WIRELESS COMMUNICATION

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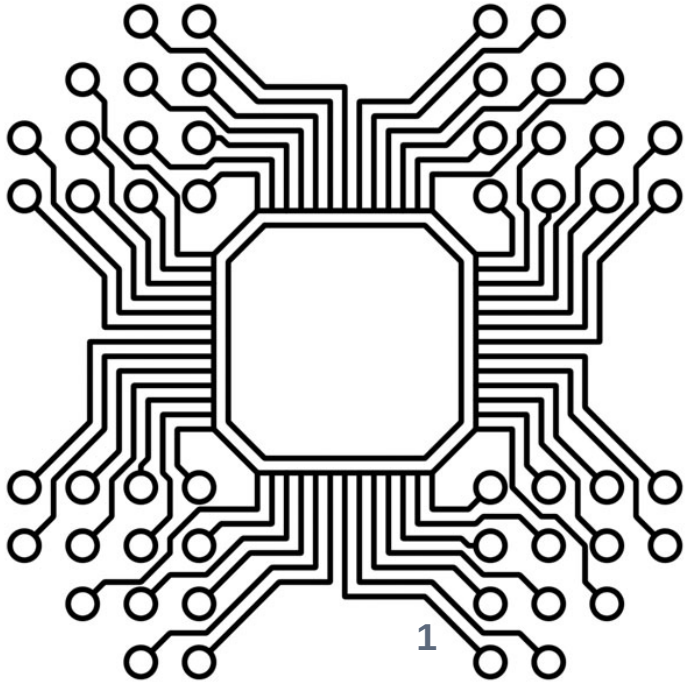
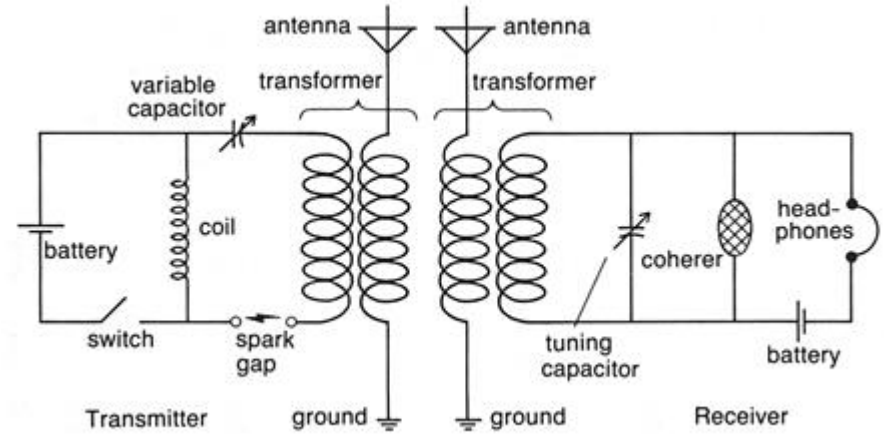


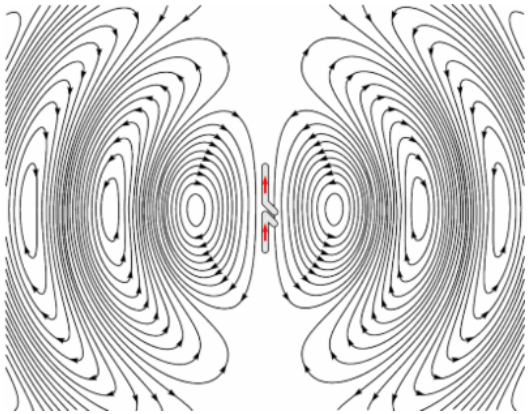
First Wireless communication

Guglielmo Marconi (1874-1937)



