Wireless Technology Fundamentals

Topics

- ❖ **Mobile and wireless communications**
- ❖ **Applications**
- ❖ **overview Frequency of Radio Transmission**
- ❖ **Signal Antennas**
- ❖ **Signal Propagation**
- ❖ **Multiplexing**
- ❖ **Modulation**
- ❖ **Spread Spectrum**
- ❖ **Coding and Error Control**

What is Wireless Communication ?

- Wireless communication is transfer of information over a distance without the use of electrical conductors or wires.

- The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications).

- Wireless communication enables us to remotely connect to external communications systems such as satellites, cellular phones, and computers throughout the world.

Communication Systems

Transmitter $\longrightarrow$ | Communication system | $\longrightarrow$ Receiver

| Information source | → | Transmitter | → | Channel | → | Receiver | → | Information Sink |

Block Diagram of a typical communication system

Information Source

- The source of data
  - Data could be: human voice, data storage device CD, video etc..
- Data types:
  - Discrete: Finite set of outcomes "Digital"
  - Continuous : Infinite set of outcomes "Analog"

Transmitter

- Converts the source data into a <u>suitable form</u> for transmission through signal processing

- Data form depends on the channel

- Channel:
  - The physical medium used to send the signal

  - The medium where the signal propagates till arriving to the receiver

  - Physical Mediums (Channels):
    - Wired : twisted pairs, coaxial cable, fiber optics
    - Wireless: Air, vacuum and water

  - Each physical channel has a certain limited range of frequencies ,($fmin \rightarrow fmax$), that is called the channel bandwidth
  - Physical channels have another important limitation which is the **NOISE**

- Noise is **<u>undesired random</u>** signal that corrupts the original signal and degrades it
- Noise sources:
  - Electronic equipment in the communication system

  - Thermal noise

  - Atmospheric electromagnetic noise (Interference with another signals that are being transmitted at the same channel)

- Another Limitation of noise is the attenuation

  - Weakens the signal strength as it travels over the transmission medium

  - Attenuation increases as frequency increases
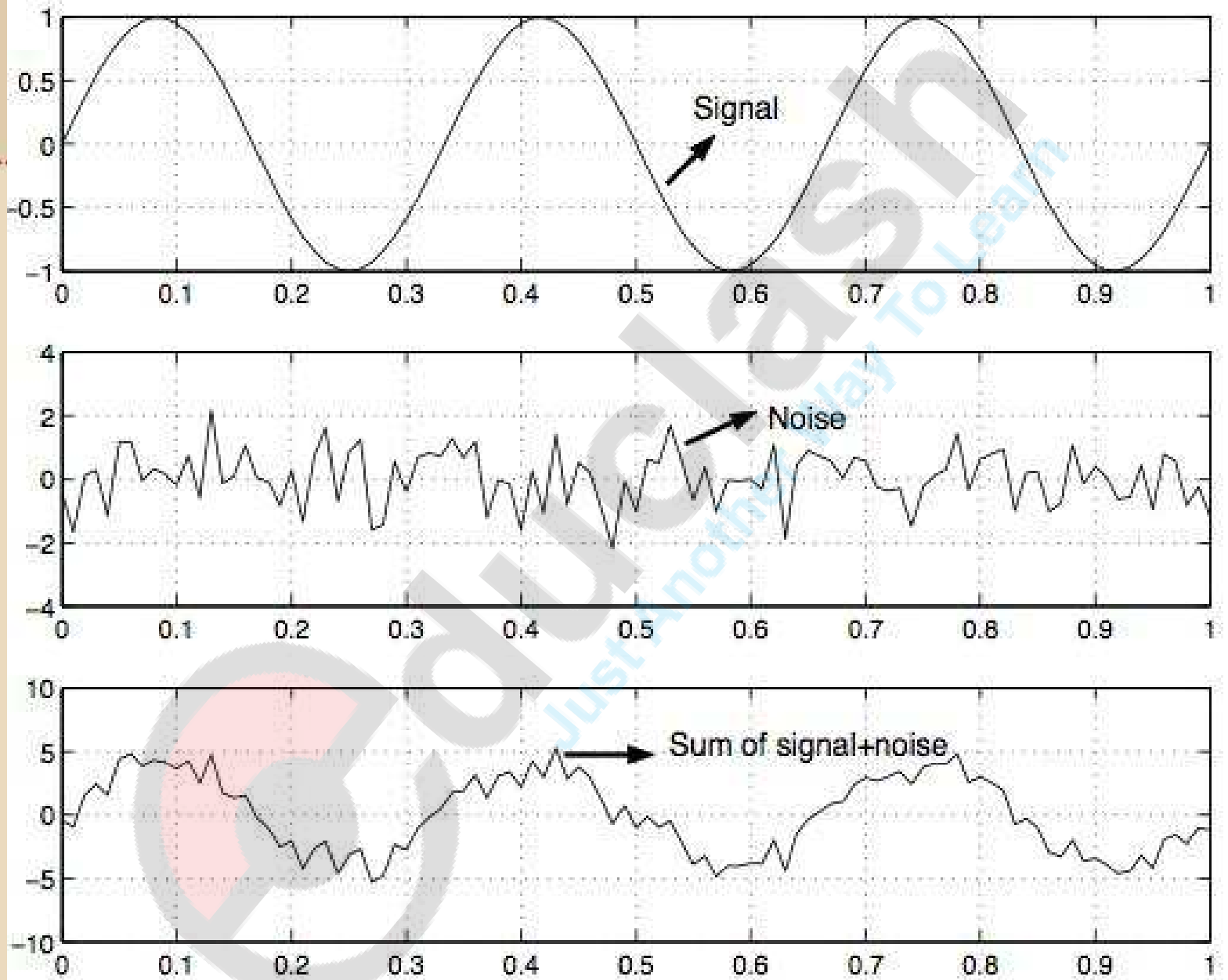
Receiver

