Getting started with Bluetooth low energy wireless design

Nordic's µBlue prototype development kit simplifies the design and test of wireless connectivity based on the company's µBlue *Bluetooth* low energy single mode peripheral solution. By *Sebastien Mackaie-Blanchi* and *Alf Helge Omre*

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Bluetooth low energy technology has been designed for applications where Classic *Bluetooth* technology is not viable because of severe power restraints. All of these applications will have one thing in common: they incorporate sensors or user interfaces (typically powered by coin cell batteries) sending small amounts of data infrequently.

The likely early applications include Personal User Interface Devices (PUID) (such as watches), Proximity, Battery Status, Temperature and Heart Rate. Other health and fitness monitoring profiles such as blood-glucose and -pressure, cycle cadence, and cycle crank power will follow. And because this is the first time a ULP wireless technology with guaranteed interoperability has been available to electronics designers, *Bluetooth* low energy promises to extend wireless connectivity to hundreds of new products.

Despite its promise, implementing *Bluetooth* low energy technology will not be trivial. But with a little help from the chip suppliers, a competent engineer should be able to meet the challenge of implementing a *Bluetooth* low energy-powered wireless connection into their next portable product.

Built on proven technology

Nordic Semiconductor, a company with over a decade of experience in 2.4GHz ultra low power (ULP) wireless design, and a member of the Bluetooth SIG, has played a significant role in drawing up the specification for *Bluetooth* low energy wireless technology, which has now been adopted as a hallmark feature of the *Bluetooth* Core Specification Version 4.0.

As befits its reputation as a leading RF chip supplier, Nordic has developed a family of *Bluetooth* low energy silicon solutions called µBlue ("MicroBlue"). The first device (the nRF8001) has already been released in sample quantities to developers, ahead of full qualification, once the complete specification is released in the summer of 2010. (See figure 1.)

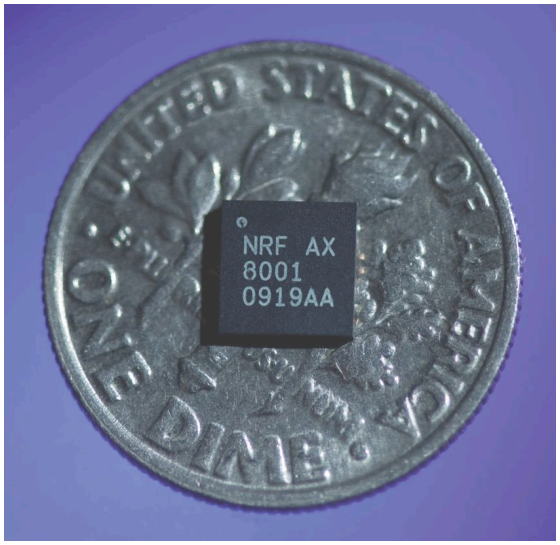

Figure 1: Nordic's µBlue nRF8001, single mode Bluetooth low energy peripheral chip, has already been released in sample quantities to developers

The nRF8001 is a single mode peripheral chip in a 32-pin 5 by 5mm QFN package incorporating a fully embedded radio, link controller, and host subsystem - suitable for watches, sensors, and remote controls among other applications. To accompany the chip, and to ease the challenge of electronics engineers designing nRF8001-based wireless connectivity, Nordic has also released the µBlue prototype kit and µBlue Software Development Kit (SDK).

This SDK is built around Nordic's existing nRFgo development platform that has been available for several years to customers working with the company's proprietary nRF24xxx 2.4GHz ULP transceivers. nRFgo integrates hardware and software tools to provide easy control of the application processor hardware and software through a graphical user interface in the nRFgo studio. Such tools include handling of the data in non-volatile memory, test modes, power control, internal software configuration and more.

The µBlue prototype kit comprises a peripheral device based around the µBlue chipset and a proprietary Master emulator that allows the user to develop and test their own *Bluetooth* low energy Slave device applications.

