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Wireless Overview

SparkFun Electronics Summer Semester

WIRELESS OVERVIEW

There's a lot of different ways to get data from a remote unit to somewhere else. In this guide, we attempt to show you different technologies and the tradeoffs between those technologies. Remember, we are completely biased. We've used a lot of these modules, and we apologize to the companies that spent a lot of effort designing them. This is just what we think!

	Power	Distance	Data Rate	Data Delivery	Cost	Learning Curve	Size
Nordic	5	1	2	2	5	3	5
Cellular	1	5	4	5	1	5	1
Bluetooth	3	3	4	4	3	5	3
Zigbee	4	1	2	2	4	2	3
XBee	3	3	3	3	4	4	3
WiFI	2	3	5	5	2	3	3
FM	4	4	*	*	4	4	4
General	4	4	1	1	5	1	4
KEY	5 = Lowest	5 = Longest	5 = Highest	5 = Guaranteed Delivery	5 = Cheapest	5 = Shortest time learning	5 = Smallest
	1 = Highest	1 = Shortest	1 = Lowest	1 = May Not Get There	1 = Most Expensive	1 = Lots of time learning	1 = Largest

Pictured above is our quick and dirty breakdown. Now let us explain ourselves…

Before you get started, think about your project goals. Then answer these questions:

- Is battery life a concern?
- How far does the wireless link need to transmit?
- How much data does your system need to transmit?
- Is it ok if some data gets lost? Or do all packets abslutely have to arrive at the base?
- How much are you able to spend?
- How much time do you have to play?
- How small does it need to be?

Answering these questions will help you significantly narrow down the search for the RF solution that best fits your project.

Features that are addressed by the questions:

- Power
- Distance
- Data rate
- Data delivery
- Cost
- Learning curve
- Size

Potential RF Solutions:

- Nordic
- Cellular
- Bluetooth
- Zigbee
- XBee
- WiFi
- FM
- General

Power:

Depending on the type of solution, power consumption can range from micro amps to amps (6 orders of magnitude). Historically, RF requires a lot of power. If you're trying to broadcast pirate radio, expect to not be able to run your station off batteries. However, if you need to chirp some data every few minutes or on the hour, your can significantly reduce your power and do some fun sleep mode tricks.

Connecting a device to the power grid will open up many RF options. On the other hand, if you're planning on making your RF device portable, consider how much mAh (mili-amp hour) time your battery has and how often you need to transmit your data. If you've got a 50mAh coin cell and your RF device uses 12mA when receiving, you've got 50/12 = ~4 hours of run time. Now if you power cycle the RF device (for example, in receive mode 5% of the time), you can significantly increase your battery life (50/0.6 = ~83 hours = ~3.5 days run time).

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Distance:

Distance is related to power. If you need to transmit ~10-50 meters (32 to 164ft), there are lots of options open. If you need to broadcast over the African Sahara, you may need a bit more umph. Some of the XBees claim miles of range, but this is usually with very directional antennas and with a bit of power behind it (210mA at 3.3V). In embedded electronics land, we deal with mW (mili-Watts). If you need watts of power for your pirate radio station, you are probably talking about miles of transmission range, but you are not going to get it with a coincell battery.

Data Rate:

Do you need to download torrents? Or do you need to receive a 4-byte analog to digital conversion? Data rate is everything. Some of the simple data links are limited to ~300 bytes per second (2400 bps). You can much higher datarates (wif being the forerunner) but this adds overhead, complexity, and power consumption. Low power go s hand in hand with low bandwidth. A small battery usually means you will be able to broadcast a handle of bytes (hundreds) every handle of seconds. If you're looking to stream audio data off Pandora, you are probably looking at the wrong tutorial.

Data Delivery:

Do I really care if my data gets to where it needs to be? Sounds funny, no? Well it's actually quite applicable. RF is a f nicky. thing. One second I can get 100 bytes where it needs to be and the next minute one of the bytes get corrupted.

