Introduction

- LoRa is a proprietary physical layer (PHY) standard for low power wide area networks.

LoRa PHY block diagram and frame structure

Carrier Frequency Offset (CFO) Analysis

Problem Formulation

- $\Delta f_c = d \left( \frac{2^k}{f_s'} - T_s \right)$: The progressing time offset of the $d$-th symbol due to sampling rate mismatch ($f_s' \neq BW$)
- Re-sampling of the signal required for a correct demodulation

Estimation and Compensation

- Assumption: The receiver is able to generate a reference signal that matches the transmitter BW. Then the SFO simplifies to a sample drift.
- Solution: discard (add) a sample when sample drift corresponds to more than half a sample is drifted $\Delta f_c > \frac{n+1/2+2^{k}}{f_s'} < \frac{n+1/2}{BW}$ (symbol realignment).

- Results: system bit error rate before/after CFO compensation

SFO effect on LoRa demodulation can be compensated by symbol boundary realignment.

LoRa Digital Receiver Analysis and Implementation

Sampling Frequency Offset (SFO) Analysis

SDR Implementation

LoRa Transceiver Implementation on USRPs

Conclusion

- LoRa receiver is partially robust against CFO.
- SFO effect on LoRa demodulation can be compensated by symbol boundary realignment.
- LoRa transceiver is implemented on a USRP platform.