Today

- Low power wide area networks
- LoRA and frequency hopping
- SIGFOX / LoRA / NB-IoT
- Choir Ideas

# Why Low Power

AAA → 1.5 - 2 Wh

Wi-Fi → 100mW | 20 hours

Cellular → 1W | 2 hours

Low power ⇒ Goal: 1 year

Goal → 10 years.

→ energy harvesting

→ duty cycling → turn off when not in use

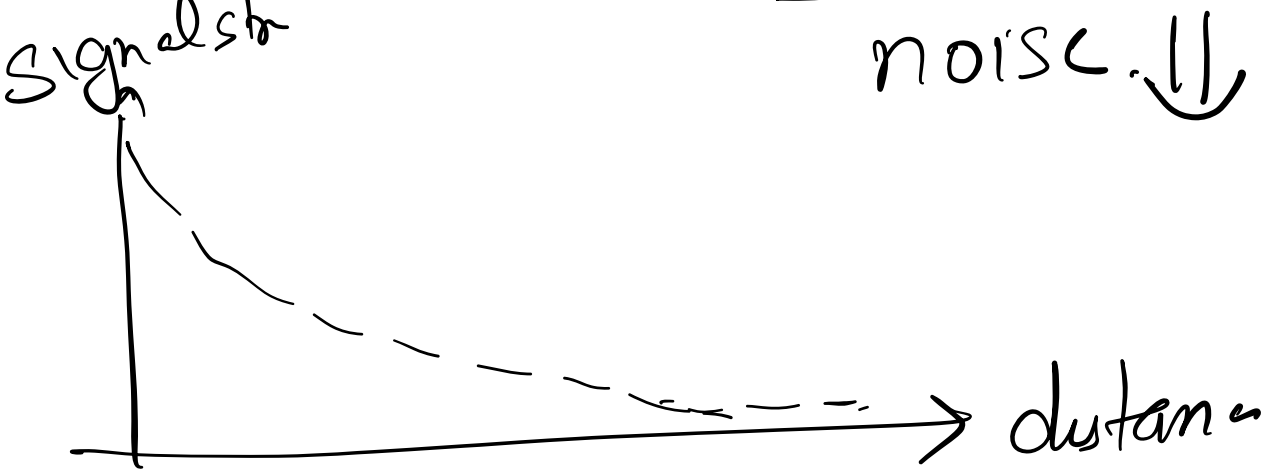
LPW → not transmit, just receive.

Long Range

+ Low power.