- Extracting the message/code in the received signal
  - Example
    - Speech signal at transmitter is converted into electromagnetic waves to travel over the channel
    - Once the electromagnetic waves are received properly, the receiver converts it back to a speech form

Information Sink

- The final stage
- The user

Effect of Noise On a transmitted signal

Mobile communication

 Two aspects of mobility:
- **user mobility:** User mobility refers to as users who have access to similar communication services at different places.

- Example: User can be mobile and he can login to his mail account from any desktop to check or compose emails.

- **Device portability** refers to the movement of a communication device with or without a user. Devices can be connected anytime, anywhere to the network

- Example: The mobile phone system, where the system itself hands the device from one radio transmitter (also called a base station)to the next if the signal becomes too weak.

Wireless vs. mobile   Examples
  ✖   ✖   stationary computer
  ✖   ✔   notebook in a hotel
  ✔   ✖   wireless LANs in historic buildings
  ✔   ✔   Personal Digital Assistant (PDA)

The demand for mobile communication creates the need for integration of wireless networks into existing fixed networks

Characteristics of communication device

Fixed and wired:

This configuration describes the typical desktop computer in an office.

Mobile and wired:

Users carry the laptop from one hotel to the next, reconnecting to he company's network via the telephone network and a modem.

Fixed and wireless:

This mode is used for installing networks, e.g., in historical buildings to avoid damage by installing wires, or at trade shows to ensure fast network set up

Mobile and wireless: Cellular Phones .

Applications

- Vehicles
  - transmission of news, road condition, weather, music via DAB/DVB-T
  - personal communication using GSM/UMTS
  - position via GPS
  - local ad-hoc network with vehicles close-by to prevent accidents, guidance system
  - vehicle data (e.g., from busses, high-speed trains) can be transmitted in advance for maintenance
- Emergencies
  - early transmission of patient data to the hospital, current status, first diagnosis
  - replacement of a fixed infrastructure in case of earthquakes, hurricanes, fire etc.
  - crisis, war, ...

Other Applications

- Military communications (robustness and speed of deployment critical)
- Search and Rescue operations (same reasons)
- Sensor networks
- Networks of satellites

Time-Domain Concepts

ജAperiodic signal - analog or digital signal pattern that doesn't repeat over time

ജPeak amplitude (A) - maximum value or strength of the signal over time; typically measured in volts

ജFrequency (f)

ജRate, in cycles per second, or Hertz (Hz) at which the signal repeats

Time-Domain Concepts

- Period (T) - amount of time it takes for one repetition of the signal
  - $T = 1/f$
- Phase (ϕ) - measure of the relative position in time within a single period of a signal
- Wavelength (λ) - distance occupied by a single cycle of the signal
  - Or, the distance between two points of corresponding phase of two consecutive cycles

