Mobile Device and Network Architecture

Module 1: Communication Principles

Topics Covered:

The main topics covered include:

- Wireless communication
- Mobile network OSI layers
- POTS
- Telephony network
- PSTN
- Telecommunication Networks

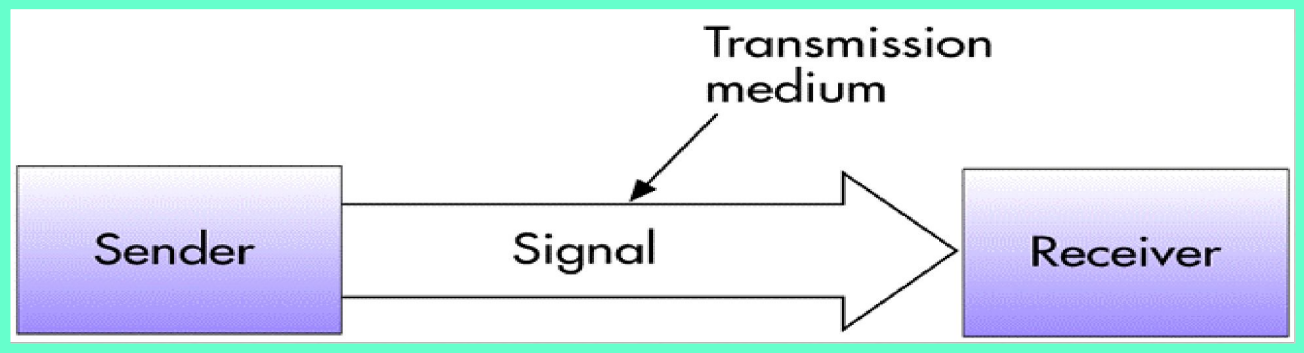
Objectives

After studying this module, you will be able to:

- elucidate the basic communication principles used in wireless communication.
- explain the fundamental principles of telephone communication and POTS.
- give a broad description of telephone networks and the PSTN.

Introduction

- The term telecommunication means communication at a distance.
- A basic telecommunication system consists of three primary elements :
  - Transmitter/Sender, Transmission medium, Receiver



Introduction

- Telecommunication relies on digital computer technology, and data communication relies on telecommunication networks.
- In the 1950s, the Bell telephone company in the United States introduced a radio telephone service for its customers.
- In 1964, the concept of shared resources was introduced.
  - This innovation allowed networks to allocate radio resources on a dynamic basis.

Introduction

- Cellular mobile communication systems use a large number of low power transmitters to create ‘cells’ (*the basic geographic service area of a wireless communication system*).
- *Frequency channels* used in one cell can be reused in another cell some distance away.
- *Cells* can be increased to accommodate subscriber growth by creating new cells in unserved areas or overlaying cells in existing areas.

Introduction

- 2G networks were built mainly for voice services.
- The focus of 3G, was data and the evolution to a packet switched network.
- The *group spéciale mobile* (GSM) standard provides a common set of compatible mobile services and capabilities to a large number of subscribers across the world.
- GSM and CDMA are the two main types of mobile networks in the world today.