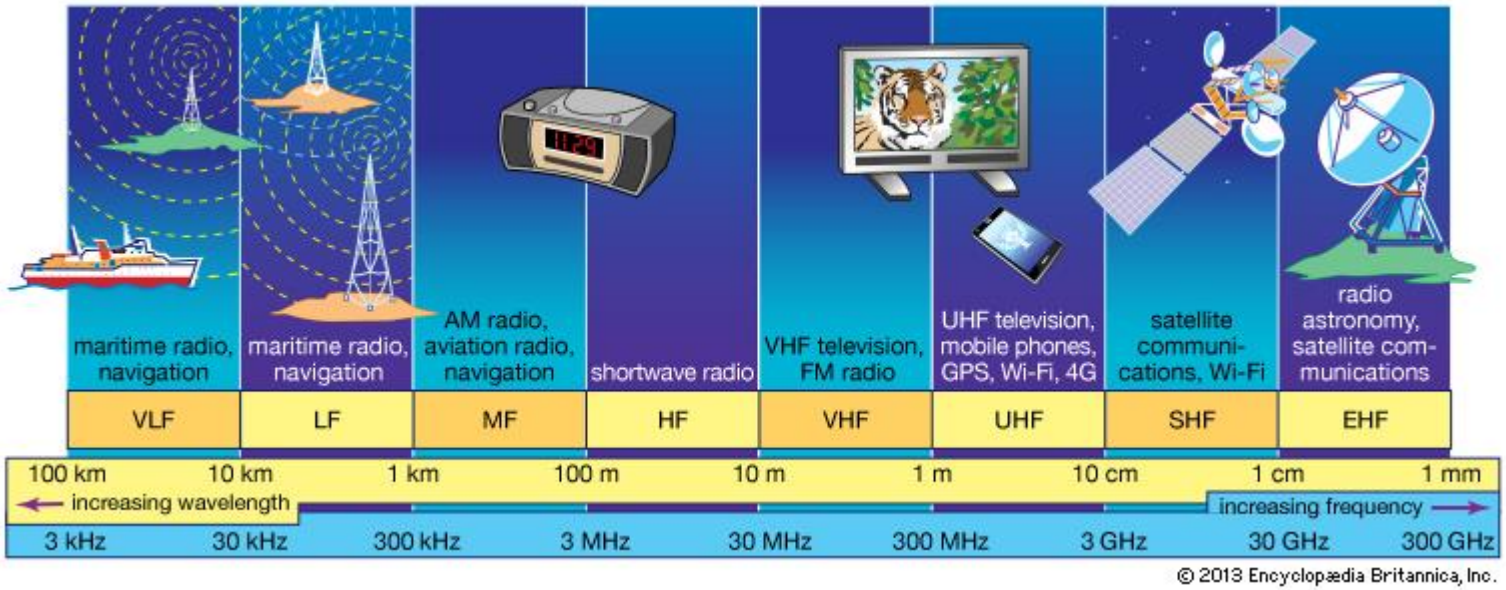
Marconi's 1901 wireless system

http://people.seas.harvard.edu/~jones/cscie129/nu_lectures/lecture6/marconi/marconi.html



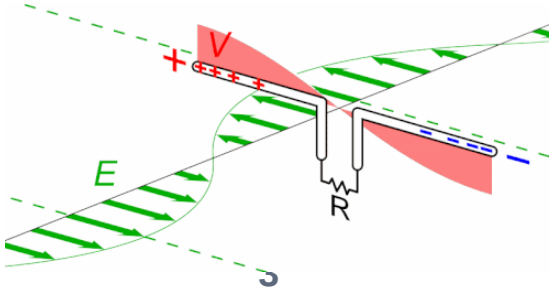
RF - Radio frequency

- RF: frequency from few KHz to 300GHz



- Relationship between frequency f and wavelength λ

$$C = f \times \lambda$$ C is the speed of light



Diffraction: [Radio Wave Diffraction vs Wavelength]

How does antenna work: [How does an Antenna work?]

ISM band – 2.4GHz

- ISM: Industrial, Scientific and Medical
- ISM band: **2.4GHz – 2.483 GHz**
- getting more crowded day by day

Why use this band?

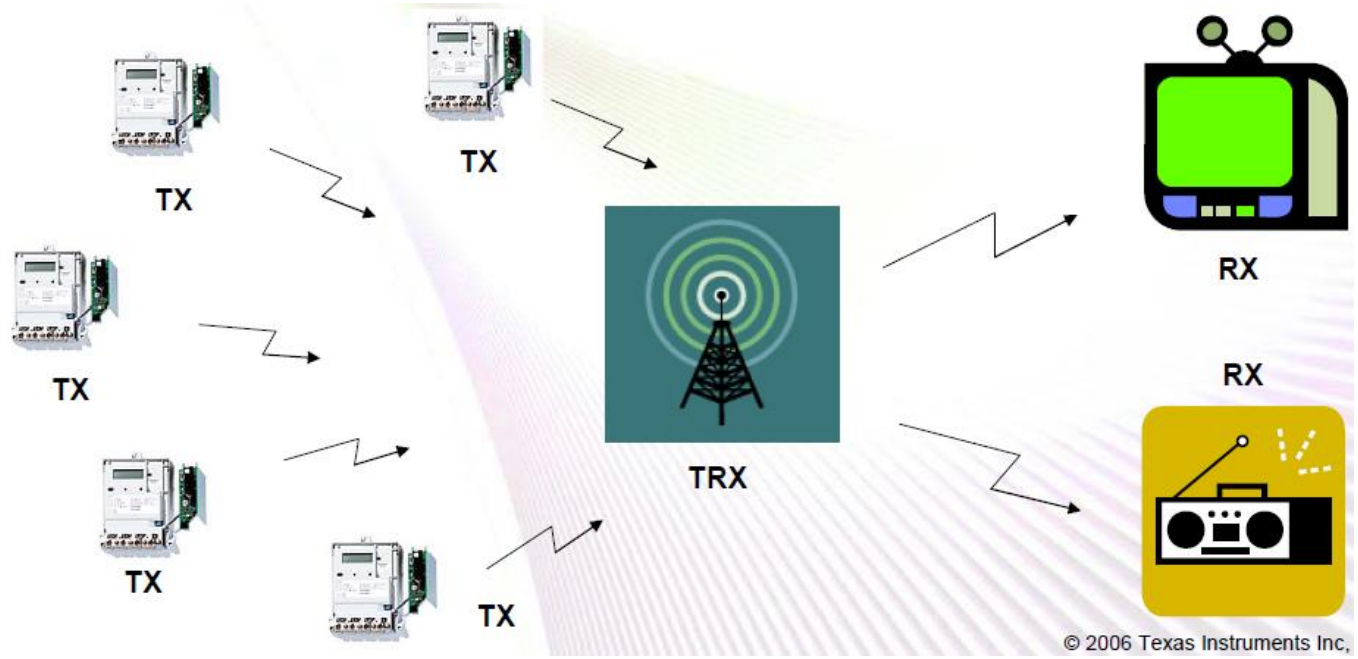
- Free
- Avoid Radio, TV, mobile phone band
- Long range
- Small antenna
- Cost
- Microwave frequency 2.5GHz

RF Communication System

Simplex RF system

- A radio technology that allows only **one-way communication** from a transmitter to a receiver
- Examples: FM radio, Pagers, TV, One-way AMR systems

Analog or Digital?



RF Communication Systems

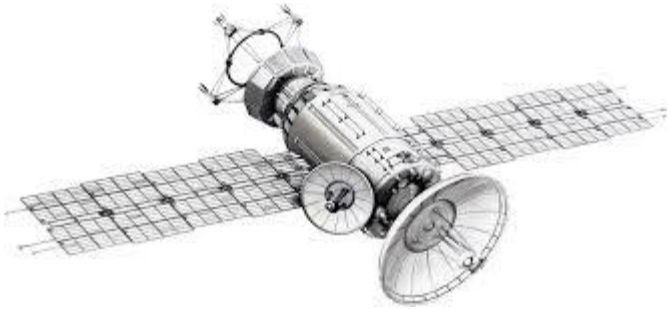
Half-duplex RF Systems

- Operation mode of a radio communication system in which each end can transmit and receive, but **not simultaneously**.
- Note: The communication is bidirectional over the same frequency, but unidirectional for the duration of a message. The devices need to be transceivers.