Because we cannot see high frequency RF do s not mean it is not there. There is a lot of radiation coming from normal house hold wiring, computer monitors, the sun, even static electricity. There are a ton of EMI (electro-magnetic interference) sources. And we really cannot predict where the interference will come from. Therefore, when we broadcast 'Hello world', it may get garbled on its way to the lunar lander. One of the ways to protect against this is verifying that the data was delivered correctly. Basically we wait for the receiver of the information to conf rm 'yes, I heard you'. This systems of:

- Broadcast
- Wait for the receiver to say 'I got it!', or if too much time passes
- Re-broadcast

can add a lot of complexity to the overhead of the protocol (more power, less data bandwidth, etc). Do you really care if your garage door opener fails to open your garage door? No, you just hit the button again. Do you care if your cardiotocograph gets recorded correctly to the nurses' station - um, ya.

Cost:

This correlates with power and complexity of use. If you've got a bunch of free time, you can probably spend a few days/ weeks hacking at the really cheap RF links, creating your own protocol, and verifying checksums. However, if you simple need to plug it in and have it work - now!, expect to spend more money to have something work out of the box (Bluetooth and Cellular are the simplest solutions for unseasoned users).

Learning Curve:

This characteristic ties closely with cost - if you've got no money, expect to spend a bit more time wading through example code and datasheets. Once you get a basic RF link working, it's awesome! But it may take a few ferocious days of beating your head against the wall. On the other hand, Bluetooth may seem exorbitantly expensive, but you can open a serial pipe with a few mouse clicks. No matter which solution you choose, expect to spend many hours pouring over datasheets and/or example code. But once you really wrap your head around the wireless solution, it will seem trivial.

Size:

Regardless of what you may have seen in the movies, slipping someone an RF pill won't allow you to track them across a country. Help us with a good movie example! RF means a certain amount of size simply for the antenna and power source. There are very sneaky ways of miniaturizing the antenna but every time you fold the antenna smaller, you generally loose transmission/reception range (the smaller the antenna, the less distance of coverage you get). As the frequencies get higher (think 2.4GHz, 5.8GHz, etc), the antennas do get smaller. However, the penetration of walls and barriers gets worse. 5.8GHz likes to bounce of household walls, 2.4GHz might make it to the neighbors, 900MHz can get through walls, trees, kids, even livestock, 125kHz can work under water. Do s GPS (1.5752GHz) work under water? No - because water is an awesome insulator (do sn't allow energy to pass through). Then how do s my dive computer work under water? That's because a wireless dive computer works in the kHz range (much lower than MHz or GHz).

It's a trade off: the longer range and better reception (more penetration) you need, the lower the frequency (think kHz, not GHz), the lower the data rate, the bigger the antenna (2.4GHz = 3cm, 900MHz = 9cm, 32kHz = 243,212cm). If you need a 32kHz antenna (giant 768ft antenna) to transmit 1Mbit/s of data, to power off a coincell battery, you may run into problems.

Antenna selection is not trivial. You could have an amazingly powerful RF engine, but a crappy antenna and all of the features will suffer. A chip antenna might seem alluring, but it may not be the best f t with your project. If you need range, use a directional biquad antenna. If you need tiny size and only feet of range, use a trace or wire antenna. Chip antennas are a little better. Bigger duck antennas are incrementally better. It all depends on your application.

Nordic - how I love you so.

