FAQs: Ultra-low power wireless connectivity and Nordic’s nRF24xxx transceivers

Q: Why add a wireless connection?

A: If you need two devices to communicate, a wireless link is very convenient. There are no connectors to plug in or wear out, no wires to become tangled and no restraints on where the two devices to be connected are positioned (provided they are within the radio’s operational range, which is typically 10 metres or more.)

The devices are “paired” or synchronised so that a communication link is established. The devices at each end of the link can both transmit and receive (hence the term “transceiver”). Data is sent in “packets”, with the receiving device acknowledging that it has received each packet. Manufacturers have worked to ease the connection process so that it has become as simple as pressing a button.

Nordic Semiconductor sees only rapid increases in the expansion and growth of wireless technology. Our experience is that consumers don’t like cables and place a lot of value on the added convenience and freedom of wireless products. This is particularly true if the cost of such products is comparable to traditional wired alternatives.

Q: How quickly will the wireless connection transfer information?

A: Wireless links have a finite bandwidth (a limit on how quickly digital information can be transferred). But the technology has improved dramatically to the point that typical transfers only take a matter of seconds or less.

For example, transferring a “virtual” business card from one smartphone to another can be done in a fraction of a second with a wireless link rated at 500 kbps, although transferring a large digital picture image of (say) several megabytes from a camera to a printer using the same link would take a few minutes.

Nordic Semiconductor manufactures transceivers in a range of bandwidths right up to 4 Mbps. This is sufficient, for example, to stream native CD-quality audio (16 bit, 48 kHz) without compression, across a wireless link. However, many of the applications that are served by Nordic’s ultra-low power transceivers only require the transfer of modest amounts of data, relatively infrequently. Nonetheless, it is still advantageous for the transceiver to feature good bandwidth, because the communication can be completed rapidly and the transceiver can return to a sleep mode, saving power. Some competitive technologies, for example, feature bandwidths of 250 kbps and would therefore need to be in a high power consumption transmission/reception mode for eight times longer than a 2 Mbps RF transceiver such as Nordic’s nRF24L01+.

Q: Does a user need a licence to operate a wirelessly connected device?

A: Low-power wireless links use licence-free portions of the electromagnetic spectrum. Providing these links adhere to local regulations (these primarily govern power output and the manufacturer is responsible for meeting them) users do not require a licence to operate the device.

The licence-free portions of the spectrum vary from country-to-country. For example, in the US the 915MHz band is available, while in Europe 434 or 868MHz are used. However, the 2.4GHz Industrial, Scientific and Medical (ISM) band is considered the “global” band applicable to almost all countries. Nordic Semiconductor makes transceivers that operate in all of these bands.
Q: How does the wireless connection avoid being disrupted by other devices?

A: All radio links are prone to interference from other devices operating on the same frequency. This is particularly a problem in the 2.4 GHz band that’s used by many wireless chip manufacturers because of its status as the global licence-free band.

To combat this, Nordic Semiconductor’s chips use RF communication software that includes sophisticated adaptive agility techniques. For example, Nordic has developed Gazell, an RF protocol designed for efficiency, low power consumption, and minimum latency. Gazell employs a simplified frequency hopping scheme where the transmitting and receiving pair establish communication on a particular frequency and then only hop to a different frequency should interference be experienced. The channel on which the interference was experienced is marked and not reused during that particular communication cycle.

In addition, devices such as Nordic’s nRF24AP2 - used in very low duty cycle applications such as sports-based heart rate monitoring and wireless transmission to a watch-based recorder – employ a proprietary form of Time Domain Multiple Access (TDMA) developed by Nordic’s design partner ANT. The nRF24AP2’s TDMA-like collision avoidance approach relies on each transceiver transmitting in a clear timeslot. If there are a number of discrete systems working side-by-side – such as a row of rowing machines all lined up next to each other in a gym – then by “listening” for drifting transmission sources on its frequency the wireless node can determine if there is approaching interference and adapt its transmissions accordingly.