RF Communication Systems

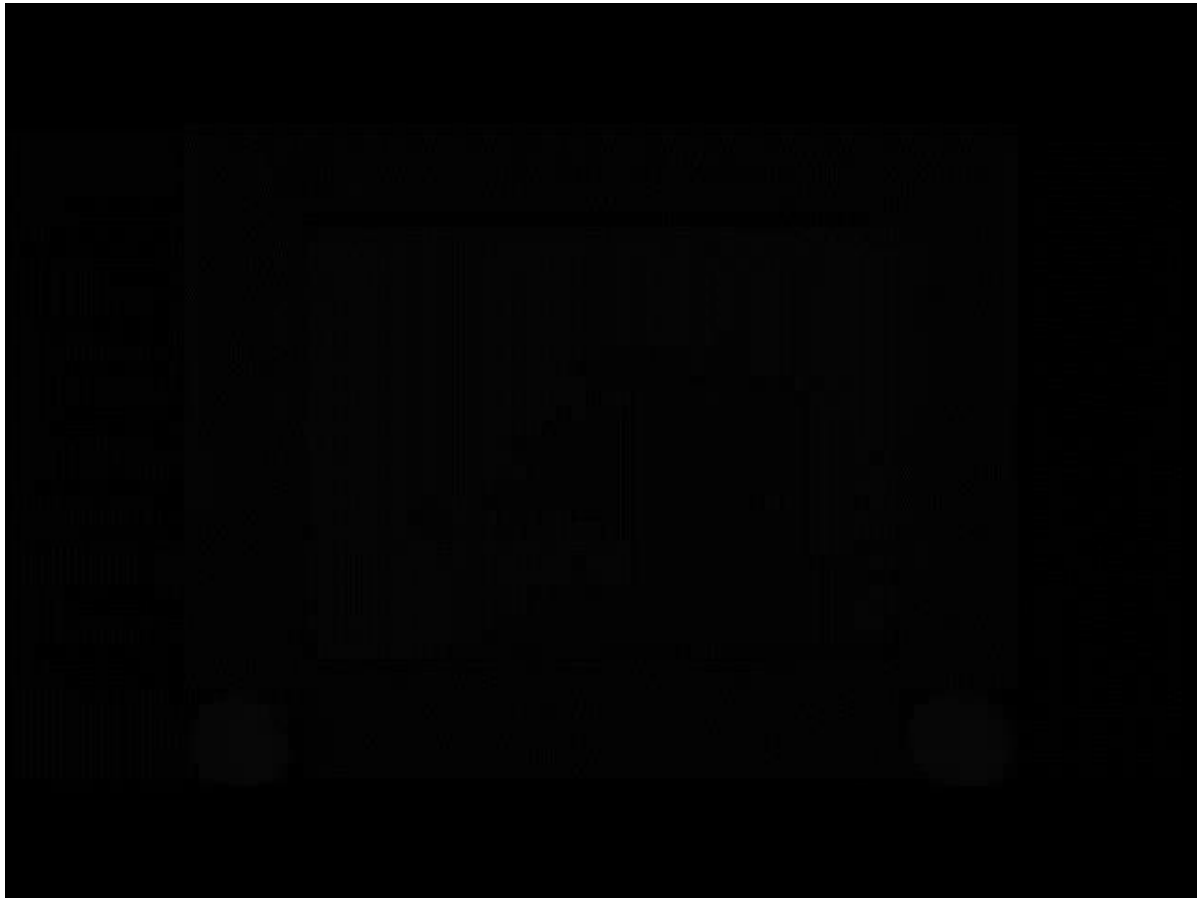
Full-duplex RF Systems

- Radio systems in which each end can **transmit and receive simultaneously**
- Typically **two frequencies** are used to set up the communication channel. Each frequency is used solely for either transmitting or receiving.
- Examples: Cellular phones, satellite communication



How Information Travels Wirelessly

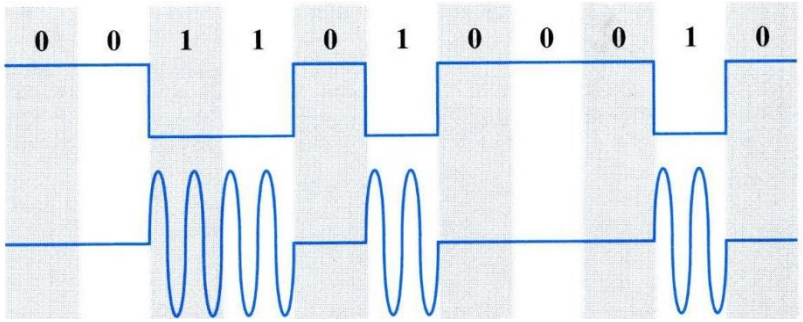
- MIT short introduction



https://www.youtube.com/watch?v=Ax7dYaRiY6o

Digital Modulation

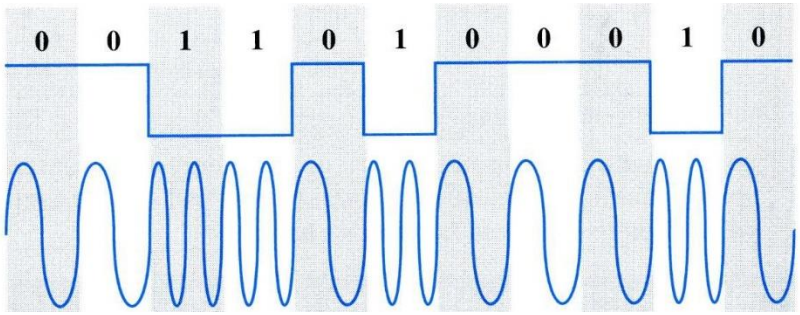
Amplitude Shift Keying (ASK)