The hardware platform of the peripheral device is the nRFgo motherboard (nRF6310) that can be used for any product in the company's transceiver families (either proprietary or *Bluetooth* low energy). Consequently, existing customers will find working with µBlue chips easier as the development environment is familiar, while new customers will benefit from a market-proven development environment.

The nRFgo motherboard offers external access to the connected device pins as well as simple interfaces such as buttons, LEDs, a UART or even an additional display allowing designers to implement their targeted end-product user interfaces.

The nRF2735 daughterboard (plugged on top of the nRF6310) offers an application processor, Nordic's nRF8200, which executes the peripheral device customer application (the nRF8001 µBlue chip doesn't include an onboard microprocessor, reducing size, cost and power consumption, and allowing the developer to select their own choice of microprocessor). While the nRF8200 is based on a cost-effective 8051 microprocessor, manufacturers can use their own choice of microprocessor if preferred.

A µBlue module (nRF2731) is then plugged on top of the nRF2735 and incorporates the nRF8001 µBlue chip. The device is connected to the application processor through an SPI interface (widely available on most microprocessors on the market and offering fast data transfer capabilities). (See figure 2.)

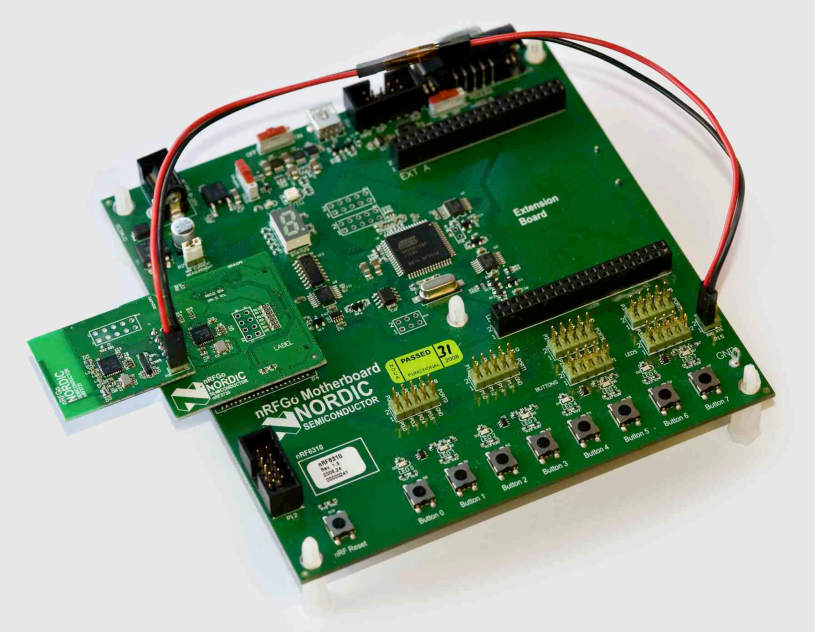

Figure 2: The µBlue prototype development kit comprises an nRFgo motherboard, daughterboard (including an application processor) and µBlue module (including Bluetooth low energy transceiver)

Developers wishing to use their own choice of application processor have the option to connect this module directly to their own development environment as well. The two connectors on the nRF2731 are standard 10-pin connectors; one is dedicated to the nRF In System Programmer (ISP) that enables Flash memory programming, the other is dedicated to the application processor SPI interface.

If the selected application processor doesn't offer an SPI interface it's still possible to use a 'bit-banging' technique to connect to the μBlue chip. If using this technique, software-controlled I/O lines are sufficient to handle SPI transfers. The μBlue SDK includes C language source code for an application processor to handle an SPI connection using bit-banging, allowing even the least expensive processor to be connected to the μBlue chip.

Determining optimum settings

The nRF2739 master emulator platform offers a fully functional *Bluetooth* low energy Master device and complements the peripheral device. The master emulator is controlled through a USB connection to a computer. (See figure 3.)