Pros:

- Low cost - ~$2
- Low power - down to micro-amps
- Super flexible
- Great way to get a very small amount of data from one point to another
- Small footprint

Cons:

- You write your own protocol
- Shorter range (~50 to 100m)

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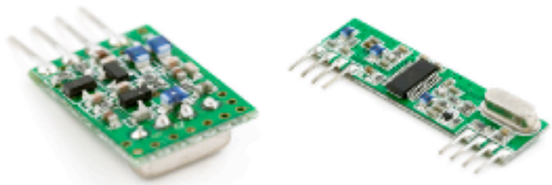

General TX/RX

Pros:

- Cheap
- Basic interface
- Reasonable range (500ft)
- Large voltage range for transmitter (2-12V)

Cons:

- Big/long learning curve to get units functioning correctly
- Limited data rate (2400-4800bps)
- No data f ltering or packetization
- Not directly FCC certif ed

Other:

The general RF transmitter and receiver pairs are commonly used for low-data rate consumer applications - like in your garage door, remote weather station, wireless window remote, the list goes on and on. These units are made cheap, and therefor have no brains. This leads to a headache from the users' perspective. It is possible to get bytes across this link, but it requires quite a bit of hacking, protocol creation, error checking, and patience.

So that's our take on the RF selection at SparkFun. We hope this gives you a bit of insight into what is, and what is not possible when using wireless devices. There are more options than what is listed here. If you know of a good solution, let us know!

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Other:

Bluetooth is pretty good. I really liked using it on the popular BlueSMiRF. It has been around for a few years now and the Serial Port Prof le (SPP) works great for opening up a serial pipe between two points (what you pass in the RX pin, you get out at the TX pin on the other side of the wireless connection). Anything Bluetooth can pretty much talk to anything else Bluetooth. This makes it pretty f exible and easy to use, but you pay for it in cost, and in power consumption. Bluetooth modules with audio are one of the very few technologies that we've played with that support audio transmission.

XBee rocks. Don't let me confuse you! XBee sounds a lot like Zigbee. That's because this company called Digi (well, Maxstream before they were bought) took all the good stuff about Zigbee, and wrapped it up into an easy to use AT command set. I don't care how you get the data from point A to point B, XBee takes care of it all for me.

Pros:

- Simple to use interface
- Creates serial pipe between point A and point B out of the box
- Comes in many different footprints to support different frequencies, distances, and power ranges.
- Short range (100m) to long range (16 miles!)
- Same AT commands for all the different f avors (awe some)
- Great conf guration software (windows only, sorry!)

Cons:

- Uses a slightly hard-to-f nd 2mm pitch connector. So we designed a bunch of breakout boards (basic, USB, RS232).
- Not low power (50mA)
- Series 2.5 supports multi-point and mesh-node-net working but does it with some really dense datasheets and nomenclature
- Not cheap. ~$25(min) per radio.
- Not all that small. Pretty small, but not really small.

Other:

I like XBee. I wasn't a believer until I started using it for all my wireless bootloading. Now I love it. If power is not an issue, these work great for beginners to get data from one place to another with the least hassle, learning curve, and setup.

WiFi

Pros:

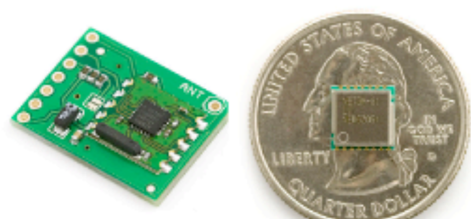
- Super common standard - pipe data to any router any where
- Good for moving large amounts of data (1Mb+)

Cons:

- Not low power - ~100mA
- Requires some serious processing power to handle 802.11 stack

Other:

I have not yet used WiFi. I usually don't need to move more than a few bytes over a wireless link so I haven't found a need for it, but many people have. There are some decent WiFi modules available that give us UART or SPI interface to WiFi, but it's still pretty complex in my opinion.



FM Radio Transmitter and Receiver

Pros:

- A great way to get audio from one device to another
- Easy interface/control
- Small size

Cons:

- Only audio, no data
- Not directly FCC certif ed

Other:

The FM Transmitter module is easy enough to use, and it works surprisingly well, but it's limited to audio paths only. You can't transmit data (without being sneaky). The module can be FCC certif ed, but it is not certif ed off-the-shelf so you have to use it under the 'research only' umbrella. The FM receiver is very handy as well but with Pandora, iTunes, and the proliferation of MP3 - who listens to the radio anymore?