Lecture 3: Classification of Communication Systems

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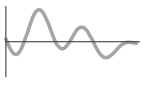
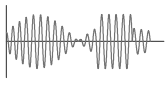
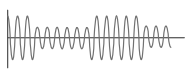
Comm Systems are classified based on the type of signal sent on the Channel

	Baseband	Carrier
Analog	***Analog Baseband Communication Systems*** 	***Analog Carrier Communication Systems*** 
Digital	***Digital Baseband Communication Systems*** 	***Digital Carrier Communication Systems*** 

Each system has its advantages!

Analog Baseband

- ***Simplest*** *system to build*
- ***Inexpensive***

Analog Carrier

- *Allows use of* ***Antennas***
- *Allows* ***Multiplexing*** *(FDM)*
- *Allows* ***exchanging*** *SNR for Bandwidth*

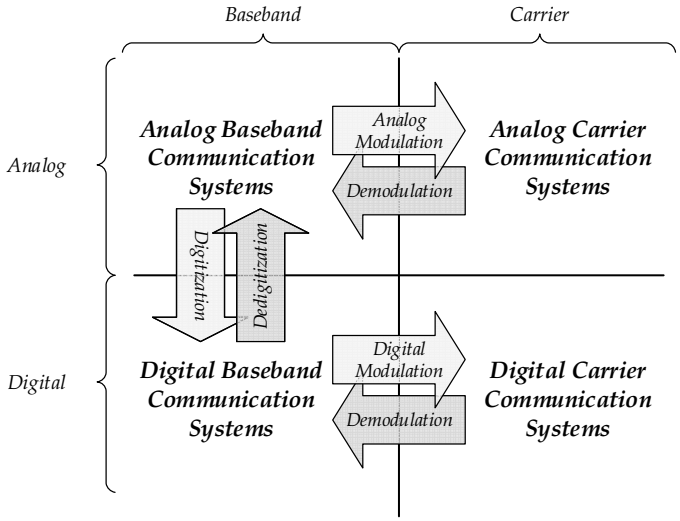
Digital Baseband

- *Immunity to* ***Noise***
- *Allows* ***Multiplexing*** *at baseband level (TDM)*
- *More bandwidth efficient*
- *Allows exchanging SNR for Bandwidth*
- *For more, see Handout*

Digital Carrier

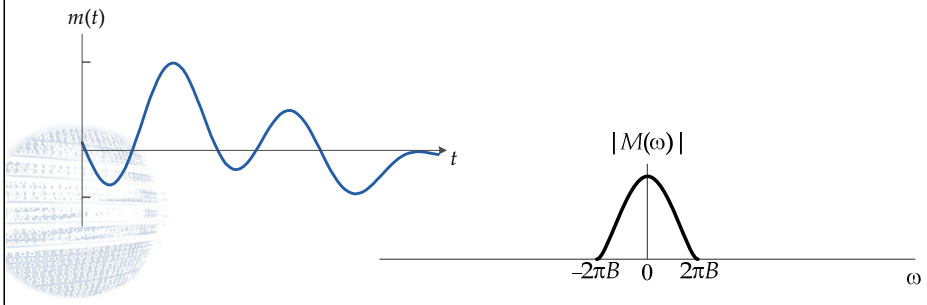
- *Allows use of* ***Antennas***
- *Allows* ***Multiplexing*** *(FDM)*
- *Allows* ***exchanging*** *SNR for Bandwidth*
- *Also the advantages of digital baseband*

