Implementing Bluetooth Smart modules in industrial IoT applications

Mike Chen - April 05, 2016

The Internet of Things (IoT) is a concept of wirelessly connecting physical objects to the network or cloud so they can collect and exchange data. There is increasing demand for these connected devices, and Bluetooth Smart technology is one of the easiest and most cost-effective ways to implement IoT. This article will present key design considerations for using Bluetooth Smart modules to develop industrial IoT products and devices.

Bluetooth technology is already embedded in peoples’ everyday lives, and it will continue to have an impact to make “Things” smarter. Instrumentation can become smarter with wireless data capture. Wireless data reporting, or capturing, offers convenience and efficiency to many different industries. In the medical field, doctors can quickly monitor patients’ status from a mobile device instead of walking from room to room. Consumers can enjoy music from their wireless Bluetooth headphones and track their heartbeat and progress from a wearable, Bluetooth-connected device while running. House doors can be unlocked and lights can be turned on or off by simply touching your smartphone. Even industrial machines can be monitored and controlled by a Bluetooth-connected device to determine their status or predictive maintenance needs.

Environment is number one

While it sounds interesting and promising how Bluetooth Smart can benefit our world, it is not always easy to implement the technology because there are many technical requirements to consider.

First and most important, an engineer must clearly understand the environment where the hardware will be located, as temperature, humidity, and vibration are all critical factors. An extreme environment can cause Bluetooth modules to fail, so selecting a durable Bluetooth Smart module is important to long-lasting, safe operation. Using Bluetooth ICs that have an operating temperature range from −40ºC to +85ºC can usually cover most temperature requirements.

As an example, let’s consider the application of a remote water tank monitor. This device will use sensors to collect tank data and a Bluetooth Smart module to push data wirelessly to a smartphone, so it will need to be placed near the water tank. Typically, water tanks are placed on the roof of a building or on top of a water tower where there is direct exposure to sunlight and temperatures can get very hot, especially during summer. Therefore, it will be necessary to select a Bluetooth Smart module and other components that can endure high temperatures.

Now, if the hardware is going to be placed in an extremely low temperature environment, the power supply is another factor that should be considered. In low temperatures, devices will consume much
more power than usual. And if the device has a small battery, its operation will be interrupted during recharging or battery changes. In this instance, engineers could use line power or solar power, if the conditions allow.

Looking at our water tank example, if the tank is located on the roof of a building, the monitoring device could use line power since a power supply is probably readily accessible. But if the tank is located on top of a water tower, the monitor will likely need to be battery-powered due to lack of a convenient power supply. Being outdoors also allows for solar power assist.

Another option is to use a lower minimum operating voltage Bluetooth IC, and some manufacturers have modules with voltage as low as 1.7V. This would extend battery life by minimizing power consumption and allow the device to keep operating during unexpected voltage drops.

**Inputs and outputs matter**

Engineers are constantly being challenged to design ever smaller and thinner battery-powered devices to meet the increasing demand for mobility. This is especially desirable for wearable IoT devices, and micro Bluetooth Smart modules provide an efficient design solution ([Figure 1](#)). However, while small size has advantages, there are also a few design disadvantages. Smaller modules limit the number of GPIOs, so knowing the number of inputs and outputs needed is a significant technical requirement, but saving space and weight are often goals, too.

![Figure 1](image) Miniature Bluetooth Smart modules provide an efficient design solution when space and weight are important. This [module from Fujitsu](#) measures 11.5×7.9×1.7mm.

Engineers also must consider what type of input and output the application requires. Will it use different sensors, such as a temperature or humidity sensor, or an accelerometer? Each sensor will occupy a GPIO and each switch or data port will need a GPIO. Moreover, some applications may require outputs, perhaps for an LED or a control signal. Therefore, determining the total number of GPIOs in your application is very important.

In determining the total number of GPIOs needed in our water tank monitor, we know the device will use several sensors to measure key data: First, is the water level, to calculate the volume of water in the tank; second, is the temperature of the water tank, to prevent water from freezing during winter; and third, is the PH level, to ensure there are no abnormal chemicals or substances in the water.
Each one of these sensors needs to be wired to the Bluetooth Smart module as inputs using GPIOs. The monitor may also have outputs for LED status reporting, which will use some GPIOs.

Determining how many of each type of I/O is also essential. Engineers must know the total number of PWM, A/D, FC, SPI, and UART interface that the module can support. All of these connections are wired, but the most important connection for a Bluetooth module is the wireless one.

**Antenna location**

The typical Bluetooth Smart communication range is around 30 meters, but this can be affected by the antenna and the surroundings. If metal conductors or conductive components are placed too close to the antenna, it will obstruct radio wave radiation and reduce the communication range (Figure 2).

![Figure 2](image)

Figure 2 To ensure proper and stable performance of the Bluetooth Smart module, be sure to keep metal conductors and conductive components 20 mm away in all directions from the module antenna.

In the case of our example, water tanks are usually made of metal, which can block the radio wave. Therefore, the antenna should face outward for unimpeded communication. It’s very important to always keep the antenna away from metal, leaving a 20-mm clearance in all directions to ensure proper and stable performance of the Bluetooth Smart module. **Software and firmware**

After considering the hardware technical requirements, engineers should then decide on the firmware and software. Some module manufacturers provide firmware-embedded modules, which can make the development process much easier because the module control functions are built in and can be implemented using simple text commands. This greatly reduces development time and costs, however, an external processor is required to control the Bluetooth Smart module.

Engineers who want to embed their control programs in the Bluetooth Smart module, developing their own unique application codes, can always use a blank module. Blank modules provide the basic layers and Bluetooth stack, on top of which a user builds their application profiles. So for our water tank monitor, the engineer may need to develop the firmware and software app for the smartphone. Using a firmware embedded module will make the process easier, but a blank module will offer more freedom to develop different functions and eliminate one processor.

A word of caution: If an engineer decides a blank module is the way to go, he must be careful not to rewrite the host layer of the module, as it may invalidate the module’s radio certification. Since
products must have specific radio certification before they can be sold in a country, it’s important to understand the certification requirements for each potential marketplace. FCC certification applies to the United States and IC certification is used in Canada only. CE Marking can cover all of Europe, while most countries in Asia have their own certification standard. Obtaining certification for a wireless product is a long and costly process, so using a certified Bluetooth Smart module can reduce costs and shorten the time to market. Premium manufacturers will assure their module’s protocol stack is fully tested and can’t be corrupted by application software development.

As Bluetooth technology has enabled the IoT market to rapidly expand into new applications, engineers are being tasked to quickly create new devices. While considering the aforementioned technical requirements, Bluetooth Smart modules are a handy development tool that makes it easy to quickly implement this wireless solution without requiring Bluetooth or RF expertise.

Author’s biography

Mike Chen is an applications engineer for wireless modules at Fujitsu Components America, Inc. He joined the company in 2015. Chen received his bachelor’s degree in Mechanical Engineering from Pennsylvania State University.

Also see:

- Bluetooth Smart update brings major changes
- Mini Bluetooth Smart module advances IoT designs
- Bluetooth Smart module requires no RF design expertise to use
- Wearable computing meets Bluetooth Smart
- One-wire bus powers water-level sensor