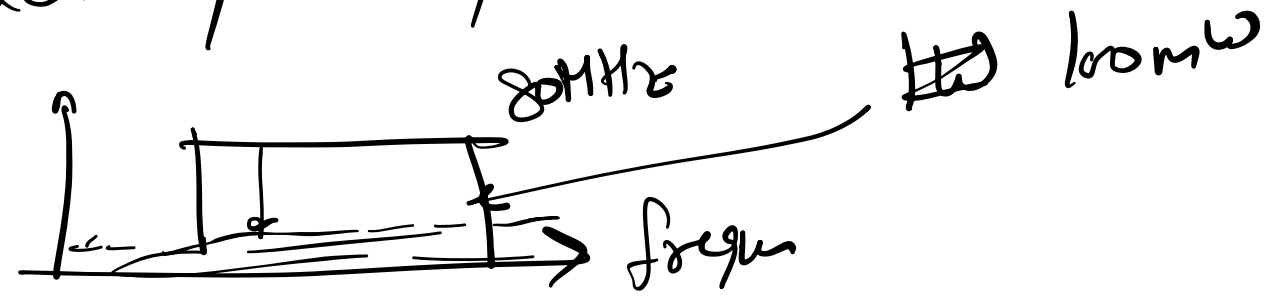
# Narrowband vs. Wideband

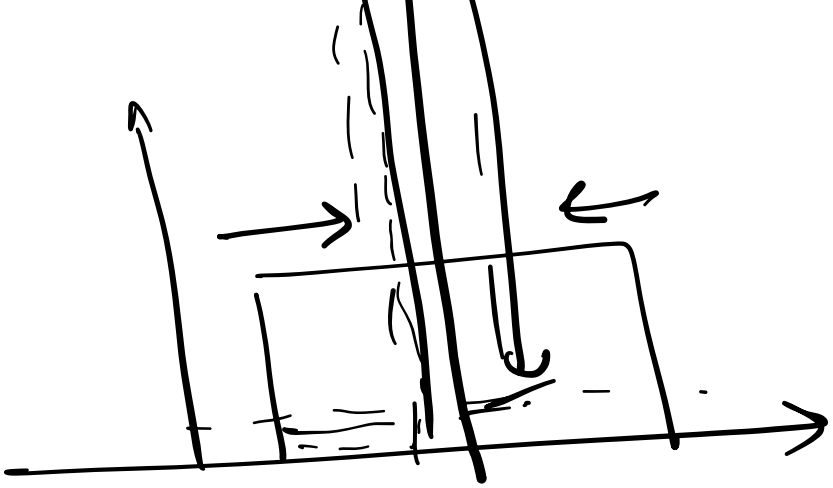
SNR ⇑ = Signal ⇑ / noise ⇓




Wideband to narrow band transmission

20MHz / 40MHz / 80MHz



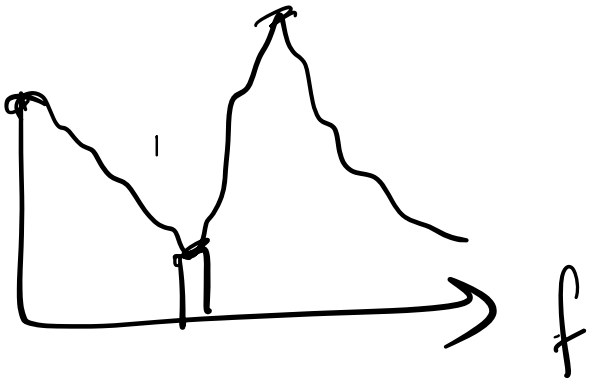



Wideband → narrowband

improves your link budget.

LoRA → 125kHz / 250kHz ← 2MHz

80x




10kHz → lower datarat

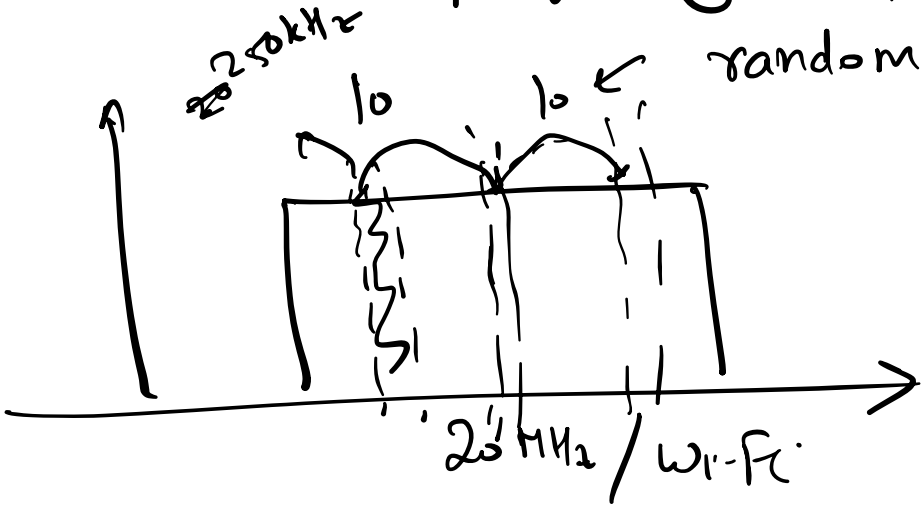
→ max SNR ~~robustness~~.

→ max prone to interference.

→ multipath.

