Analog Communications Systems (ELE 280)

LEC (01)

A bird's eye view on Communications Systems

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LECTURE OUTLINES

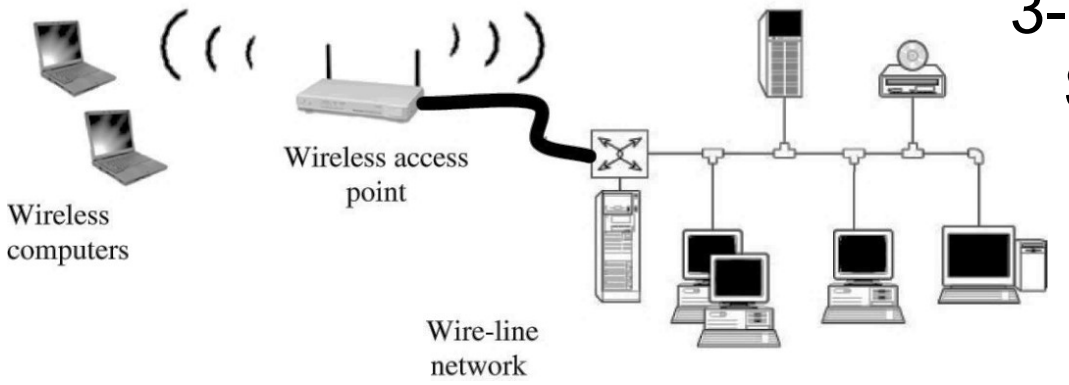
Content
1- Wireless Evolution
2 - Telecommunication Systems
3 - Communication System Components
4 - Signals and Systems
5 – Analog and Digital Signals
6 - The Frequency Band/spectrum allocation

1 - WIRELESS EVOLUTION

WIRELESS EVOLUTION

1- Wired Telephone System (Voice)

2- TV/Radio Broadcasting System



3- Internet Comm System (Mail)

TELECOMMUNICATIONS

- Telegraph
- Fixed line telephone
- Cable
- Wired networks
- Internet
- Fiber communications
- Communication bus inside computers to communicate between CPU and memory

WIRELESS EVOLUTION

- Satellite
- TV
- Cordless phone
- Cellular phone
- Wireless LAN, WIFI
- Bluetooth
- Wireless Laser
- Microwave
- GPS
- Wireless Sensor Networks (WSN)