Naturally, a crowded wireless environment will reduce bandwidth, as the transceiver has to change frequency more often and is likely to need to resend more packets.

Q: Why not just use Bluetooth wireless technology?

A: Bluetooth wireless technology is defined in a specification published by the Bluetooth Special Interest Group (SIG). This specification details the architecture to which all Bluetooth wireless technology products must comply. This ensures that any Bluetooth wireless technology product will communicate with any another.

It’s true that many designers do select Bluetooth wireless technology because of its “one-size-fits-all” approach. But this does mean their competitors have easy access to the same technology, making it difficult to differentiate the product in a fiercely competitive global market. And standard-based solutions offer little opportunity for design flexibility.

That said, Bluetooth wireless technology is a good solution if you’re designing a cellphone or a PDA that is going to communicate with a device from another manufacturer. But if you’re making both ends of the link – for example an MP3 player streaming wireless audio to a pair of wireless headphones – it’s worth looking at proprietary alternatives.

In order to meet the demands of many groups and manufacturers, Bluetooth wireless technology is a compromise; although it has been very successful in its aim of meeting the demand for an interoperable wireless link, it’s not optimised for all applications, particularly those powered by small batteries. Adhering to the specification does extend time-to-market because the design must be ratified. In addition, this adds to non-recurring engineering (NRE) overheads.

Bluetooth wireless technology can be out-performed by Nordic Semiconductor’s proprietary transceivers for many applications because they can optimized for a specific use case, improving performance, extending battery life, and reducing cost.

Q: What if there’s a need to create a low-power wireless network?
At Nordic Semiconductor we realise that many designers will want to do this and we offer an ideal technology. Developed by Canadian company Dynastream, ANT™ is a Wireless Sensor Network (WSN) communications technology focused on delivering ultra-low power, low-cost, and ease of implementation to a product design.

Designed to be integrated into small form factor product environments - such as those powered by a coin cell battery - ANT’s power performance is significantly lower than Bluetooth wireless technology or ZigBee. The protocol supports different network topologies, device pairing, and selectable transmission types.

The ANT protocol uses Time Division Multiple Access (TDMA)-like technique for the basis of its communications channels. TDMA techniques combined with ANT’s multiple access channel technology allow networks comprising hundreds of nodes to be connected in a wireless network.

Q: What are the design challenges when adding wireless connectivity into battery-powered portable products?

A: Adding a wireless link to a portable device presents four key design challenges: cost, complexity, power, and size.

Designers are responding to consumer demand for wireless functionality but those same consumers are unwilling to pay more for unwired convenience. At Nordic Semiconductor we have been careful to price our chips to optimise the performance/cost ratio.

It’s very important that wireless links are simple to design-in. Many designers are wary of adding wireless functionality because they perceive it to be complex. After all, silicon radios feature RF, analogue, and digital functions and are complicated products. However, by producing highly integrated transceivers, reference designs, and RF communication software, Nordic Semiconductor has worked hard to simplify the design process.

But it’s still not just a case of mounting a chipset onto a PCB though; you have to be aware of the issues that will affect the performance of the design, such as antennae positioning, range, and interference with other devices.

Carefully consider the level of support you’ll get from your supplier. You may need help with testing or antenna positioning, for example. Or if your PCB layout isn’t that good from an RF perspective, your radio may be more prone to interference so advice may be required there.

As a specialist wireless company, Nordic Semiconductor employs many RF experts who are able to support our customers with their wireless design problems.

Q: What is an “ultra-low power” RF transceiver?

A: Despite impressive development in battery technology, a portable device designer will always be faced with a modest power budget. If the device is powered by low capacity batteries, such as AA, AAA or even coin cell types, the challenge is even greater.