# BLE

## frequency hopping



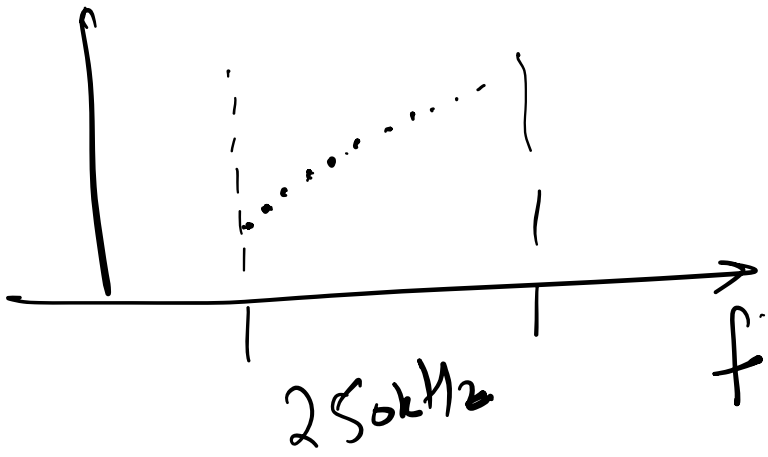

low data rate

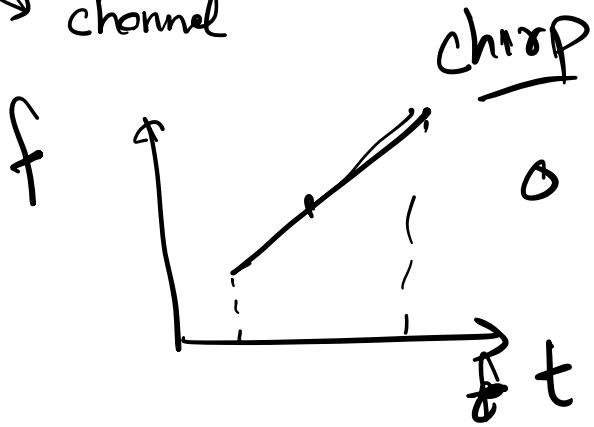
high resilience

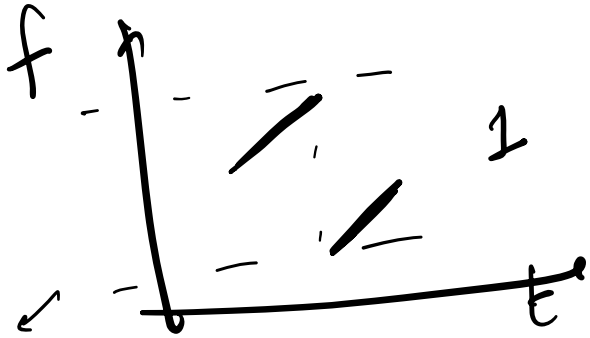
small range.