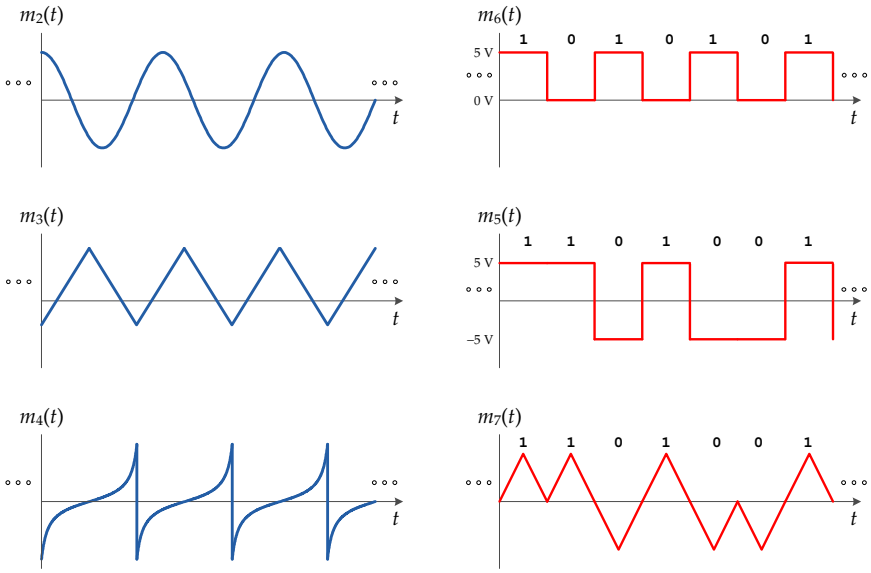
Modulation and Digitization

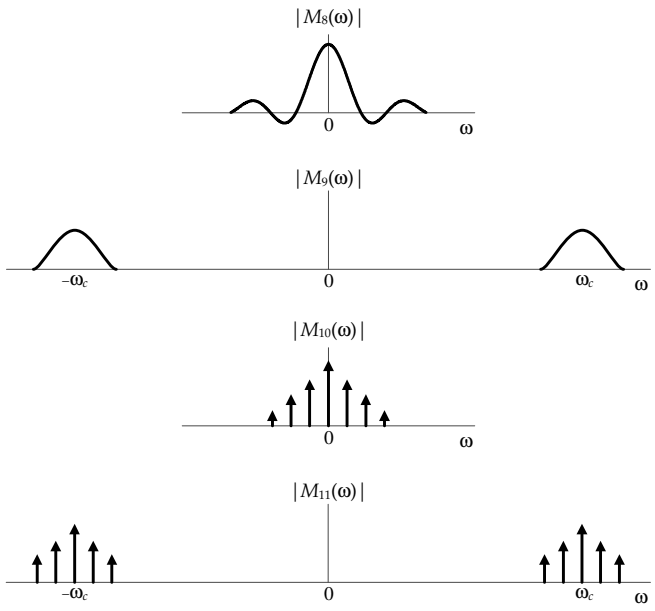


Analog Baseband Systems

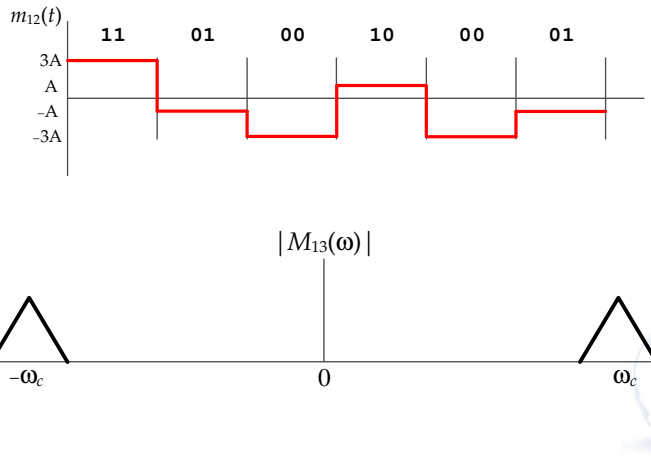
- **Analog:** $m(t)$ can assume **any** value in a continuous range of values at **any** point in time t.
- **Digital:** $m(t)$ can assume only finite voltages or shapes and uses threshold detection.
- **Baseband:** $m(t)$ has a frequency-domain spectrum clustered around zero frequency (the base).