WIRELESS EVOLUTION

Analog | Digital

Mobile 1G
AMPS, NMT, TACS

Mobile 2G
D-AMPS, GSM/GPRS, cdmaOne

Mobile 3G
CDMA2000/EV-DO, WCDMA/HSPA+, TD-SCDMA

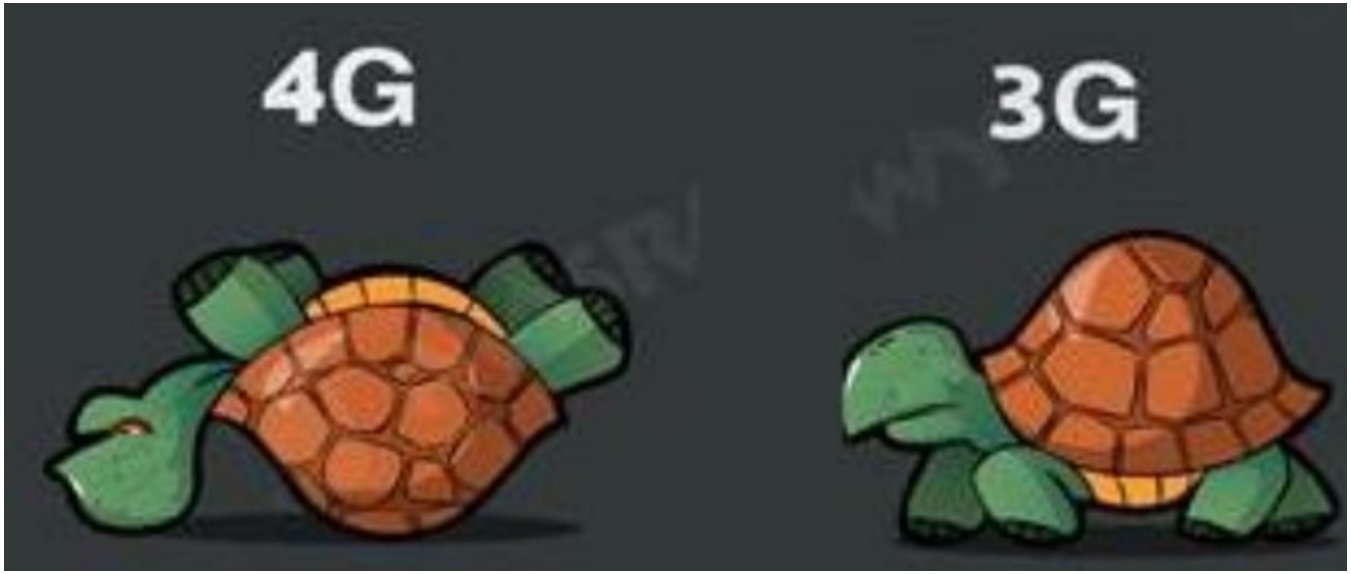
Mobile 4G LTE
LTE, LTE Advanced

N/A	<0.5 Mbps[1]	63+ Mbps[2]	300+ Mbps[3]
Analog Voice	**Digital Voice + Simple Data**	**Mobile Broadband**	**Faster and Better**

Richer Content (Video)