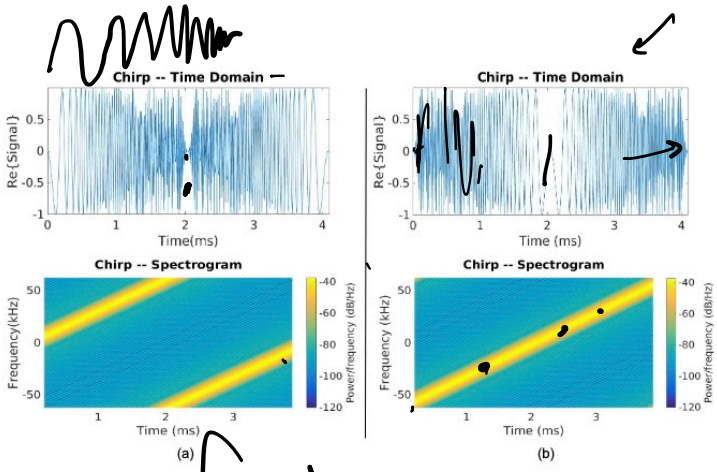
# LoRA Modulation

- chirp
- spreading factor
- channel

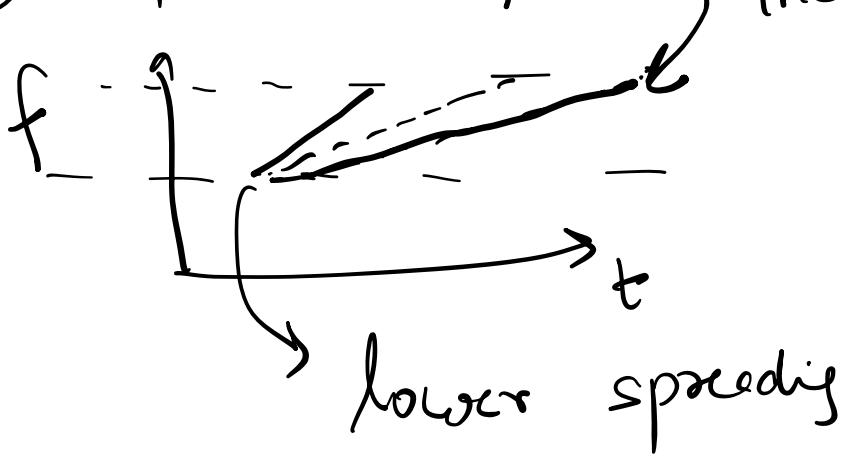


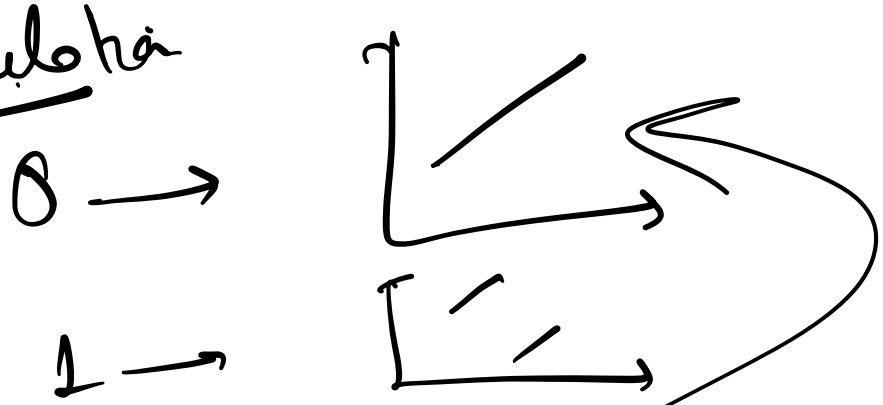




## ① Spreading factor.

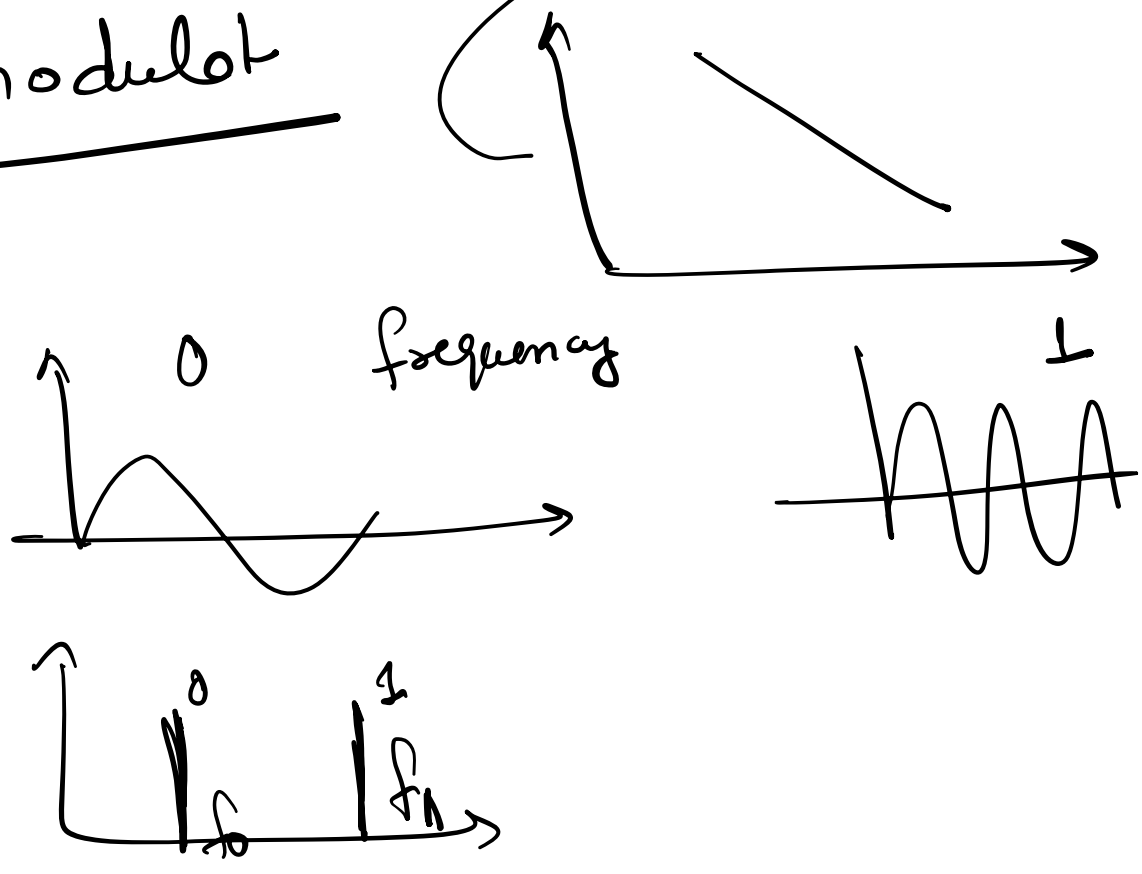



increases robustness or increases range.

