What is LoRa?

LoRa is a type of chirp spread spectrum transmission and has been implemented by Semtech for use in low cost ISM band devices.

For a normal FSK style transceiver (such as the Hope RFM22B) the receiver needs to see signal that is strong enough to be greater than the local RF noise level. Noise levels in the ISM bands are a performance limiter and each device in use adds to the local RF noise level. The total noise a receiver sees is a combination of local RF noise and noise generated by the electronics inside the receiver.

Assume a typical FSK transceiver needs to see a signal that is 5dB above the receiver's noise level in order to decode it. In comparison LoRa technology allows for signals to be received that are as much as 20dB below noise level, thus the LoRa signal can be up to 25dB (5dB + 20dB) weaker than the FSK one and still be received. If LoRa can decode a signal that is 25dB weaker, then the transmitter can be further away than in the FSK example. If you double the distance that a transmitter is away from the receiver then the receiver will see signals that are 6dB weaker, thus the 25dB difference equates to a distance difference of approximately 17 times.

So due in the main to the below noise level performance of LoRa it is able to receive signals that are much weaker and thus much further away than with some previous ISM band modules

LoRa modules are straight forward to drive and very flexible, the internal firmware takes care of all internal adjustments and optimisations. The parameters that need to be configured for LoRa are, Spreading Factor, Coding Rate, Bandwidth and transmit power. These parameters can be easily changed so that you can set-up for low data rate long range or high data rate shorter range.

LoRa is also a two way technology, the tracker transmitter is a receiver too, so if you can pick-up signals from your tracker you can send it commands or exchange data with it also.

Bandwidth

We first need to consider the impact of the bandwidth setting. The LoRa bandwidth is the amount of frequency spread the signal occupies. The bandwidths LoRa can be set to are;

7.8Khz, 10.4Khz, 15.6Khz, 20.8Khz, 31.25Khz, 41.7Khz, 62.5Khz, 125Khz, 250Khz, 500Khz.

A low bandwidth signal, such as 7.8Khz will give the best (longest distance) performance, but with the low cost components used in the Hope and Dorji modules a transmitter and receiver may not talk to each other at this bandwidth. The receiver has a capture range, this is the percentage difference allowable in relation to the bandwidth that the transmitter and receiver can be apart in frequency in order for the receiver to pick up the transmitters signal. This percentage is typical 25% of the bandwidth.

Lets assume the bandwidth in use is 10Khz, the allowable variation is 25% or 2.5Khz and the transmitter is on 434.000Mhz. For the link to work the receiver needs to be on or between 433.9975Mhz and 434.0025Mhz. This is an exacting requirement for a low cost crystal, even if transmitter and receiver are at the same temperature.

Low bandwidths of 20.8Khz have been used for tracking and they do give better performance, but care is needed as devices used at this bandwidth may not talk to each other unless a calibration factor is measured and applied.

A bandwidth of 62.5KHz has been found to be reliable and allows for differences in manufacturing tolerance and temperature between transmitter and receiver devices.

Spreading Factor

This controls the amount of signal processing gain. The spreading factor can be set between 6 and 12. A setting of 6 can only be used with fixed length packets, so has not been used in my applications.

The spreading factor defines the below noise performance. SF6 gives a -7.5dB below noise performance and SF12 a -20dB below noise performance.

The larger spreading factors therefore give more range, the trade off is that higher spreading factor packets take longer to transmit.

Coding Rate

Additional data can be added to the packet to allow for error correction. This can result in small signal gains at the limit of reception. The coding rate can be varied between 4:5 and 4:8, the higher 4:8 rate will result in longer packets.

A fuller description of LoRa will be found in this document;

AN1200.22

How the LoRa settings affect range

Having established a practical LoRa bandwidth, 62.5KHZ for a tracker, we can use this to look at how the spreading factor affects range and the time to transmit a typical 20 byte GPS location payload.

The lower spreading factors will give the highest data rates and the shortest packets in time terms, in turn this is more battery efficient. The lowest spreading factor we will consider is 7.

Now, assume we are using a bandwidth of 62.5KHZ and a spreading factor of 7, that will give an equivalent data rate of 2734bps, according Semtech's 'Lora Calculator' tool. The time taken to transmit our 20 bytes is 98mS. Assume that is our base and that in a typical urban area the limit of reception is 500m. To find a 'lost' model you would need to explore an area on a 1km grid, so that you are always within 500m of the 'lost' model.

If we switch to spreading factor 12 then the data rate drops to 146bps and the transmit time goes up to 2.2 seconds so this is a slow packet. The benefit of the higher spreading factor (and longer transmit time) is significant, we now have an approximate 14dB of extra signal gain. This is equivalent to 5 times further range, so our 500M now extends to 2.5km and the search grid is now strips 5km apart.

Now 5 times longer distance may not seem a lot, but appreciate how much difference it can make to the transmit power required to cover the extra distance. If we were transmitting at 10mW and that gave us the 500m range, to cover 5 times further range just by increasing transmit power would require a transmitter putting out 25 times the 10mW (250mW) and a very much larger battery.

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