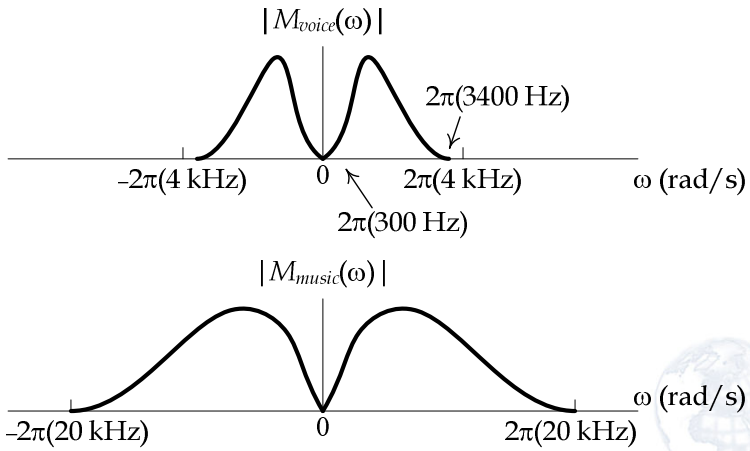




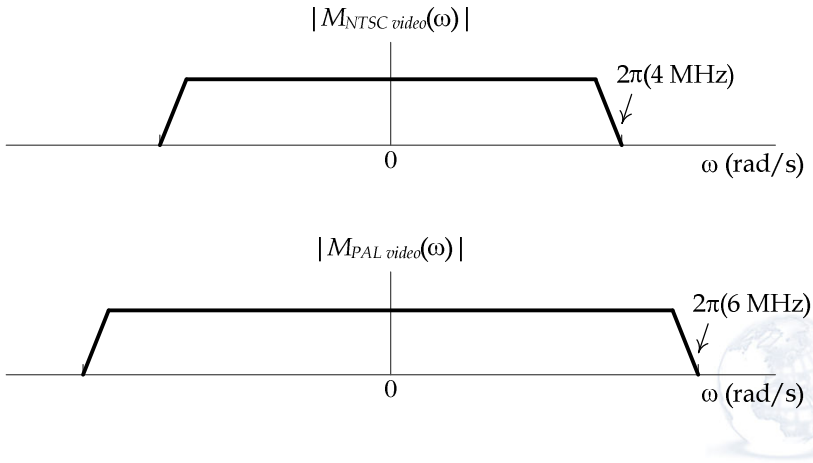
Homework



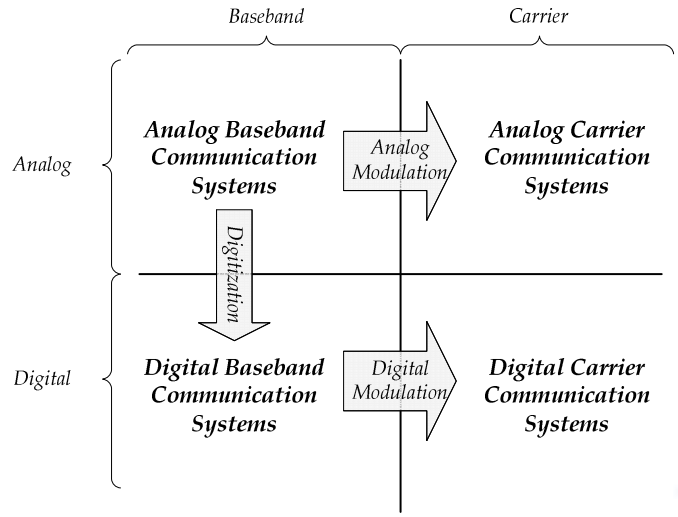
Examples: Audio



Examples: Video



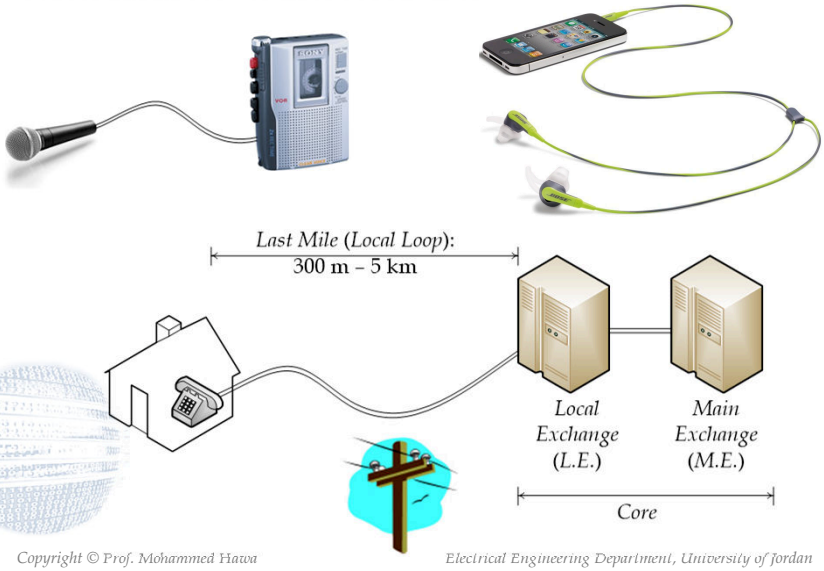
Modulation and Digitization



Analog Baseband Systems

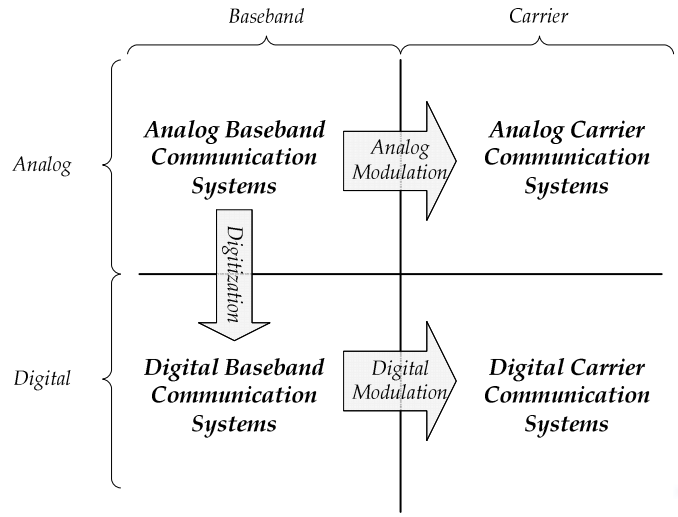
- An analog baseband system sends the analog baseband signal $m(t)$ as is (without any modifications).
- Advantages:
  - Simplest possible system.