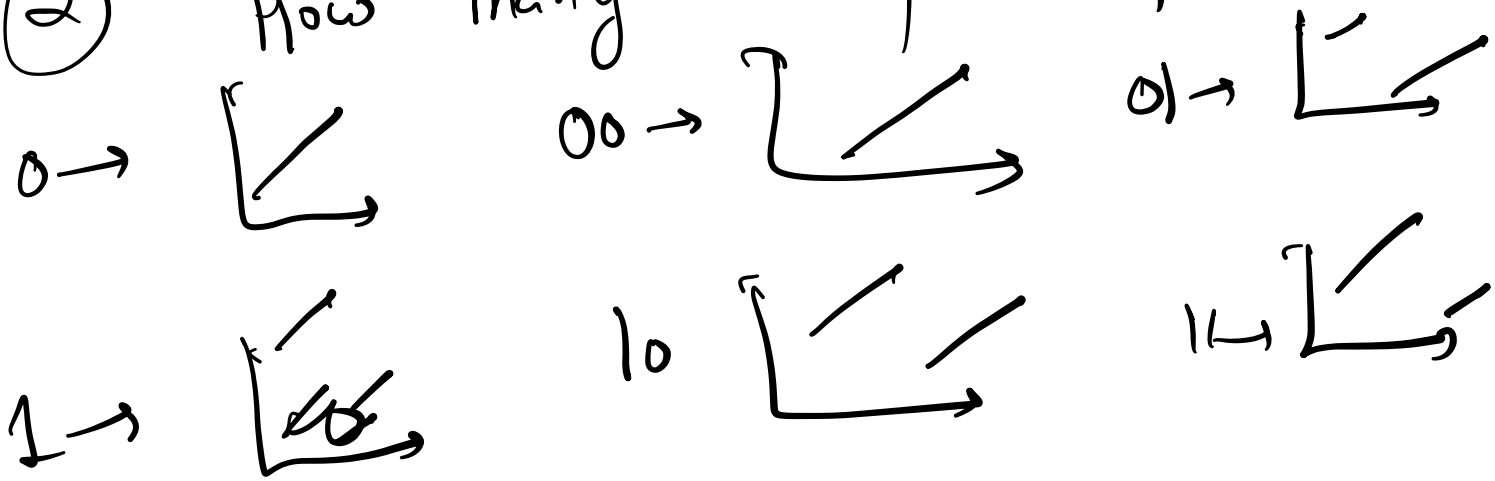
Modulation



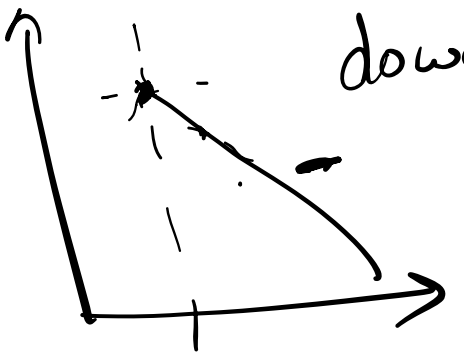

Demodulation

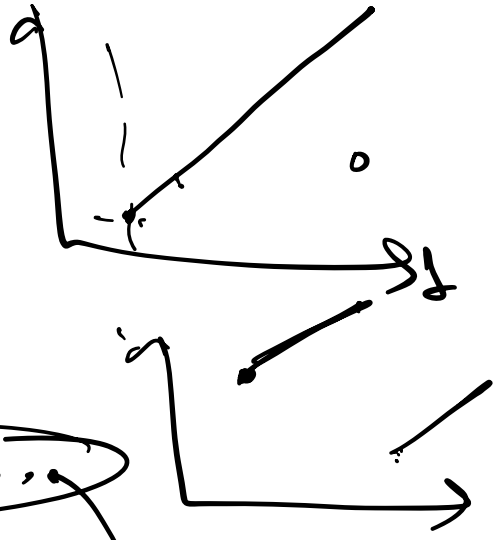


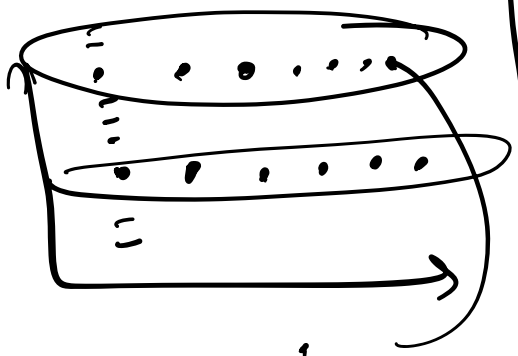

(2) How many bits per chirp

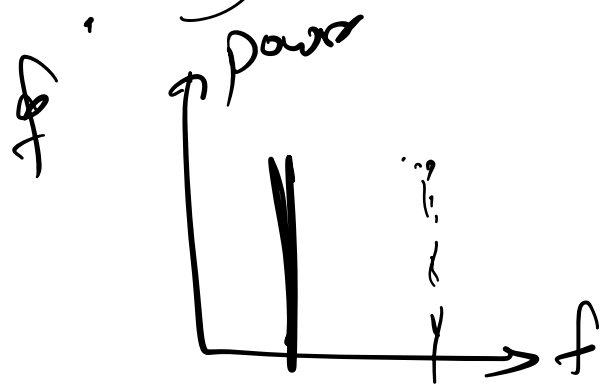


# Decoding



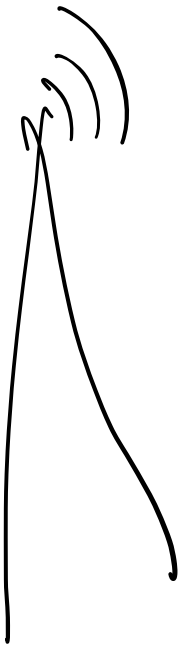







SIGFOX | LoRA | NB-IoT

→ Europe



narrowband.

sensor

10 bytes per day.