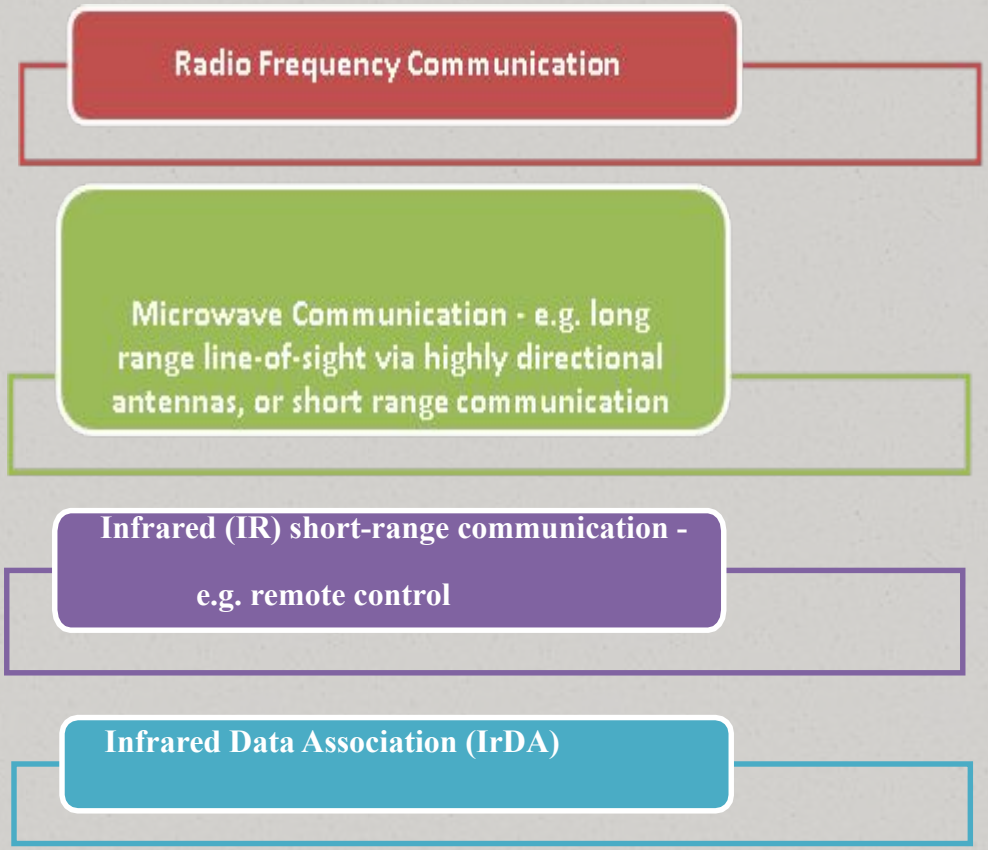
Introduction

GSM aims at providing:

- Standards based numbering, switching and mobility management compatible with fixed public telephone networks
- Cost efficient network and user equipment
- Optimum radio frequency utilization
- High quality of service and security
- Service portability

Wireless Communication Principles

Wireless communication can be via:



Wireless Communication Principles

- A wireless LAN has a *transmitter/receiver (transceiver)* device which is also called as *Access Point (AP)*.
- Access point will *receive*, *buffer* and *transmit* **data** between the wireless LAN and the wired network.
- One access point can support a small group of users.
- A wireless access point will have an *antenna* attached to it.
- Access point can connect to a *modem*, for internet access.
- Wireless networks are based on the **IEEE 802.11** standards.

Wireless Communication Principles

Wireless communication can have two operating modes:

- **Infrastructure mode:** Computers with wireless network adapters are known as wireless *clients*. In infrastructure mode, these wireless clients can be connected to wired network *using an access point* or a wireless *router*.
- **Ad hoc mode:** In ad hoc mode, wireless clients can be connected to each other *without using an access point*. They will be able to send data directly.

Common examples of wireless being used today

Cellular Telephones and Pagers	• Portable • Use - personal and business
Global Positioning System (GPS)	• To ascertain the location on earth • Helps while travelling
Cordless computer peripherals	• E.g. cordless mouse, keyboard, printer
Cordless telephone	• Limited range • Not cell phones
Satellite Television	• Viewers from any location
VHF radios	• Consumer and professional marine
Professional LMR (Land Mobile Radio) and SMR (Specialized Mobile Radio)	• Used by business, industrial and public safety entities
2-way Radio	• FRS (family Radio Service) • GMRS (General Mobile Radio Service) • Citizens band (CB) radios
Amateur Radio Service	• Ham Radio

Wireless Communication Principles

1. Radio Communication

- Currently electromagnetic airwaves are used for wireless communications.
- This can be either infrared or radio frequency.
- At the transmitting side, the data will be superimposed on the radio carrier. As soon as the data reaches the receiving end, it can be extracted.
- Radio wave's frequency is between 1 GHz and 3 GHz.