  - Inexpensive to build.
- Usually used for short-distance communications.
- Examples of such systems in the next slide.

Example Analog Baseband Systems



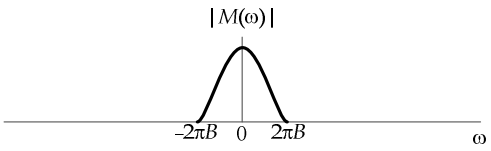
Audio Jack vs USB Adapter

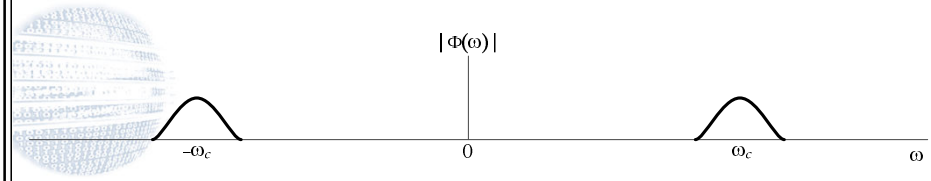
Modulation and Digitization



Modulation

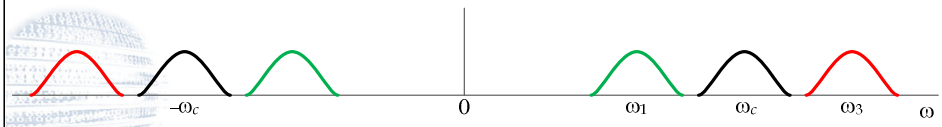
- In modulation, the signal $m(t)$ is combined with a high-frequency signal called the carrier.
- Hence, frequencies are shifted.