Pros: simple

Cons: susceptible to noise

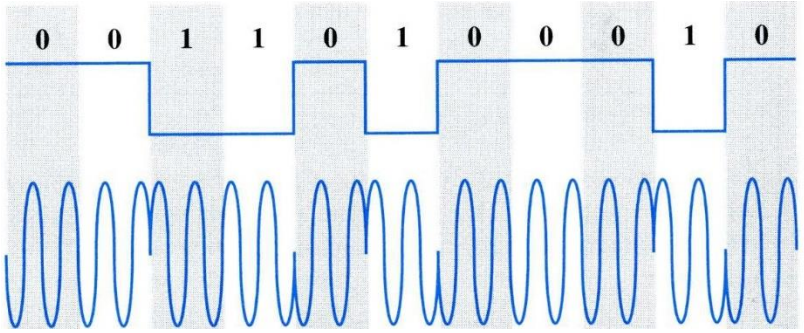
Frequency Shift Keying (FSK)



Pros: less susceptible to noise

Cons: requires larger bandwidth/bit than ASK

Phase Shift Keying (PSK)

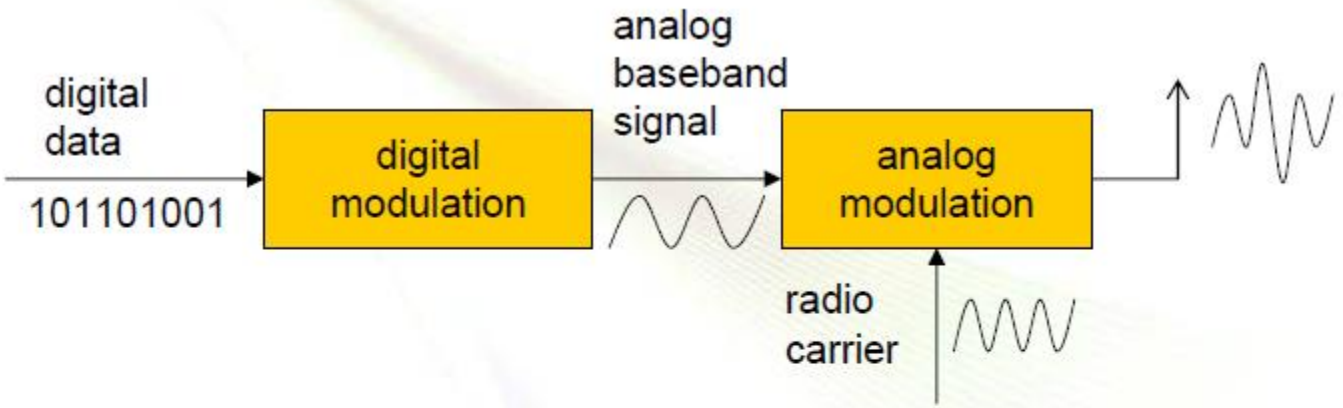


Pros: Less susceptible to noise, Bandwidth efficient

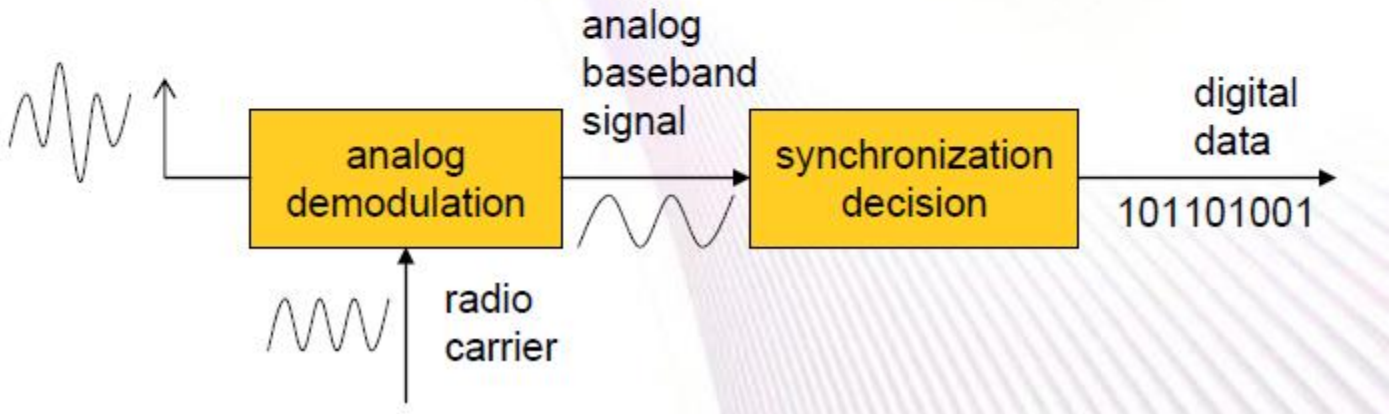
Cons: Require synchronization in frequency and phase

