LEVEREGE

LPWAN RF Discussion

UPDATED ON
December ‘19

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Introduction

There has been much discussion in the Low Power, Wide Area Network (LPWAN) community about the use of other RF frequency bands for data transmission outside of the typical 868 MHz/915 MHz (LoRa Europe/North America) and 2.4 GHz (Ingenu RPMA) ISM bands. This white paper provides a brief discussion of the pros and cons of using the lower 433 MHz band for LPWAN applications and provides implications for certain use cases.

This white paper assumes a working knowledge of Semtech's LoRa technology and Ingenu's RPMA techologies as well as some basic familiarity with RF propagation. If you are unfamilar with these technologies and disciplines, we recommend reading Leverege's primer on LoRa and LoRaWAN or our white paper on LPWAN technologies in general.

Discussion

LoRa is a modulation format, not tied to a specific frequency, which is why we see the 868 MHz vs. 915 MHz in Europe/Americas. This means that you can transmit and receive LoRa signals even at 433 MHz. However, base stations that incorporate the Semtech LoRa chipset are designed to operate only at 850 MHz to 1 GHz. This is a clear advantage for using 915 MHz since there is more vendor availability and industry support. With that said, there are no built-in restrictions to using the SX1276 LoRa chip (end-node vs. base station/gateway) and operating in the 433 MHz frequency range.

Theoretically, LoRa offers slightly better receive sensitivity than 433 MHz. At face value, attenuation and penetration for 433 MHz would be better the same reason LoRa frequencies are innately better than higher frequencies such as 2.4 GHz. However, 400 MHz bands have much lower power limits than in the ISM Bands at 900 MHz. At 433 MHz, the output power is limited to -22.4 dBm vs. 915 MHz at -1.25 dBm (smaller number is better as dBm to mW conversion is 10^(dBm/10)). This equates to a hundred-fold increase in output power for LoRa at 915 MHz compared to 433 MHz.

Speaking of regulations, 433 MHz is regulated under 10CFR47 Part 15.231. It specifies that this frequency band is intended for remote control, and while other uses are allowed, they are not optimal. Part 15.231.a.3 prohibits scheduled periodic data transmissions, while allows polling transmissions that do not exceed two seconds of transmission time per hour. Part 15.231.e makes a provision for frequent polling as long as each transmission is under one second and that the silent period is at least 30 times the duration of the transmission and no less than 10 seconds. This is a significant restriction: essentially you are allowed one transmission every 10 seconds. That could pose a huge problem in asset tracking and other use cases that require frequent sensor updates. Also, at scale, the maxi- mum of 2 seconds per hour limits the number of events a 433 MHz system can process. Let's assume that one update event in an asset tracking use case takes 2 milliseconds. Then, you can only transmit 1,000 of these messages in an hour. Considering how many assets may need to be tracked and how often you may want to update them, 433 MHz system may impose a limitation on the number of events.

These are all theoretical performances (very similar to Ingenu vs. LoRa). It is hard to make a claim that one is inherently better as radio transmission depends on so many factors. One controlled study found that the 900 MHz tends to get better coverage than 400 MHz. 1 But this is also based on finite element analysis and simulations, not real-world testing, illustrating how difficult it is to claim that one system is better over the other based on frequency alone.

Summary

- Claims that a 433 MHz system is *inherently* more reliable than a 915 MHz system are unfounded and not supported by detailed analysis.
- 433 MHz may be inherently superior for longer range in a theoretical situation due to less signal reaction (equating to better penetration) in a similar manner that 915 MHz typically has longer range than 2.4 GHz.
- 915 MHz, however, makes use of more bandwidth available and uses LoRa's spread spectrum technology to mitigate its penetration problem (relative to 433 MHz).
- 915 MHz enjoys significantly less power limitations than 433 MHz. 433 MHz suffers from transmission time and frequency limitations, which may make it unsuitable for asset tracking applications, especially where there are a large number of assets with frequent updates.
- 915 MHz clearly has an advantage in vendor support for LoRa-based systems since there is such a large and diverse ecosystem.

1 M Philippakis, C martel, D Kemp, and S Massey. "Application of FSS Structures to Selectively Control the Propagation of signals into and out of buildings." ERA Technology. 2004-0082 A4.