Analog and Digital Carrier Systems

- Modulation (i.e., analog and digital carrier systems) advantages:
  - Allows the use of reasonable antenna lengths.
  - Allows Multiplexing (FDM). As well as CDMA and OFDMA in digital systems.
  - Allows exchanging SNR for Bandwidth.



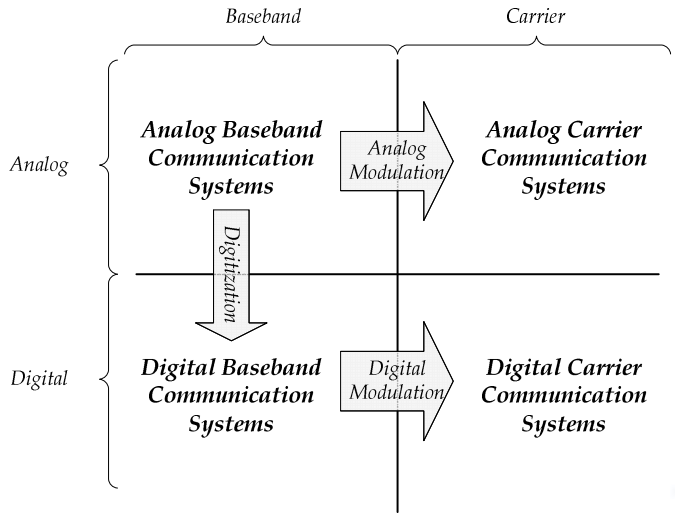
Multiplexing

- Multiplexing is the process of sending multiple signals over the same channel simultaneously.
- Popular multiplexing techniques:
- **FDM**: Frequency-Division Multiplexing
  - Requires: Modulation
- **TDM**: Time-Division Multiplexing
  - Requires: Digitization
- **CDMA**: Code-Division Multiple Access
  - Requires: Modulation and Digitization
- **OFDMA**: Orthogonal Frequency-Division Multiple Access
  - Requires: Modulation and Digitization

Example Carrier Systems

- Examples of **analog carrier** systems:
  - AM and FM radio broadcasting.
  - Analog TV broadcasting (NTSC and PAL).
- Examples of **digital carrier** systems:
  - Digital radio broadcasting (DAB).
  - Digital TV broadcasting (DVB-S, DVB-T, ATSC)
  - Cellular Telephony (2G, 3G, 4G, 5G, 6G generations).
  - Wi-Fi wireless local area network.
  - Bluetooth, Zigbee, UWB and NFC
  - Old dial-up modems.
  - ADSL modems.

Modulation and Digitization



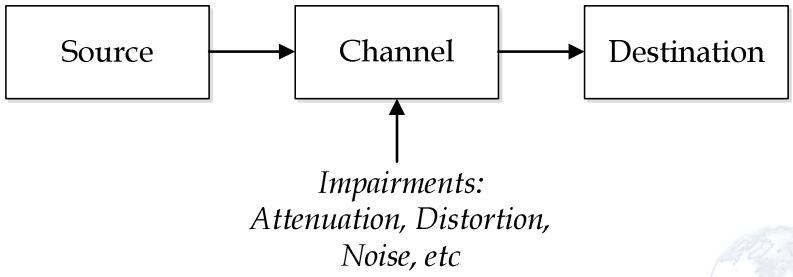
Digitization

- To convert the analog baseband signal into a digital baseband signal :
  - Sampling.
  - Quantization.
  - Mapping.
  - Encoding (coding).
  - Pulse Shaping.
- Digital baseband Advantages:
  - Immunity to Noise and Attenuation.
  - Allows Multiplexing at baseband level (TDM).