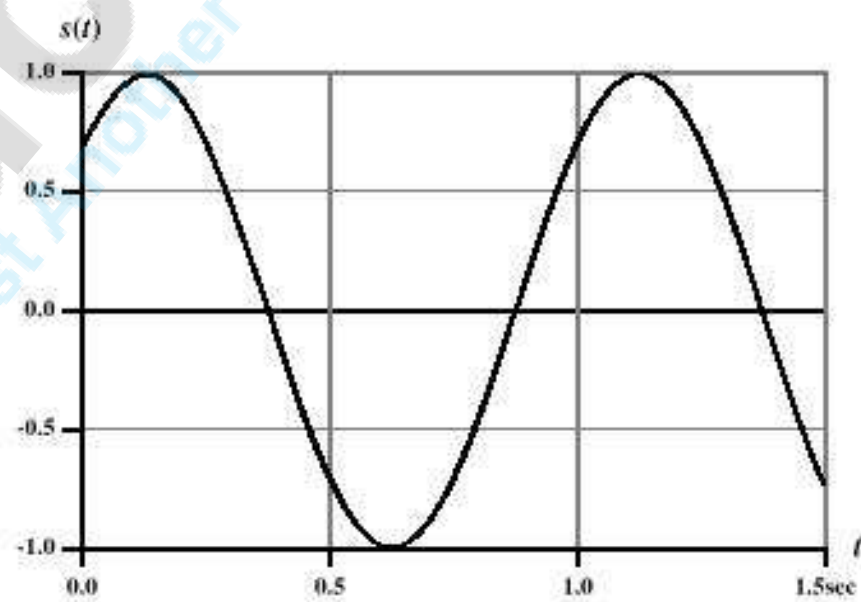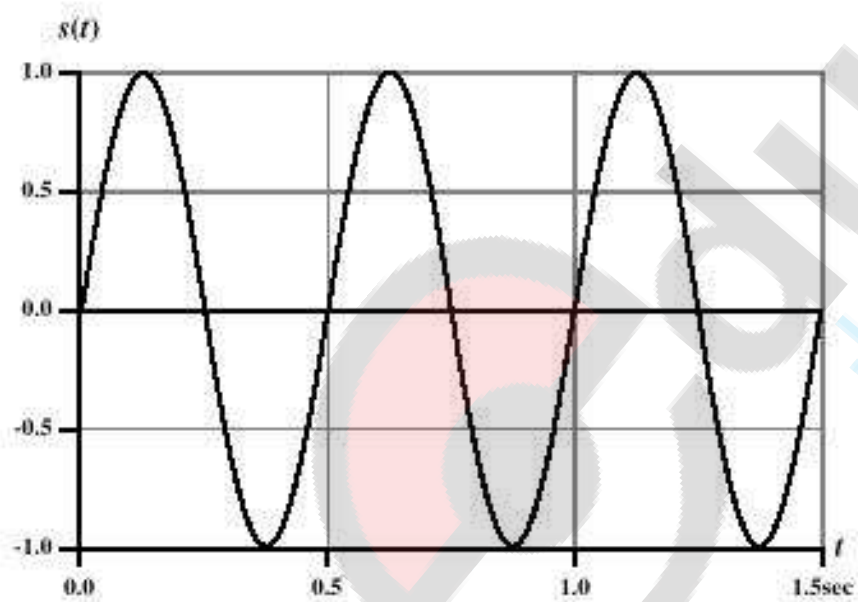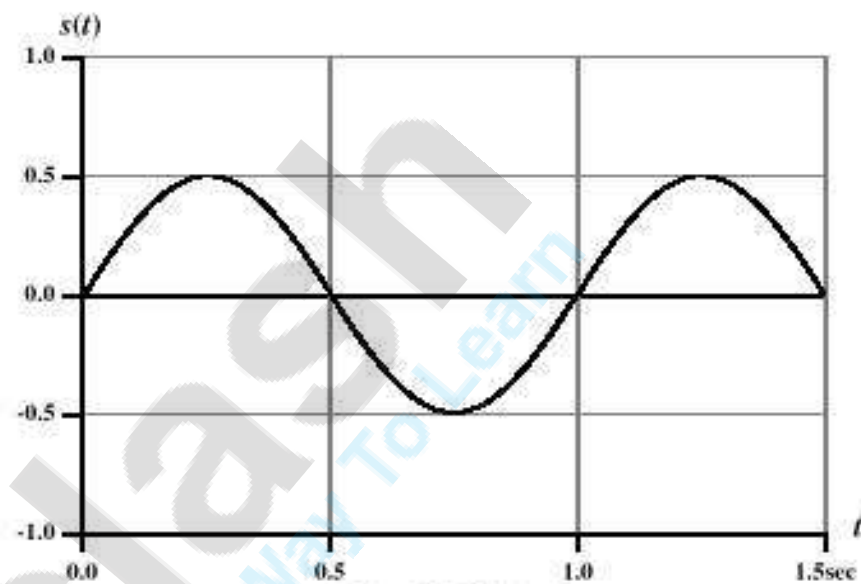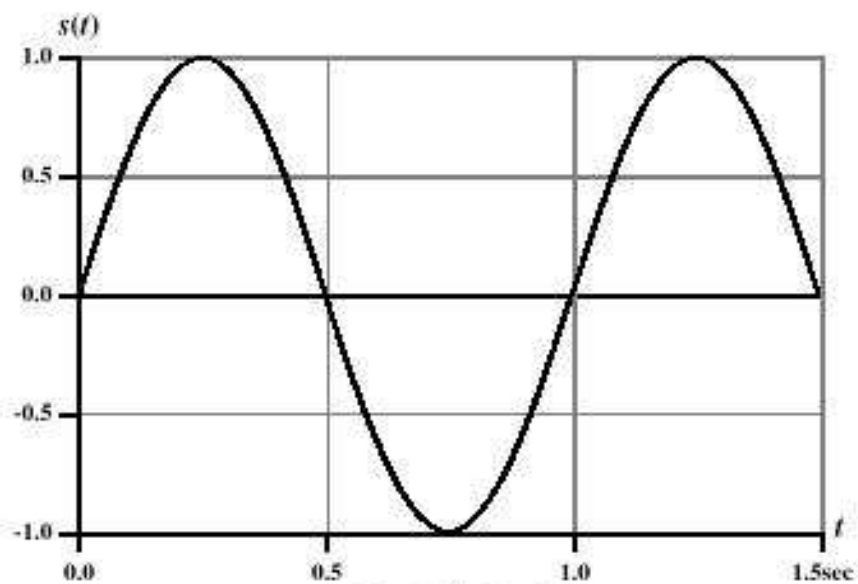(a) $A = 1, f = 1, \phi = 0$