Wireless Communication Principles

1. Radio Communication

- Since radio waves can penetrate concrete structures, they are used for both indoor and outdoor communications.
- At low frequency, radio waves can pass through obstacles.
- At high frequency, radio waves travel in a straight line and will bounce off obstacles.
- Radio waves can also be absorbed by rain.
- In VLF, LF and MF bands, radio waves follow the ground. But in HF and VHF bands, radio waves will be absorbed by earth.

Wireless Communication Principles

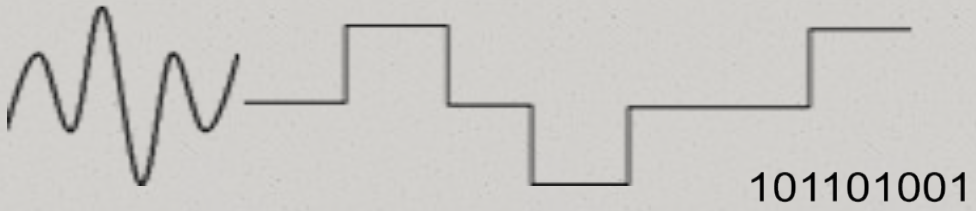
1. Radio Communication

- Radio waves are used for the following:
  - AM and FM radio
  - Television
  - Cordless phone
  - Cellular phone
  - Pager
  - Wireless LAN