SIGFox

NB-IoT

cell towers as gateways

LoRA ⟺ Wi-Fi models

D D D D

← power

← backhaul connectivity

Helium → 2-5Km of range

ISM 1Km

900 MHz

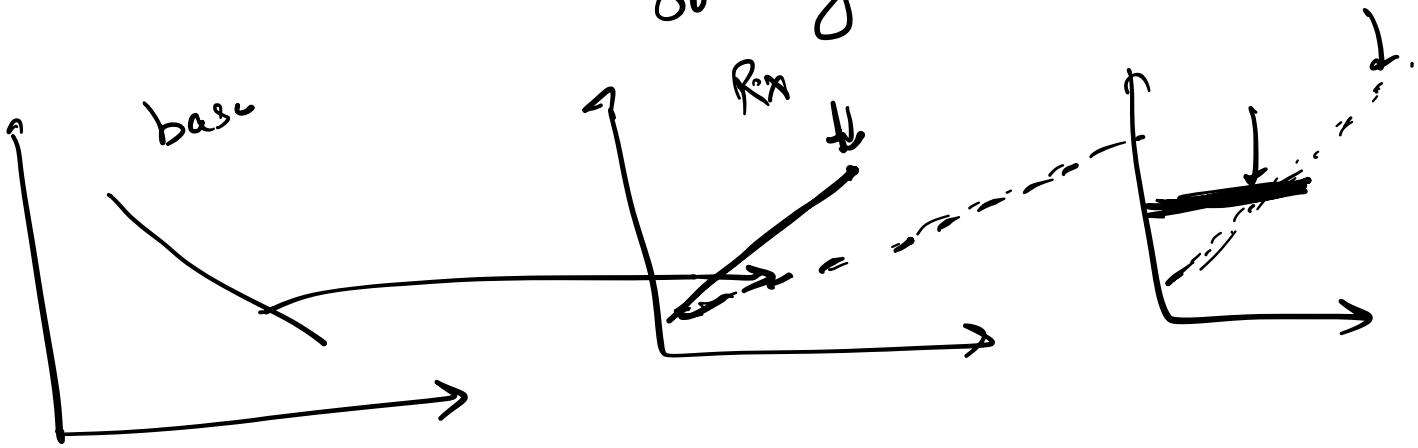
2.4 | 5 GHz

# LoRA Medium Access

Different spreading factors.

↓

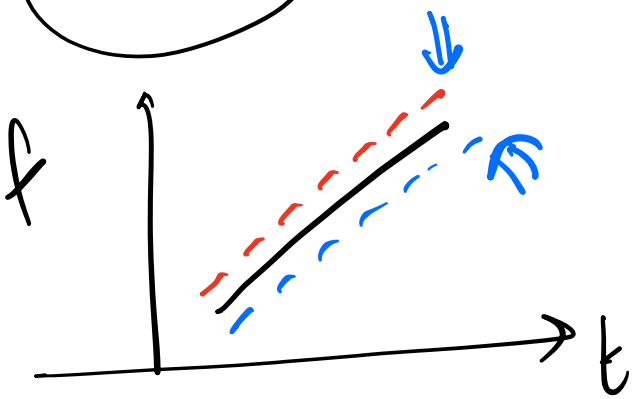
orthogonal.

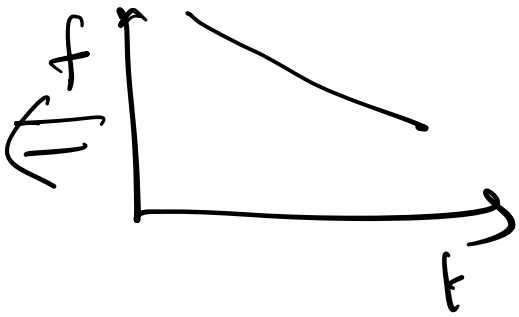


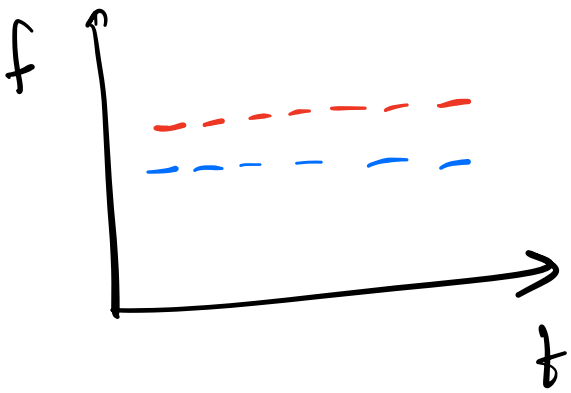
Choir

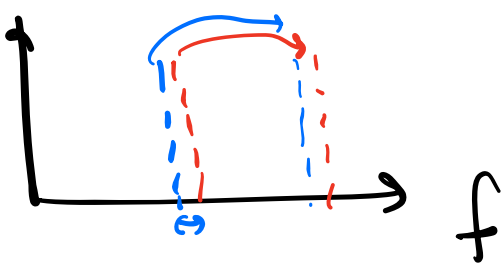
- Decoding collisions
- Identifying bits
- Super-resolution