More Connections

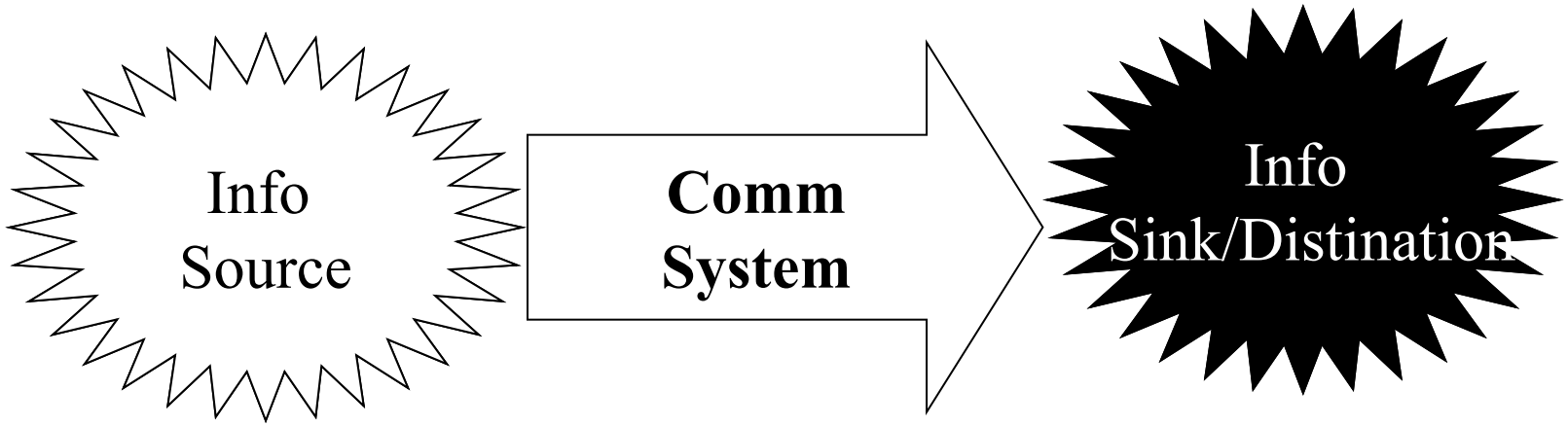
Limitations



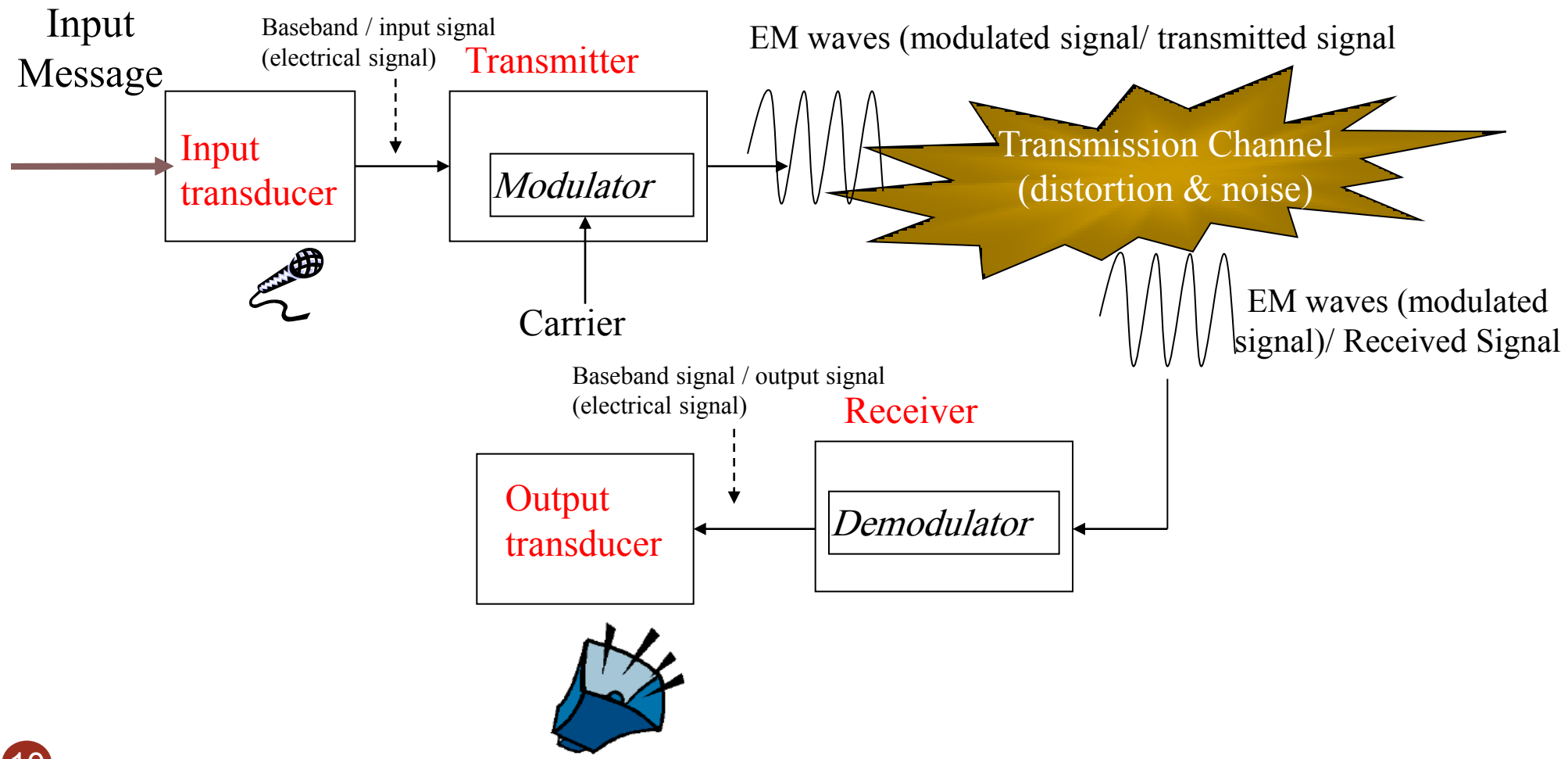
2 – TELECOMMUNICATION SYSTEMS

WHAT IS A COMMUNICATIONS SYSTEM?

- **<u>Communications Systems</u>: Systems designed to transmit and receive *information***



Basic analog communications system

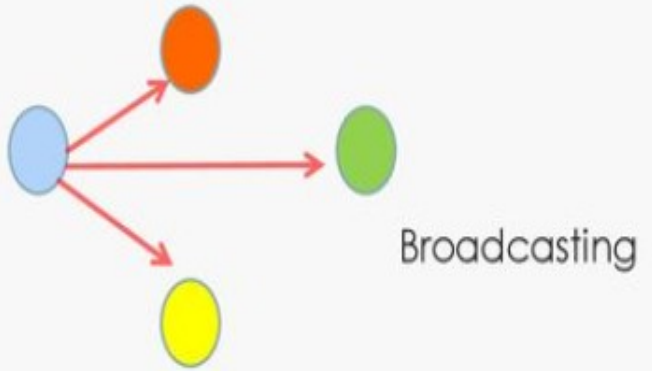


MODE OF COMMUNICATION

- There are two basic mode of communication:

1- **Broadcasting** → single transmitter and numerous receiver.

2- **Point to point communication** → single transmitter and single receiver.



Broadcasting

Point to point

3 - COMMUNICATION SYSTEM COMPONENTS

COMMUNICATION SYSTEM COMPONENTS

- **Source (information) or (Message):** Generates the information that we want to transmit, such as a human voice, a television picture, a teletype message (used for telegraph) or data. The output of the information source is a Physical signal (e.g. Voice is a longitudinal mechanical wave not an electromagnetic wave).

