

05/08/23

Fundamentals of Wireless

Communications = OPAI Workshop

Digital Communications
Fundamentals and
Applications -
Besard Skopje

Grouping based on: Transmission mode, distance.

Radar vs other Comm. Systems

- Transmitter/Receiver vs Send/Detect
(Tx/Rx)

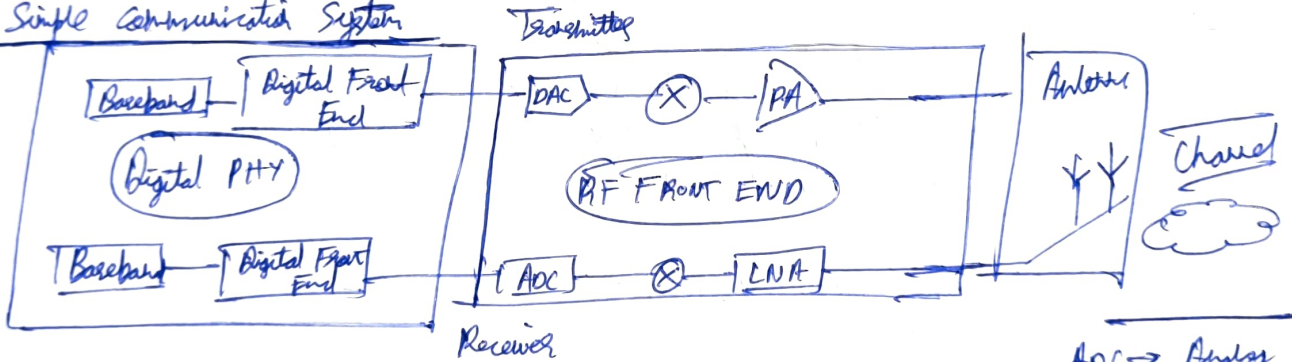


- Known vs Unknown signals.
- Characterize the "path" vs determine the "target system".

Why is wireless communication relevant today?

- Mobility is the basic expectation.
- Economical - Not practical to have wires everywhere.
- Elegant
- Remote access/services - Control, check, maintenance remotely.
- Seamless service - Change in location/device/network.
- Network efficiency - Dynamic monitoring for power, cost, break-down.

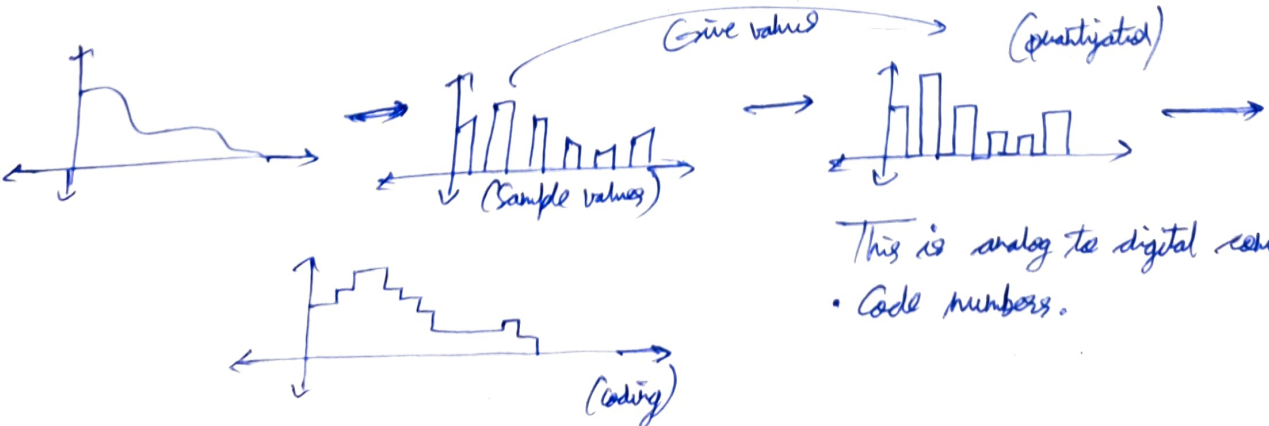
A Simple Communication System



ADC → Analog to Digital Conversion.
DAC → Digital to Analog Conversion.

Digital Communication System (DCS)

- ① Sampling: Converting analog to digital or digital to analog.
- Sampling.
 - quantization.
 - coding.



This is analog to digital conversion.
• Code numbers.

(ii) Pulse Modulation: Formatting results in bits which has no physical representation (mathematical only). Eg: RZ, NRZ (Return to zero, NRZ return to zero). This step is common for wired and wireless comm systems. It is called pulse modulation because voltage/amplitude is assigned some value?

(iii) MODEM/Detect:

Digital Signal Processing

- Modulation / Demodulation.
- Why modulate?
 - Pack bits and give meaning.
- What type of modulation?
 - Quadrature Modulation (Most popular nowadays).