CFO ← hardware imperfections



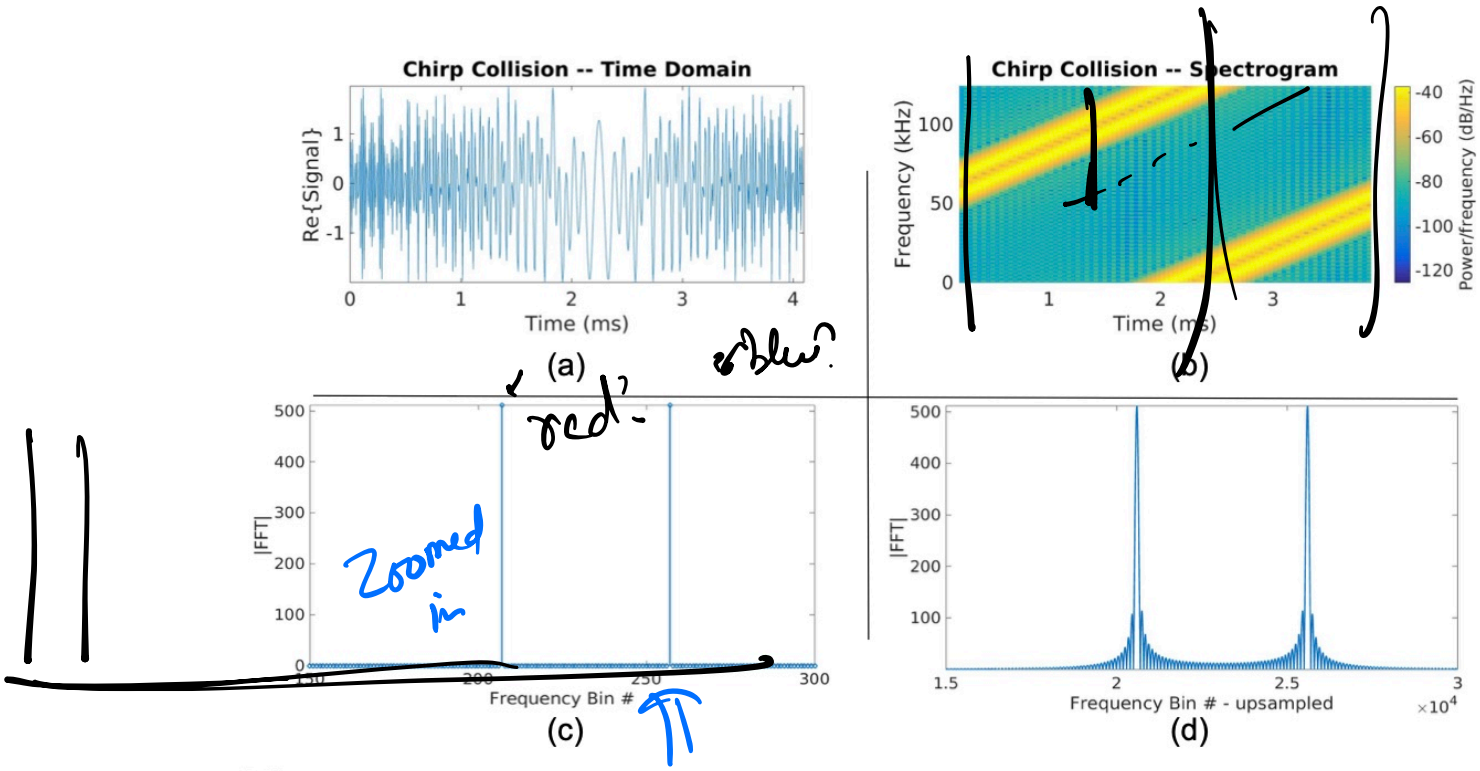
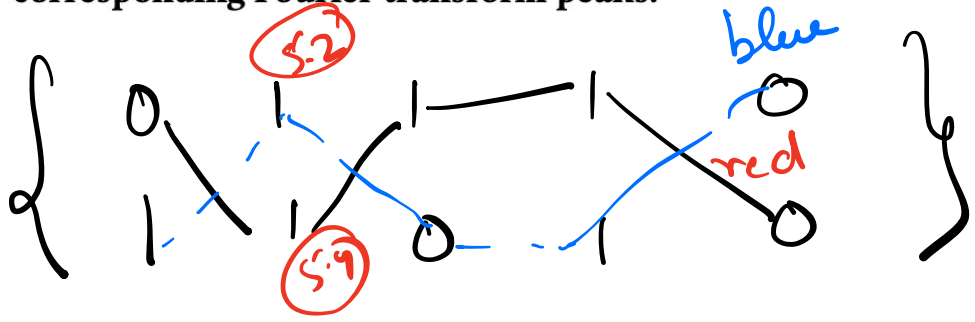
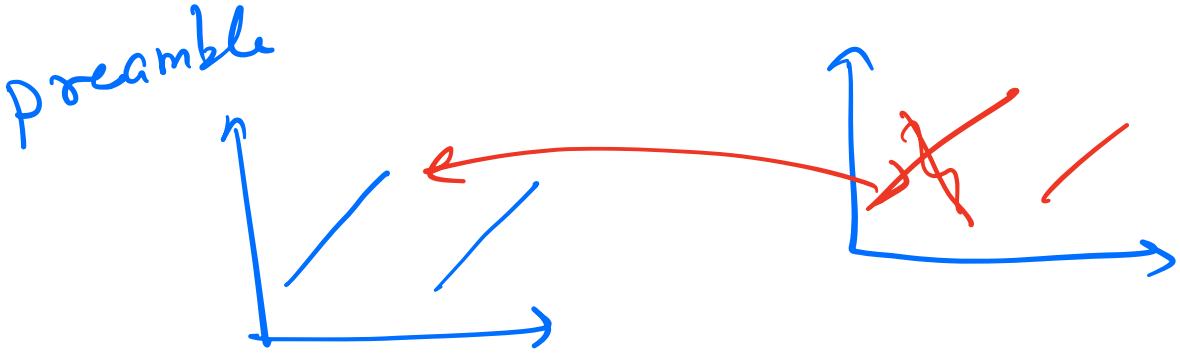
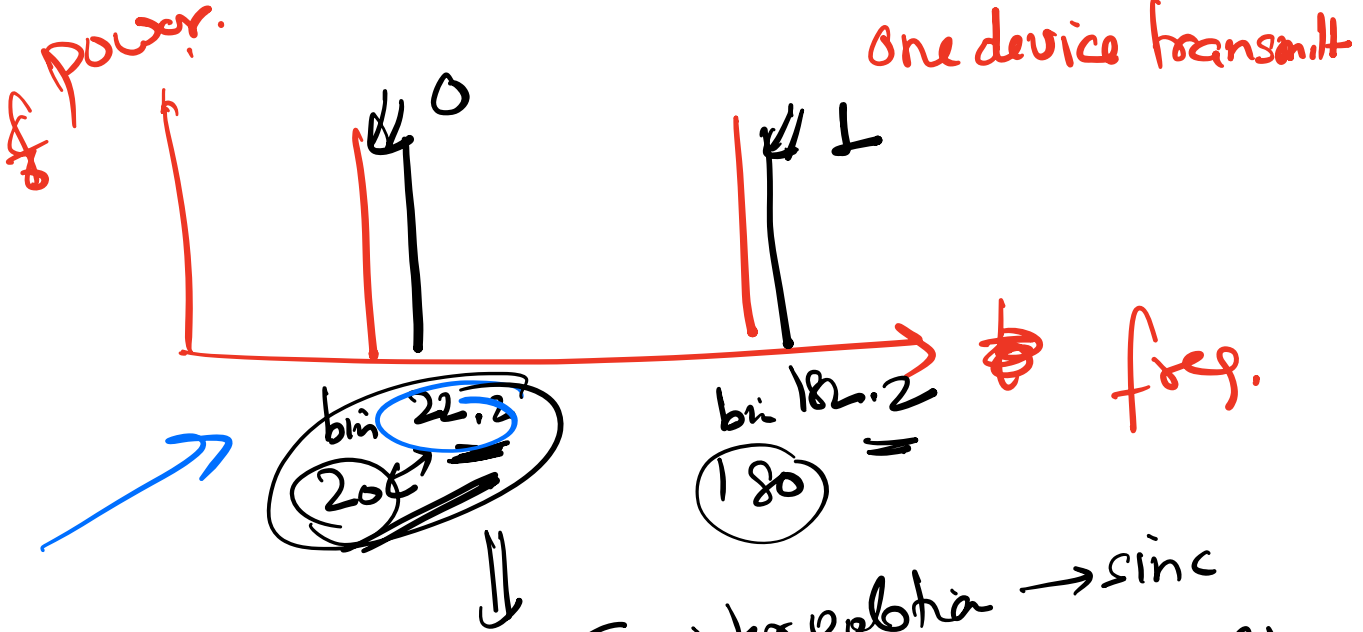