Information:	Type(s):	Example(s):
Message	Analog	Temperature, voice, image, etc.
	Digital	English text, teletype (Morse-coded) text, etc.
Signal	Analog	
	Digital	
Data	Digital only	01100010100101111010 …

Bits
(**B**inary Dig**it**s)

- **Input transducer:** converts (physical signal) nonelectrical messages (e.g. human voice, etc.) into electrical waveforms (signals) called *baseband* or *message signal*.
- **Examples:** Microphone (audio), Photodetector (light sensor) , Camera (Video / Still Pictures) Computer Keyboard (data).

Note: The baseband signal:

- Is the electrical signal coming out of the input transducer. This signal is usually not suitable for transmission.
  - Low power. (very short distance).
  - Cannot be radiated .

- **Transmitter:** modifies (adjusts) the message signal to make it possible (efficient) for transmission.
- **Channel:** It is the medium in which the transmitted signal (modified) is transmitted and travels to the destination. E.g. wire, a coaxial cable, an optical fiber or a radio link (i.e. wireless).

1. It can be either guided (one to one) or unguided (one to many).

❑ Simplex – only in one direction

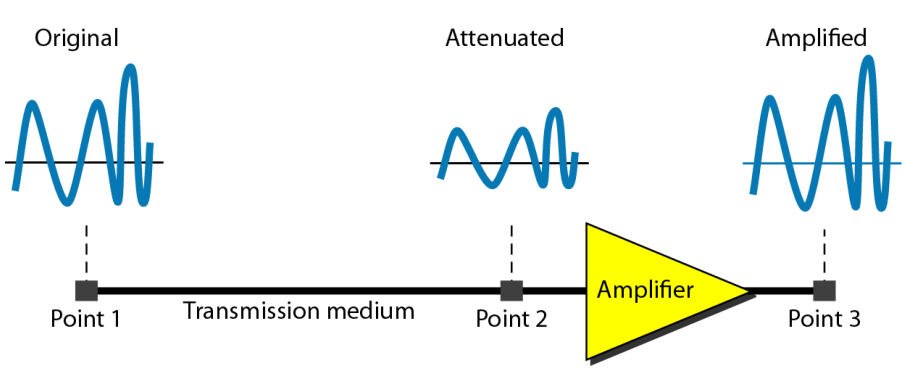
❑ Half-Duplex – Travels in either direction, but not both directions at the same time

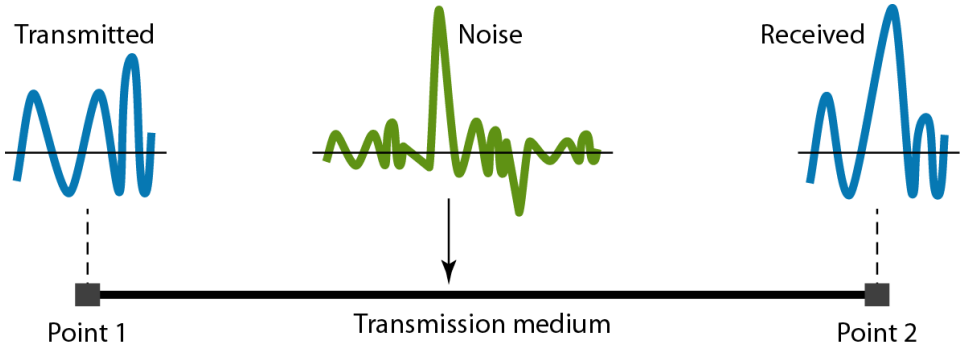
❑ Full-Duplex – can travel in either direction simultaneously

COMMUNICATION SYSTEM COMPONENTS

The transmitted signal suffers different impairments in the communication channel.

- ***Noise*** (*e.g. thermal,* fluorescent *light*)
- ***Interference*** (*mixing with other sources*)
- ***Jamming*** (specially in military applications)
- *Due to the physical properties of the channel* (***Distortion***).
- ***Attenuation*****:** is a reduction in the strength of a signal due to loss of energy while passing through different materials. Solved by repeaters





COMMUNICATION SYSTEM COMPONENTS

- The fundamental parameters that control the rate and quality of information transmission are:
  1. **Channel Bandwidth B**
  2. **Signal Power S**
- The **bandwidth** of a channel is the range of frequencies that it can transmit with without loss of energy (attenuation).