http://ironbark.xtelco.com.au/subjects/DC/lectures/7/

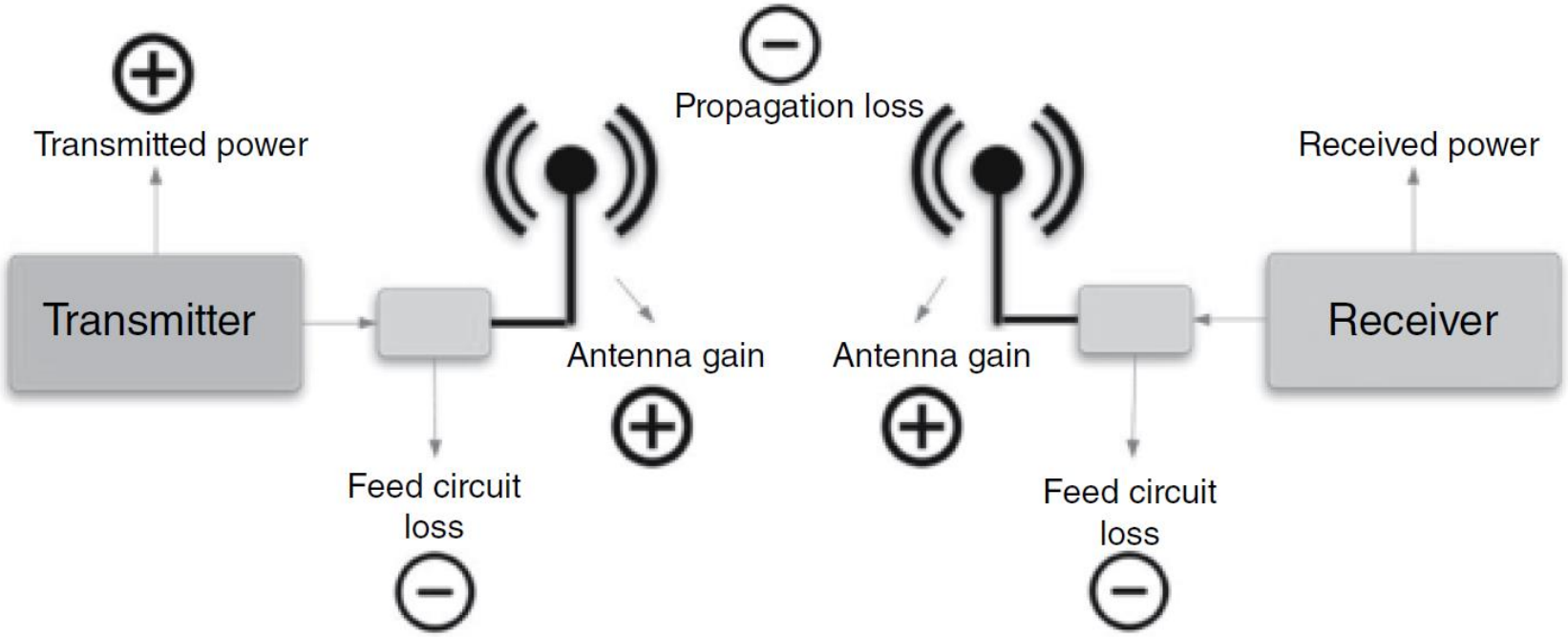
Wireless Communication Systems



Radio Transmitter



Radio Receiver



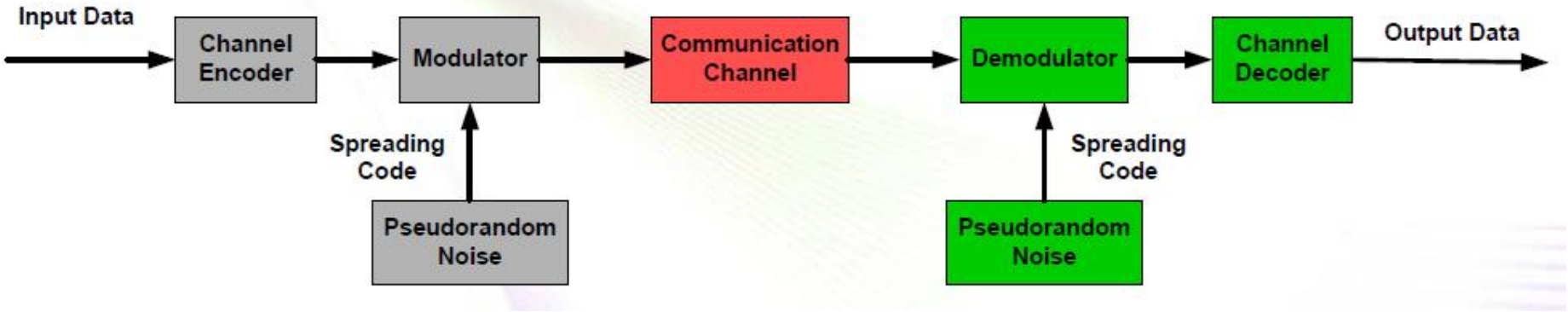
Example A 2.4 GHz antenna of an access point has a gain of 10 dBi, a transmitting power of 20 dBm (equivalent to 100 mW), and a receiving sensitivity of −89 dBm. Five kilometers away, there's a stationary IoT device equipped with a 2.4 GHz antenna of 14 dBi gain, a transmitting power of 30 mW (15 dBm), and a receiving sensitivity of −82 dBm. The cables and connectors have a loss of 2 dB at each end. Is the communication link feasible?