Orthogonal basis functions is used for packing bits?

Eg: 8-PSK, M-QAM ($M=2^n$, n = input bits).

- Increased data rate (processing of more bits at same time).
- Notice the physical value.

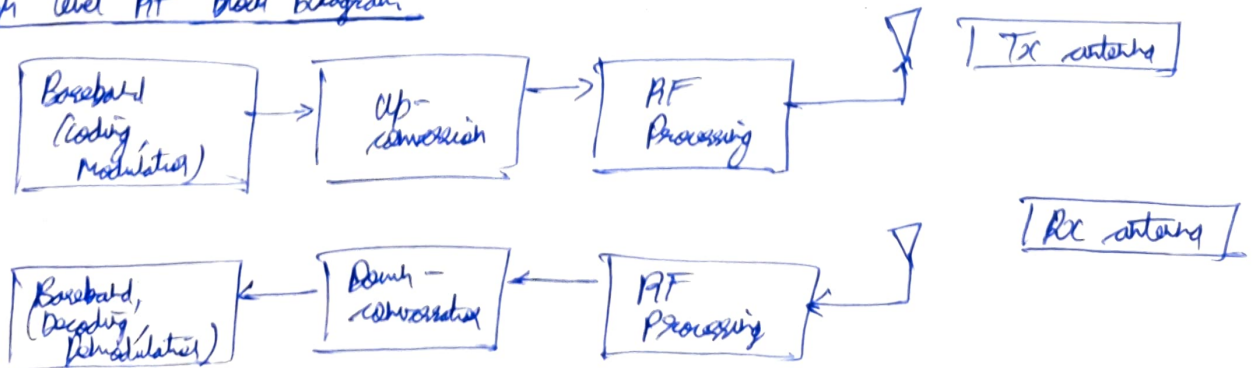
(iv) Synchronization:

- What and why Sync?
 - Network / device, Tx / Rx, blocks.
 - Lost info, erroneous message.

RF

- Radio Frequency
- Radio Frequency / Microwave used interchangeably.
- Radio refers to analog / High Frequency (HF) portion of the communication system.
- Also high-power portion of the communication system.
- Why?
 - Multi-user support / User separation.
 - Govt. regulations.
 - Higher BW / data rate application.
 - Antenna design.
- RF system is b/w baseband and antenna + air interface. (TXMT, RXV).

High Level RF Block Diagram



- Processing / analysis in freq. domain.
- Key functions - amplification (high power / low noise), filtering, switching.

ANTENNA

Defⁿ, purpose, property.

Reciprocal: one antenna can transmit and receive.

- IEEE defⁿ: A means for radiating or receiving radio waves.
- Device to ~~transfer~~ 'direct' EM signals from hardware to air as Electro Magnetic waves and vice-versa.
- BB-Tx | Rx, RF-Tx | Rx, Antenna - Tx | Rx (reciprocity theorem).
- Mostly passive device, shape is the key.

Antenna Designs

- Antenna Types
 - Wire, aperture, array, reflector, patch.
- Antenna Shapes
 - PCB based.

An antenna is a device which directs EM signal from hardware to air interface and vice-versa.

We have a lot of freedom in designing the other blocks. But channels can't be engineered.

- What is a "wireless channel"?
 - Air interface.
- Line of Sight (LOS) communication. (Radio waves with freq. $> 2\text{MHz}$).
Ex: GPS, Satellite, Infrared.
Cellular are not LOS.
- Non-Line of Sight (NLOS).
 - Reflector, diffraction and penetration.
 - Cellular / wifi tech takes advantage of NLOS waves.
 - Overcome in OFDMA (4G, 5G, wifi).

Multi path advantage.

NFC → Near Field Communications.

NOTES:

- Wi-Fi is the most suitable for high-speed data transfer between devices within a short range.
- Low error rate is a key requirement of a good communication system.
- Multiplexing communication system allows simultaneous transmission of multiple signals on the same channel.
- Half-duplex is the communication mode in which the data can be sent in both directions but not at the same time.
- Ethernet is NOT a wireless communication technology.
- Digital Communication System is less susceptible to noise and distortion.
- NFC wireless technology is commonly used for contactless payments and access controls.
- Telephone call is an example of full duplex communication.
- Satellite TV is an example of an analog communication system.
- A transmitter converts information into EM signals.
- When a signal loses strength as it travels through a medium is called attenuation.

- QAM is a digital modulation scheme.
- RFID (Radio Frequency Identification) uses NFC wireless technology.
- The channel is responsible for carrying the signal from the transmitter to the receiver.
- LOS and NLOS both are common modes of channel behavior in cellular communication.
- Sampling is a step in converting analog signals into digital form.
- GSM (Global System for Mobile Communications) is the earliest wireless technology used in cellular communication.