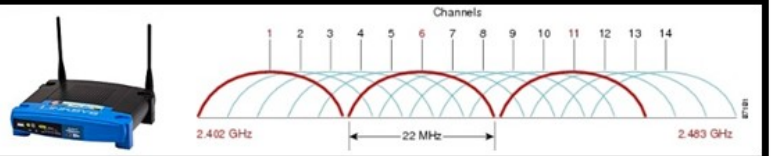
Ex; FM signal transmitted between 88MHz and 108MHz , so BW=20MHz

- The **signal power S** plays a dual role in information transmission
  - Increasing S reduces the effect of channel noise, and the information is received more accurately
  - A larger signal-to-noise ratio (SNR) also allows transmission over a longer distance.

COMMUNICATION SYSTEM COMPONENTS

- **Receiver:** it is an electronic System designed to extract the electrical (baseband) signal from the received signal. It re-processes the received signal by undoing the modification made at the transmitter and channel (reverses the changes made in the original signal.
- **Output transducer:** converts electrical signal back into its original nonelectrical (physical)baseband form (i.e. message, Loudspeaker, Monitor, CRT screen, LED, Printer).
- **Destination:** is the unit to which the message is communicated (transmitted).

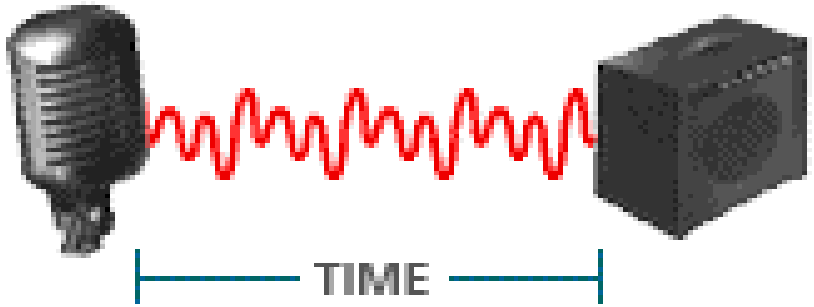
CHANNEL AND SIGNAL BANDWIDTH (CONT.)

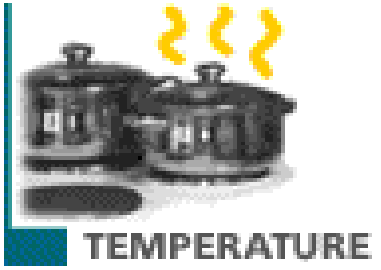
Channel:	Bandwidth:	Picture:
Telephone Voice Line	4 KHz	
Copper Pair (UTP, STP & FTP)	1 – 600 MHz (CAT1 – CAT7)	
Coaxial Cable	500 MHz (6 MHz Channels)	
2.4 GHz Radio (IEEE 802.11)	22 MHz / Channel (11 Channels)	
Optical Fiber	Many Tera Hertz	

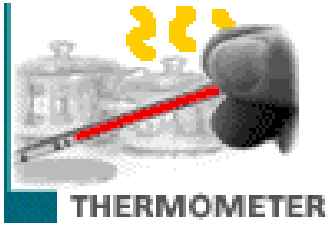
4 – ANALOG AND DIGITAL SIGNALS

ANALOG SIGNALS

- Examples : Human Voice – temperature - car speed
- Ear recognises sounds 20KHz or less
- AM Radio – 535KHz to 1605KHz
- FM Radio – 88MHz to 108MHz