Nordic Semiconductor’s chips have been specifically designed to operate from coin cell batteries (such as a CR2032 or CR2025) for periods of months or even years (depending on application duty cycle). These coin cell batteries are compact and inexpensive, but have limited energy capacity, typically in the range of 90 to 240mAh (compared to, for example, an AA cell which has 10 to 12x that capacity) - assuming a nominal average current drain of just 200µA. To operate from such a power supply demands an efficient RF transceiver with minimal, or “ultra-low power” (ULP) energy consumption

Limited capacity batteries (coupled with typical Nordic RF transceiver operating characteristics featuring peak currents of 11 to 13mA) restrict the active duty cycle of a ULP wireless link. For
example, a 220mAh CR2032 coin cell can sustain a maximum nominal current (or discharge rate) of just 25µA if it’s to last for at least a year (220mAh / (24hr x 365days)). A silicon radio featuring peak currents of tens of milliamps can transmit for no more than about 0.25 percent of the time – quickly reverting to a sleep mode, drawing just nanoamps - if the average current is to be kept to just a few tens of microamps.

A typical use case for a Nordic ULP RF transceiver is the transmission of data from compact wireless sensors such as those used in wireless desktop peripherals, heart rate monitors, or remote controls. These devices send relatively low volumes of data (i.e. a few bytes) infrequently.

Nordic’s ULP RF transceivers do this waking up quickly, sending very short but relatively high-bandwidth “bursts” of data (up to 1 or 2 Mbps), before immediately returning to the low energy consumption sleep state. When drawing on the modest power reserves of a coin cell battery, Nordic’s ULP RF transceivers are not capable of high duty cycle applications and therefore don’t compete directly with traditional Wi-Fi and Bluetooth wireless applications. However, the chips’ ULP operation does open up a new range of wireless products that are beyond the capability of these technologies.

**Q: Will the wireless connection take up a lot of space on the PCB?**

**A:** As if the designer doesn’t already have enough to think about, they will also usually be put under a lot of pressure to shrink the electronics to fit the compact profile demanded by consumers of mobile devices. That means there’s little space to add chunky transceivers and peripheral components onto an already crowded PCB.

While most silicon radio vendors have done a pretty good job of integration, the chips tend to demand some form of supervisory MCU and an array of support components. In contrast, for example Nordic’s nRF24LE1 transceiver – which offers up to 2 Mbit/s air data rate – measures just 4 by 4 mm yet integrates a fully featured nRF24L01+ 2.4GHz transceiver core, 8051 mixed signal microcontroller and flash (or one time programmable (OTP)) memory. These transceivers only need a couple of peripheral passive components to get them up and running on a development board.

**Q: How can I get started in wireless design?**

**A:** Nordic Semiconductor has specialised in meeting the critical challenges for designers looking to add a wireless link to their products. Our transceivers are integrated and compact, relatively simple to design-in, can be supplied with efficient protocols, are extremely power frugal and offer an attractive price/performance ratio.

We realise that, for the non-RF expert, wireless design can be daunting. That’s why we allocate a lot of resource to helping our customers get started on their wireless connectivity projects. We don’t just provide silicon radios, we supply complete “silicon solutions” including:

- Highly integrated RF silicon;
- Sophisticated and flexible development tools;
- Application specific communication software;
- Complete reference designs.

We look at the typical applications our customers want to solve and then come up with a silicon solution to suit. For example, our nRF24LE1 is a fully integrated System-on-Chip (SoC) that together with our Gazell RF communications software a manufacturer suits manufacturers who are looking for a “turn key” wireless connectivity solution for a high volume application such as a wireless mouse. Nordic has also introduced a lower cost version of this chip with one time programmable (OTP) memory instead of flash that suits markets such as toys.
However, for designers looking for a more customisable product to differentiate their product in a niche application, Nordic supplies Single-Chip-Connectivity solutions such as the nRF24L01+ or nRF24AP2. These devices are fully functional ultra-low power 2.4GHz transceivers that can be linked to the designer’s choice of microprocessor. This allows the designer to develop the firmware for the specific application safe in the knowledge that the wireless connectivity part of the design needs little or no further development.

Nordic’s Single-Chip-Connectivity solutions are a cost effective way to implement the wireless connectivity for low-to-medium volume designs such as cycle computers.

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