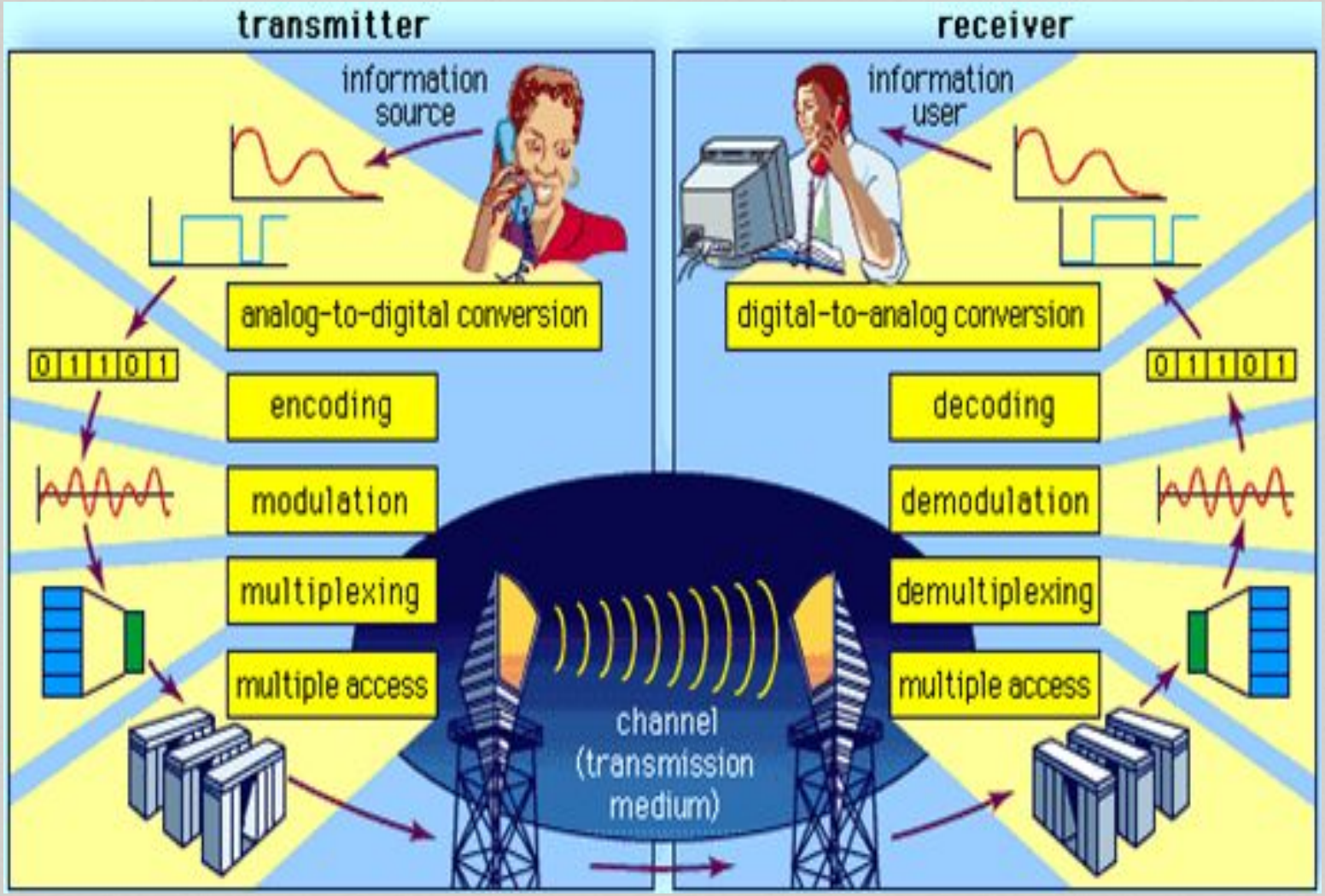
Wireless Communication Principles

2. Analog and Digital Communication

- Communications signals can be either analog or digital.
- An analog signal is one in which the signal is varied continuously with respect to the information.