Avoiding Interference in ISM Band

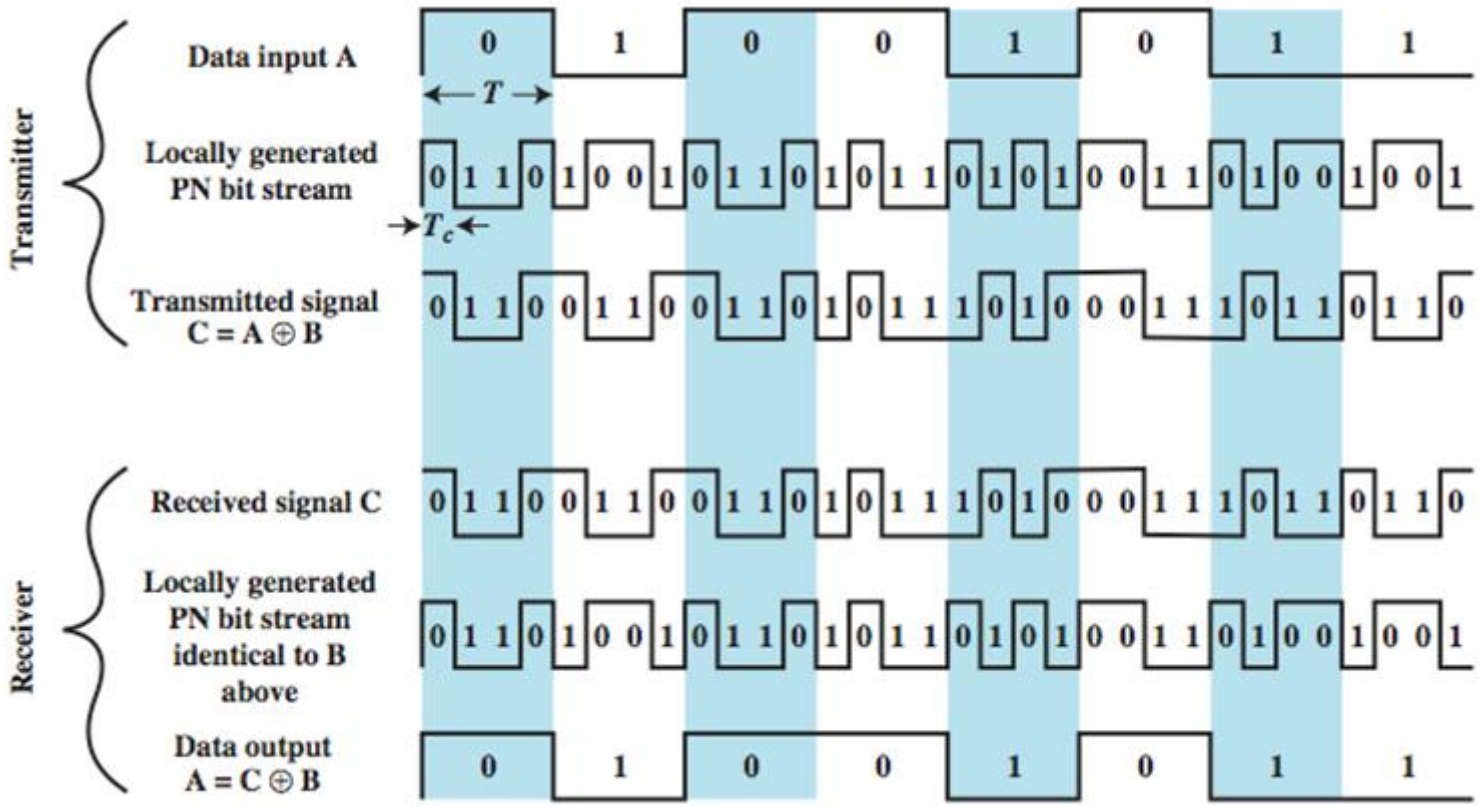
Spread Spectrum Technique

- Data sent using spread spectrum is intentionally **spread over a wide frequency range**
  - Resistant to noise and interference thus increasing the probability that the signal will be received correctly
  - Unlikely to interfere with other signals even if they are transmitted on the same frequency
- Types of Spread Spectrum common in ISM bands:
  - Direct Sequence Spread Spectrum (DSSS)
  - Frequency Hopping Spread Spectrum (FHSS)
  - Orthogonal Frequency Division Multiplexing (OFDM)
  - Chirp Spread Spectrum (CSS)

