a project. In the future, I would invest more in the search for good components. Planning and organization can save a lot of effort in a project.

“Having the right tools, knowledge and a reliable electronics component supplier is the key to success to building the best in-class IoT device.”

Key Points

- 1** Wireless modules play a big role in managing design costs. Coming up with your own design on the printed circuit board is a huge investment that makes sense only if you have a special requirement and a large budget.
- 2** Always look for the best components from reliable suppliers. In the rush to complete a project, you will not always have time to conduct a thorough component search, but changing a component later is costly.



Sabin Banuleasa
IoT Software Engineer
Oerlikon Metco AG



Erik Jensen

Head of Wireless System Integration,
Denmark—WSAudiology

Working with electronics since his teens, Erik Jensen has always been fascinated by communication and wireless connectivity. For the past fifteen years, he has worked in telecommunication companies, bringing internet connectivity to machine-to-machine equipment, people with hearing loss, and people in remote places without cellular coverage. He believes that information is key and should be available from everywhere and to everyone.



“A common way to combat interference among components is to make the device larger, but that is not an option for devices.”

Using a Wireless Chip Protects Against Technology Obsolescence

Physical configuration of components, radio interference, and power consumption are the biggest challenges when making small wireless devices such as hearing aids. Each of these elements affects the others in the device.

When you make a small device, you must put processors, sensors, radio-frequency (RF) components, and power supply close together in the same small package. That design creates a problem for RF immunity because all these different components create noise. A common way to combat interference among components is to make the device larger, but that is not an option for all devices. The issue becomes even more complicated when you have different radios in the same small device. It's not just RF immunity within the device itself, either. The device must be immune from other sources of RF noise in the environment, such as mobile phones, Wi-Fi, and television.

Power consumption is another significant challenge, especially in small devices such as hearing aids that must operate for a full day between charges. In normal use, a hearing aid is not always using its RF connectivity functions; however, it consumes the most power when it is transmitting. There's always a trade-off among power consumption, connectivity range, and size.

In the design stage, you work out as many of these challenges as possible through simulation, because once you commit to a physical design, you can't move a component to solve an RF immunity problem.

For many small devices, time to market is critical for product success. Competition can be fierce, and features that provide a competitive edge increasingly rely on RF connectivity. In addition to the engineering time required to put more RF power in a smaller package, more and more time is spent on software development to solve complex problems, such as ambient noise management and, in the case of hearing aids, inter-ear communications. It's also necessary to plan for updates and compatibility with future technology for devices that typically have an operational life of five or six years.

Using a standard wireless chip—one that you connect to external crystals, capacitors, and filters, and then is ready to operate with your software—saves a lot of engineering time. Some companies have created their own custom Bluetooth chips, but doing so takes a lot of time, and these companies risk having an obsolete design by the time it is complete. Using a wireless chip from a reputable supplier offers greater flexibility to keep up with changing technology. Designing in a wireless chip in the early stage of its life cycle is key, as you probably need to update the FW with new features or test for new regulatory requirements two years down the line.

The key is finding quality components from a reputable supplier. These components must be reliably available for the market life of your product because you cannot just swap a component if it is no longer available without going through a long process of regulatory and medical certifications. Also, components must be stable through the operational life of the device, which is six years of continuous use for most hearing aids. Some manufacturers render their components obsolete quickly. You cannot have that. When you identify a component that fits your product needs well, your first question should be, "What about availability?"

“Using a wireless chip from a reputable supplier offers greater flexibility to keep up with changing technology.”



Key Points

- 1 When you make a small device, you must pack processors, sensors, RF components, and power supply close together in the same small package. That creates a problem for RF immunity because all these components create noise.
- 2 The key is finding quality components from a reputable supplier. The components must be reliably available for the market life of your product, and they must remain stable for the operational life of the device.



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