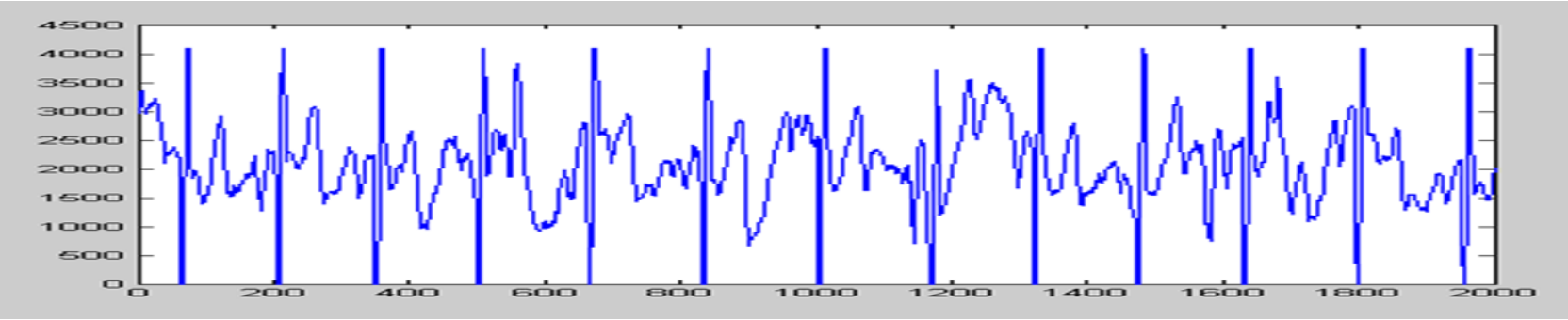




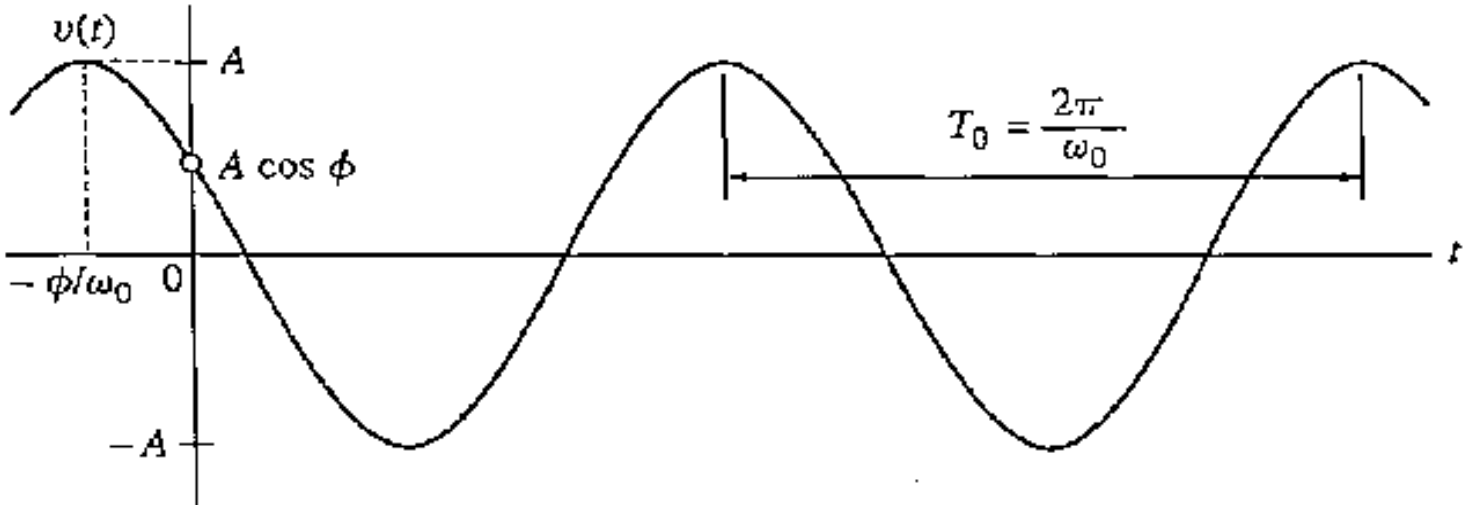


SIGNALS AND SYSTEMS

- Signals are variables that carry information
- **System** : process input signals to produce output signals
- Examples : Motion, sound, picture, video, traffic light…
  - ❑ Electrical signals --- voltages and currents in a circuit
  - ❑ Acoustic signals --- audio or speech signals (analog or digital)
  - ❑ Video signals --- intensity variations in an image (e.g. a CAT scan)
  - ❑ Biological signals --- sequence of bases in a gene
  - ❑ Noise: unwanted signal



SINUSOIDAL WAVEFORM



The sinusoidal signal (waveform) is represented mathematically as:

$$v(t)=A\cos(\omega_0 t+\emptyset)$$

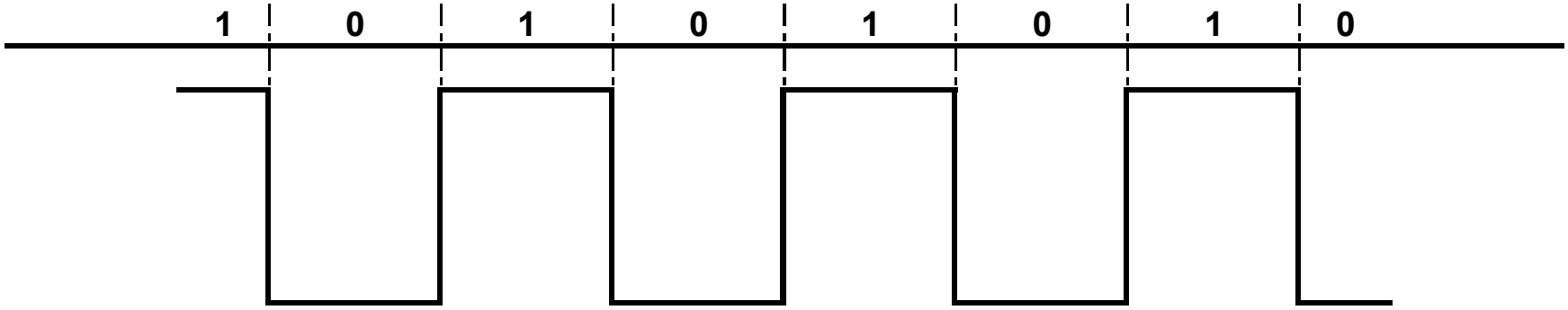
SINUSOIDAL WAVEFORM (CONT.)

- A: is the maximum amplitude. If $v(t)$ is a voltage signal, then A unit is Volt.
- ω_0: is the radian frequency in (radian/sec). This is also called "radial frequency", "angular frequency" or "angular speed" (which is the magnitude of angular velocity).
- $\emptyset$: is the phase angle (usually written in degrees).
- T_0: is the period of the signal (since it is periodic). It is measured in second .
- f_0: is the cyclic (or cyclical) frequency in hertz. It is the reciprocal of the period $T0$. Recall that Hz ≡ 1/s.

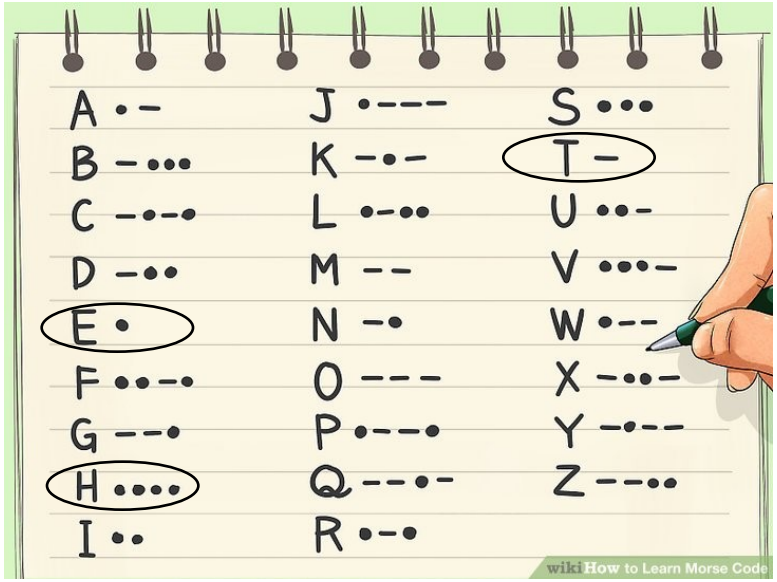
$$f_0 = \frac{1}{T_0} = \frac{\omega_0}{2\pi} \Rightarrow \omega_0 = 2\pi f_0$$

DIGITAL SIGNALS

- Represented by Square Wave
- All data represented by binary values
- Single **B**inary Digi**t** – **Bit**
- Transmission of contiguous group of bits is a bit stream
- Not all decimal values can be represented by binary
  - Printed English language (50 symbols → *M-ary* message).
  - Morse-coded telegraph message (2 symbols → *binary* message).

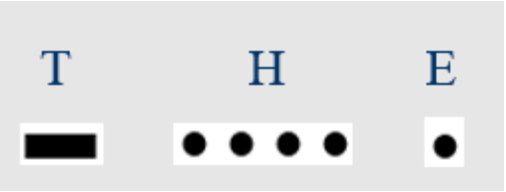


MORSE CODE ALPHABET



1	•▬▬▬▬
2	••▬▬▬
3	•••▬▬
4	••••▬
5	•••••
6	▬••••
7	▬▬•••
8	▬▬▬••
9	▬▬▬▬•
0	▬▬▬▬▬

Example:

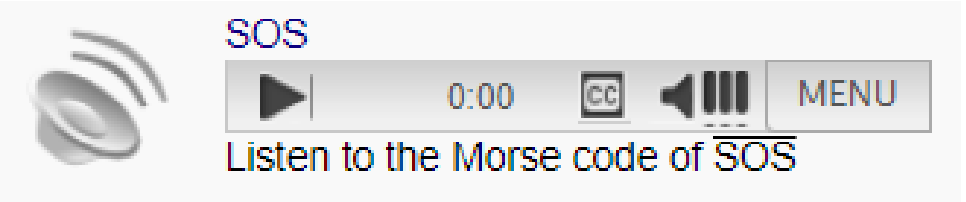


Also, punctuation marks have Morse Codes

- The length of a dot is <u>one</u> unit.
- A dash is <u>three</u> units.
- The space between parts of the same letter is <u>one</u> unit.