(b) $A = 0.5, f = 1, \phi = 0$

(c) $A = 1, f = 2, \phi = 0$
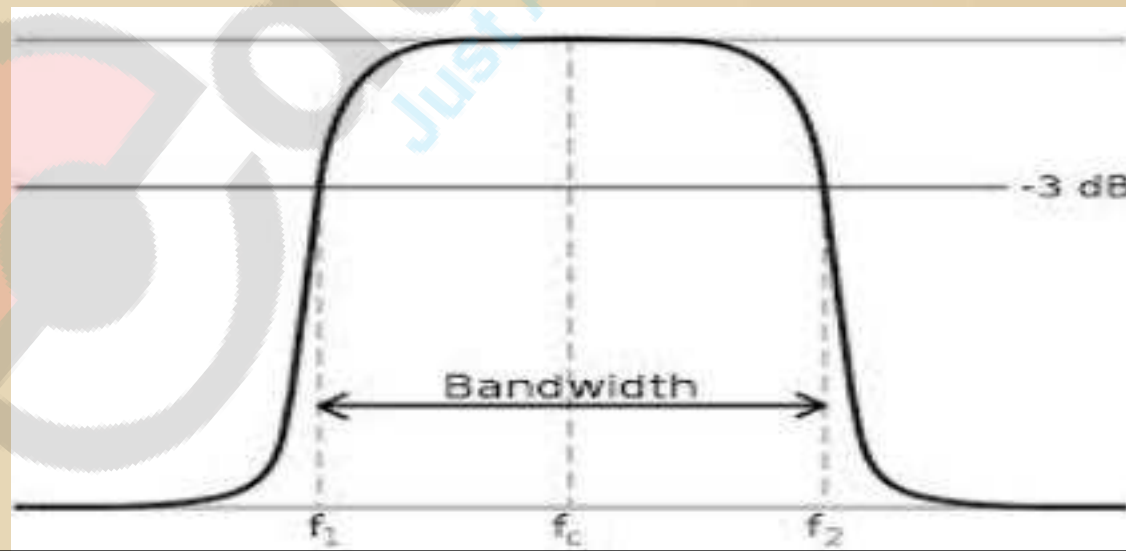
(d) $A = 1, f = 1, \phi = \pi/4$

Figure 2.3 $s(t) = A \sin(2\pi ft + \phi)$

Frequency-Domain Concepts

- Any electromagnetic signal can be shown to consist of a collection of periodic analog signals (sine waves) at different amplitudes, frequencies, and phases
- The period of the total signal is equal to the period of the fundamental frequency

Wireless networks in comparison to fixed networks

- Higher loss-rates due to interference

- Restrictive regulations of frequencies

- Low transmission rates

- Higher delays, higher jitter
  - connection setup time with GSM in the second range, several hundred milliseconds for other wireless systems
- Lower security, simpler active attacking
  - radio interface accessible for everyone, base station can be simulated, thus attracting calls from mobile phones
- Always shared medium
  - secure access mechanisms important

Relationship between Data Rate and Bandwidth

- The greater the bandwidth, the higher the information-carrying capacity
- Conclusions
  - Any digital waveform will have infinite bandwidth
  - BUT the transmission system will limit the bandwidth that can be transmitted
  - AND, for any given medium, the greater the bandwidth transmitted, the greater the cost
  - HOWEVER, limiting the bandwidth creates distortions