**Figure 3: Decoding collisions: Spectrogram of two collided chirps, and the corresponding Fourier transform peaks.**

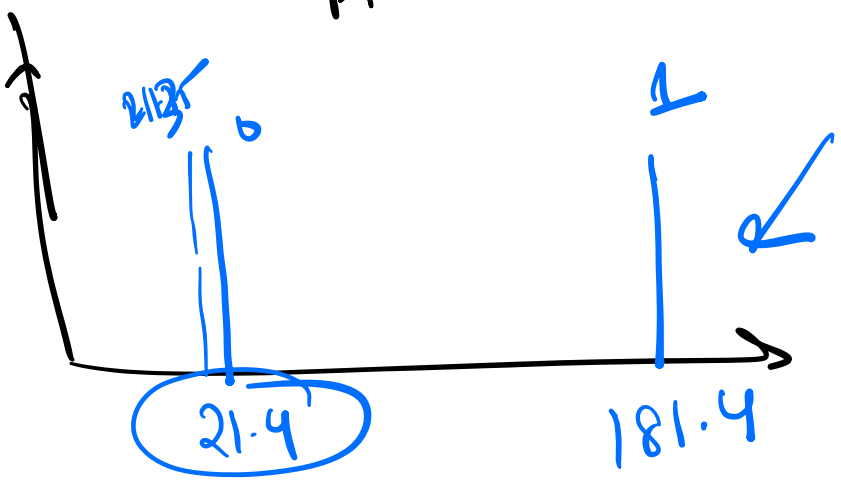




one device transmit




FFT interpolation → sinc interpolate




Critique