Figure 3: A master emulator platform offers a fully functional Bluetooth low energy Master device and is controlled through a USB connection to a computer

Nordic has developed several proprietary tools each offering high-level functionality to simplify control of the Master device. Chief among these tools is the Master Control Panel which provides full control of the *Bluetooth* low energy Master device. Among the main features of the Master Control Panel are: device scanning; display of device information; selection and connection/disconnection to a specific device; pairing and bonding *Bluetooth* low energy security procedures; scan of Slave device services and details about services characteristics and read and write of characteristics values.

The Master Control Panel can execute high-level procedures developed to test *Bluetooth* low energy features with just a few mouse clicks. The panel also features a detailed trace to quickly identify potential issues during peripheral device application development. The Panel allows precision configuration of the *Bluetooth* low energy connection parameters that are the key to understanding, estimating and measuring performance and power consumption trade-offs from both the *Bluetooth* low energy Slave and the Master points of view. Using these settings, it's simple for a developer to determine the optimum *Bluetooth* low energy connection settings required by the embedded applications in order to meet the end product's performance specification.

In addition to the development tools facilitated by the Master Control Panel, it's also possible to tune some specific parameters of the *Bluetooth* low energy specification in order to adapt the Master device's behaviour to suit the end product.

For example, while the connection interval, slave latency and supervision timeout are set by the Master device they will directly impact the Slave device data transfer rate and power consumption (in addition these parameters determine reactivity to a link loss). With power consumption the critical concern for *Bluetooth* low energy devices, this tool allows the designer to anticipate worst-case scenarios that could come from a high demanding Master application.

In a second example of how specific parameters affect behaviour, the scan interval and scan window parameters will determine the Master device reactivity in analysing the available *Bluetooth* low energy network (for example, new devices in detection range, devices no longer in detection range and features supported by available devices). However, note that better reactivity will be at the expense of increased power consumption.

A familiar environment

Software development is based on the Keil™ IDE; Keil's product is available for most widely deployed microprocessors. By basing its device software development on the Keil tool suite, Nordic is providing developers with a familiar environment. Moreover, this allows the re-use of Nordic sample applications source code, and the modification or merger of this code with any code the developer has written previously.

All source code is in C language and structured so that application processor architecture-specific routines are independent from the main application code. It is therefore easy to port the code to an application processor other than the nRF8200, as only these architecture specific (hardware abstraction) routines have to be modified to suit the selected processor.

The nRF8001 integrates a qualified *Bluetooth* low energy software stack including Host and Link Layers. The (upper layer) Profiles reside on the application processor, but are downloaded to the nRF8001 before runtime. The nRF8001 is then controlled through a simple software interface. This interface is designed to simplify the complex *Bluetooth* low energy specification details, removing the burden of acquiring intimate knowledge of the *Bluetooth* low energy specification from developers.

Consequently, profiles can thus be developed and tested rapidly without any errors caused by a misunderstanding of the *Bluetooth* low energy Host specification. Because there is no possibility that the application software can corrupt the pre-qualified Nordic software stack (running on the nRF8001), the Qualification process is much simplified.

Supplied with Profiles

The µBlue SDK is supplied complete with *Bluetooth* low energy Profiles developed by Nordic. The full source code and binary files are delivered with the SDK so it's possible to easily test the *Bluetooth* low energy capabilities of µBlue right "out-of-the-box". Any new Profile will appear through a Service Discovery tool. Developers can use this tool to read or write data and check the correct behaviour of their Slave product.

The Battery Status Profile and Proximity Profile - which the Bluetooth SIG considers to be two of the most common profiles for single mode peripheral devices - can be easily understood by viewing the step-by-step demonstration of the Nordic Profiles (detailed in the user's manual).

The Profiles have been developed using the Keil development environment, and can be downloaded into the application processor using nRFgo Studio.

The µBlue prototype kit offers complete hardware and software suites to enable immediate testing of Nordic's µBlue *Bluetooth* low energy solution. Developers can re-use well-known tools, either from Nordic or from other suppliers, to quickly integrate µBlue in their system solution and write new applications by using extensive source code and manuals delivered in the kit. Although RF design will never be trivial, with the µBlue prototype kit, access to the exciting world of interoperable ULP wireless connectivity is much less of a challenge.

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