Model of a Spread Spectrum system

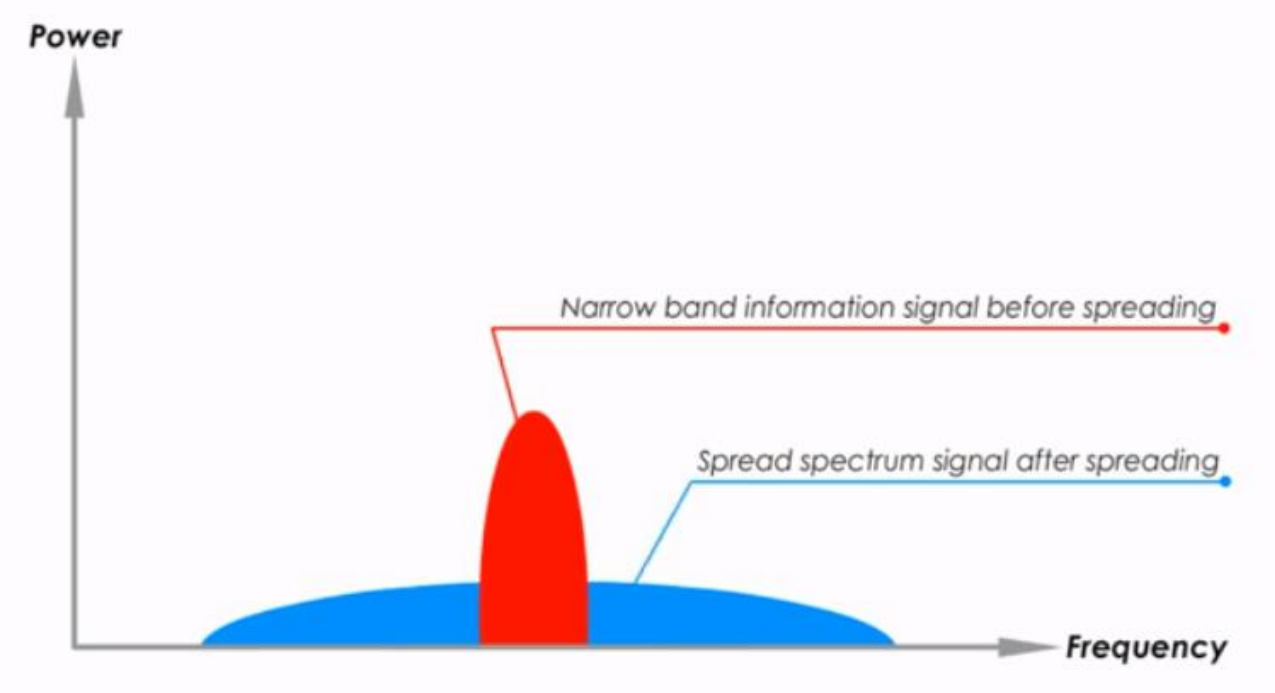


Direct Sequence Spread Spectrum

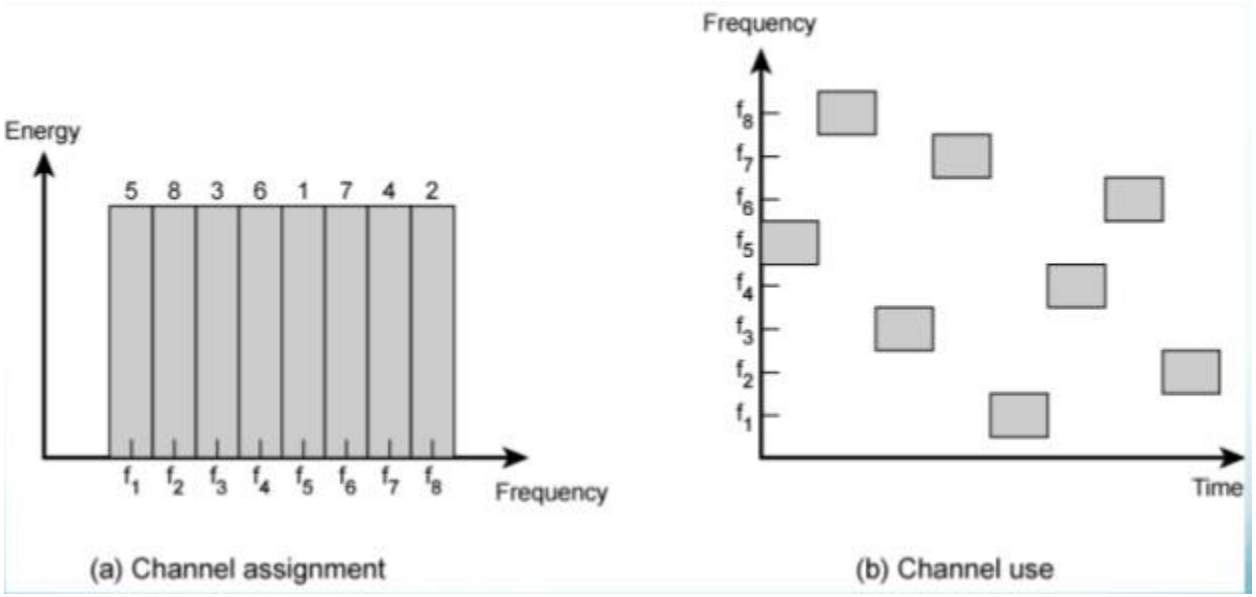


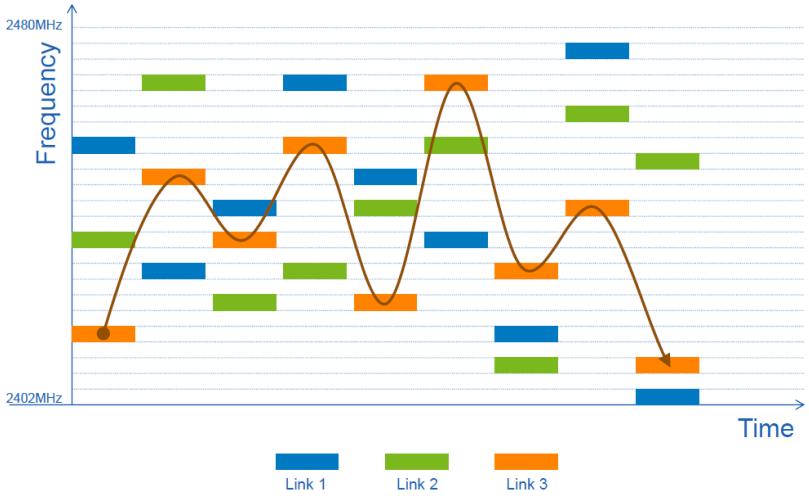
Direct Sequence Spread Spectrum

- Advantages of DSSS:
  - More bandwidth
  - Data are encoded
  - Low power density, noise-like signal