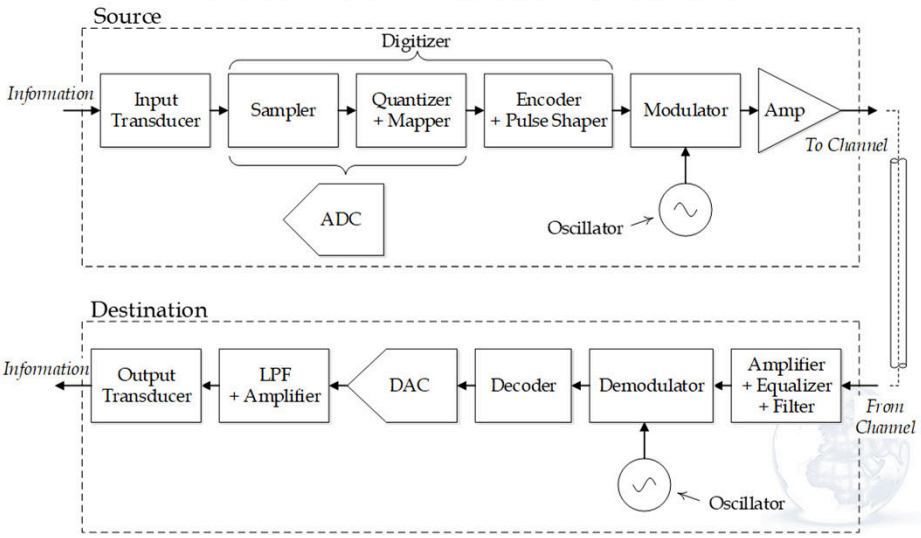
Example Digital Baseband Systems

- Digital baseband Advantages (*Continue*):
  - More bandwidth efficient (compression and line coding).
  - Allows exchanging SNR for Bandwidth at the baseband level.
  - For more, see Handout.
- Examples of digital baseband systems:
  - Serial (RS-232) and USB port connections.
  - Ethernet (a popular local area network).
  - Telephony (between local exchanges), such as the T-1, T-2, …, E1, E2, … etc PDH carriers.

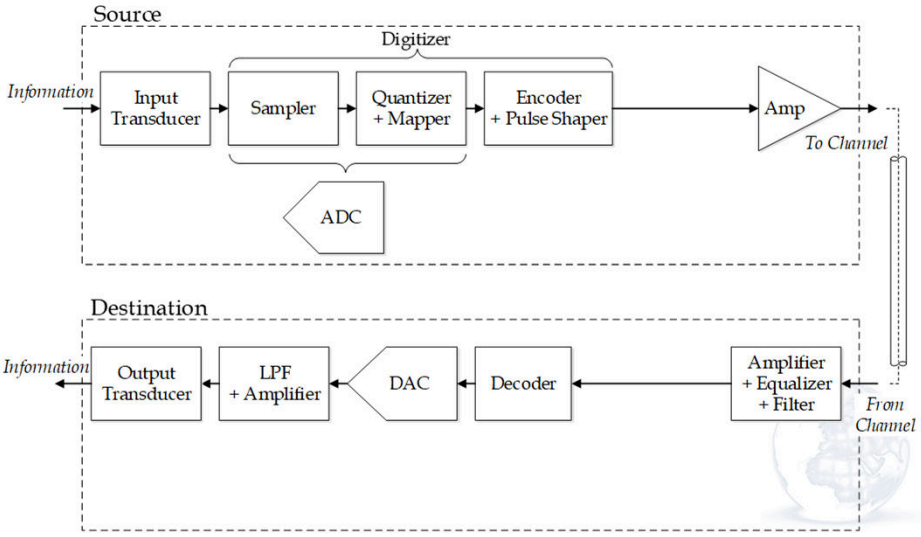
Block Diagram of Communication System



Digital Carrier System



Digital Baseband System



Analog Carrier System