- The space between letters is <u>three</u> units.
- The space between words is <u>seven</u> units.

Famous Example ⇨ S O S



ANALOG VS. DIGITAL

Analogue Advantages

- Best suited for audio and video
- Consume less bandwidth
- Available world wide
- Less susceptible to noise

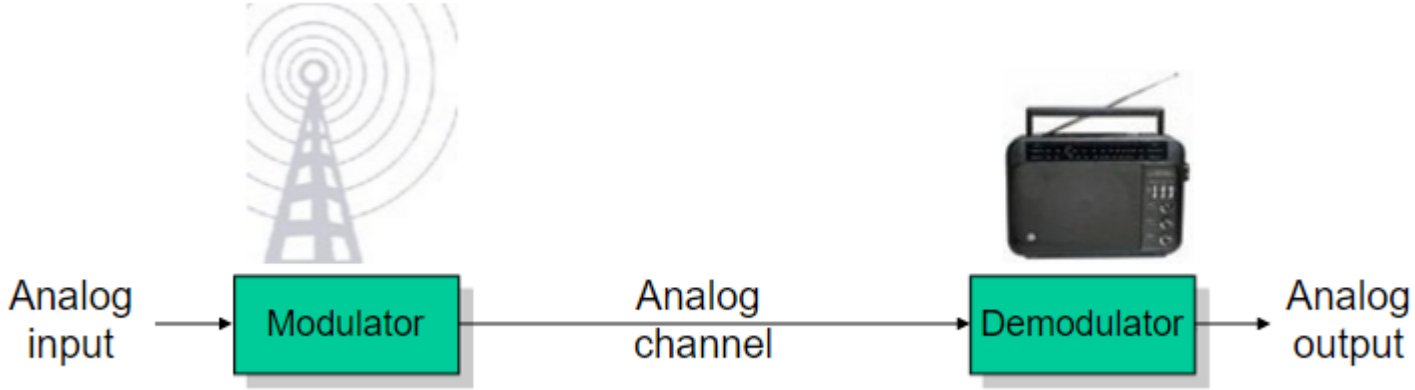
Digital Advantages

- Best for computer data
- Can be easily compressed
- Can be encrypted
- Equipment is more common and less expensive
- Can provide better clarity

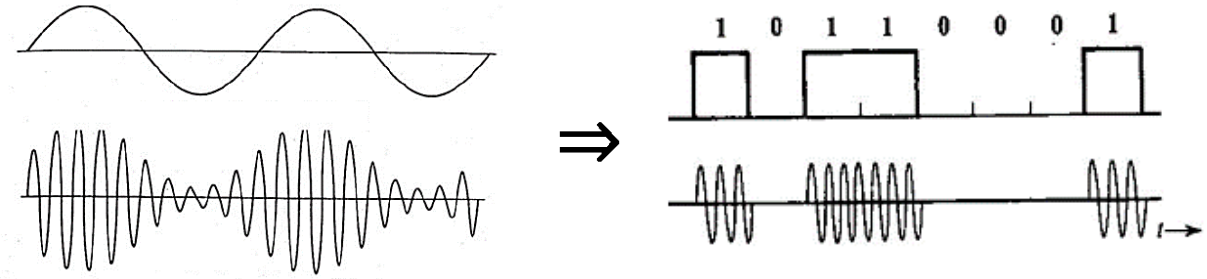
Analog Message:

- AM, FM for voice sound
  - Traditional TV for analog video
  - First generation cellular phone
  - Record player
- **Digital message**:
  - VCD, DVD
  - 2G/3G/4G/5G cellular phone
  - Data on your disk
  - Your grade

SO WHY DO WE STUDY ANALOG COMMUNICATION?



Old analog communication facilities such as AM and FM radio broadcasting are still in use (quality of the received signal is still acceptable).



The only way to understand digital communication is to study the modulation and demodulation techniques used in analog communication systems.

Thank you for your attention

Dr. Moataz Elsherbini