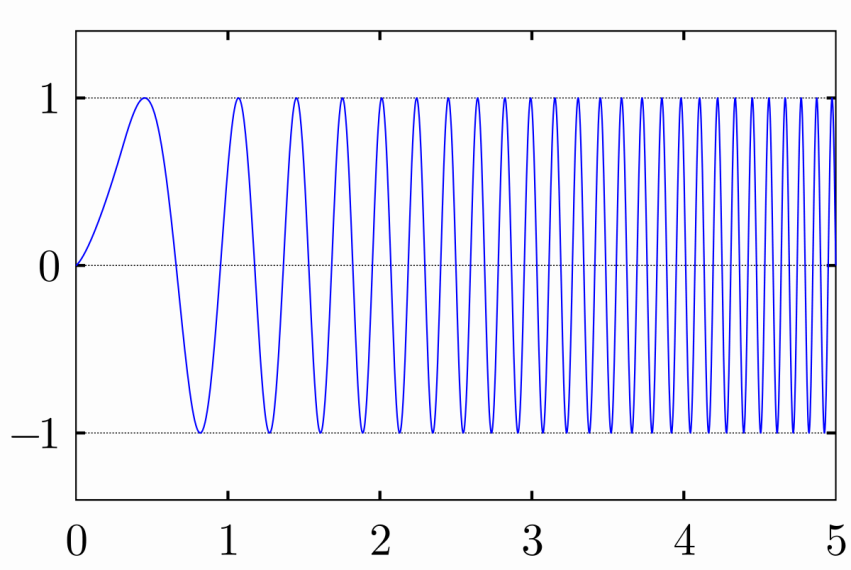


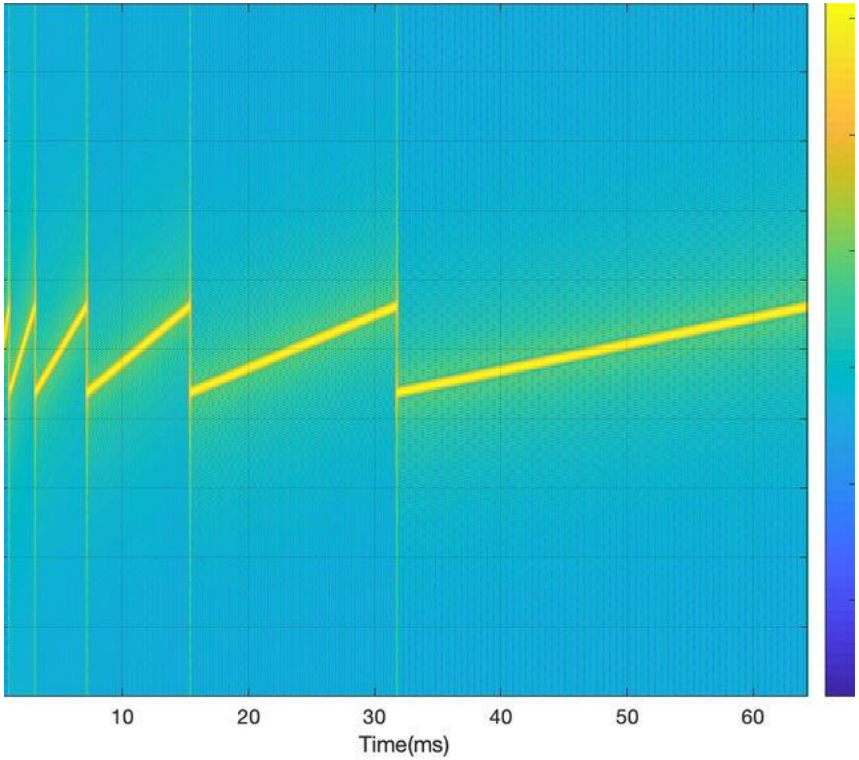
Frequency Hopping Spread Spectrum





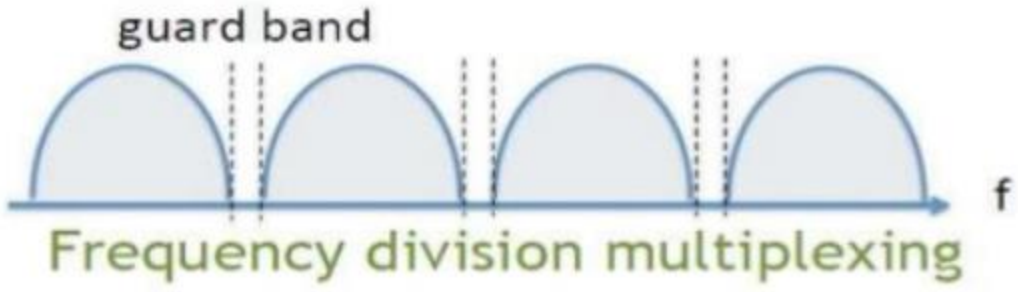
Chirp Spread Spectrum

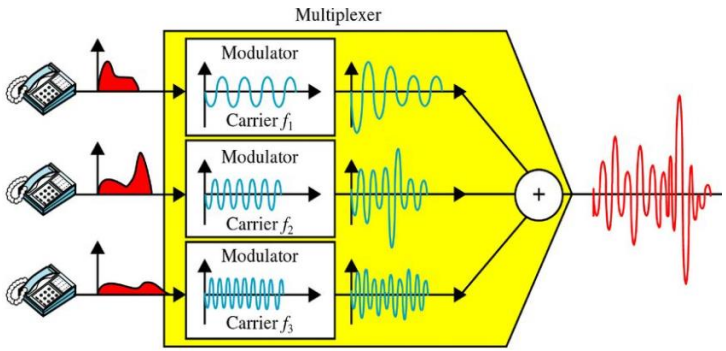


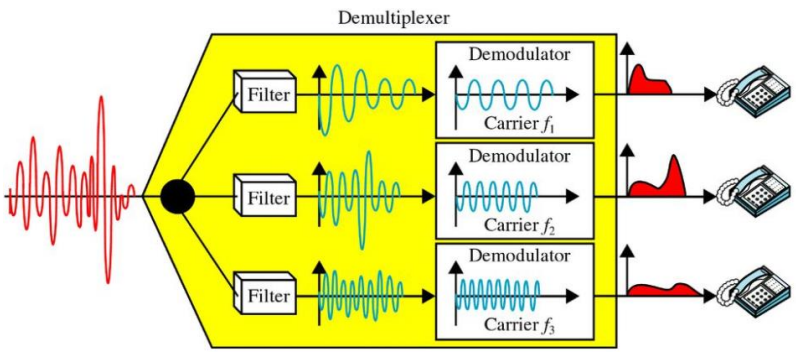


Orthogonal Frequency Division Multiplexing (OFDM)

- Multiplexing is a technique that allows the simultaneous transmission of multiple signals.
- FDM:







Orthogonal Frequency Division Multiplexing (OFDM)

- OFDM