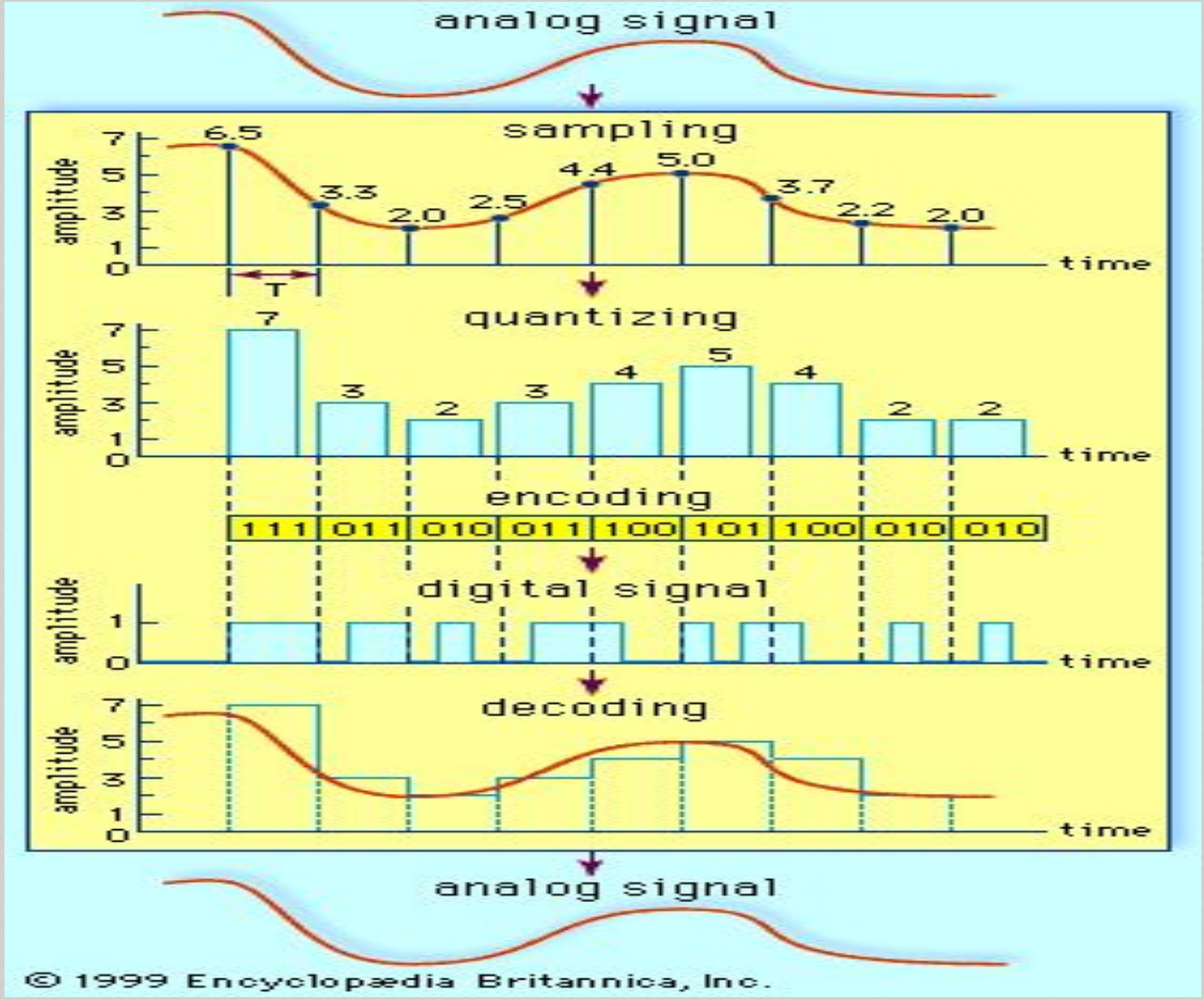
Analog Signal Digital Signal


transmitter
receiver
information source
information user
analog-to-digital conversion
digital-to-analog conversion
0 1 1 0 1
encoding
decoding
modulation
demodulation
multiplexing
demultiplexing
multiple access
multiple access
channel (transmission medium)

Wireless Communication Principles

2. Analog and Digital Communication

- In a digital signal, the information is encoded as a set of discrete values (for example, a set of ones and zeros).
- During signal propagation and reception, the information contained in analog signals will inevitably be degraded by undesirable physical noise.
- The resistance to noise represents a key advantage of digital signals over analog signals.
- Analog signals are converted into digital signals by *sampling* and *quantizing* the analog signals and representing in discrete form.


analog signal
sampling
amplitude
time
6.5
3.3
2.0
2.5
4.4
5.0
3.7
2.2
2.0
T
quantizing
7
3
2
3
4
5
4
2
2
encoding
111 011 010 011 100 101 100 010 010
digital signal
decoding
analog signal
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Wireless Communication Principles

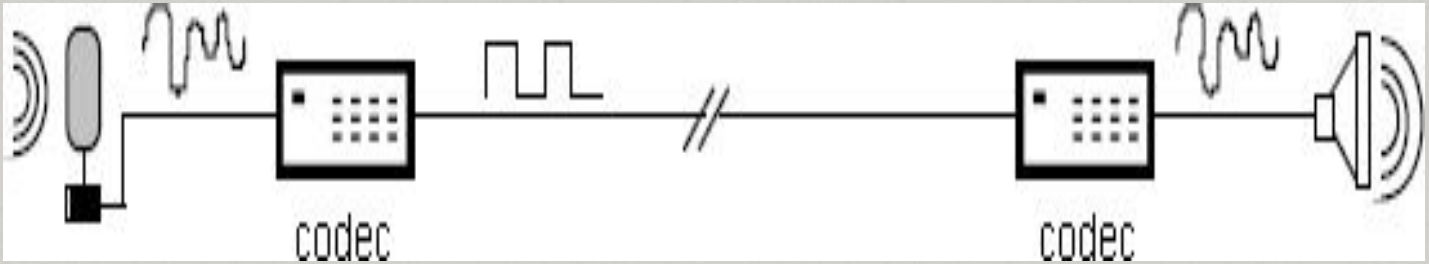
2. Analog and Digital Communication

- The *Nyquist theorem* states that a signal must be sampled at least twice as fast as the bandwidth of the signal to accurately reconstruct the waveform.
- This is also called the Nyquist rate.
- If the sampling rate is less than twice the signal bandwidth, the signal will lead to an effect called ‘aliasing’ and the signal will be misrepresented.

Wireless Communication Principles

2. Analog and Digital Communication

- An analog signal such as human speech can be sampled and converted into digital data, transmitted over digital lines and converted back to the analog signal at the receiving end. These two functions are performed by a device called a *codec*.



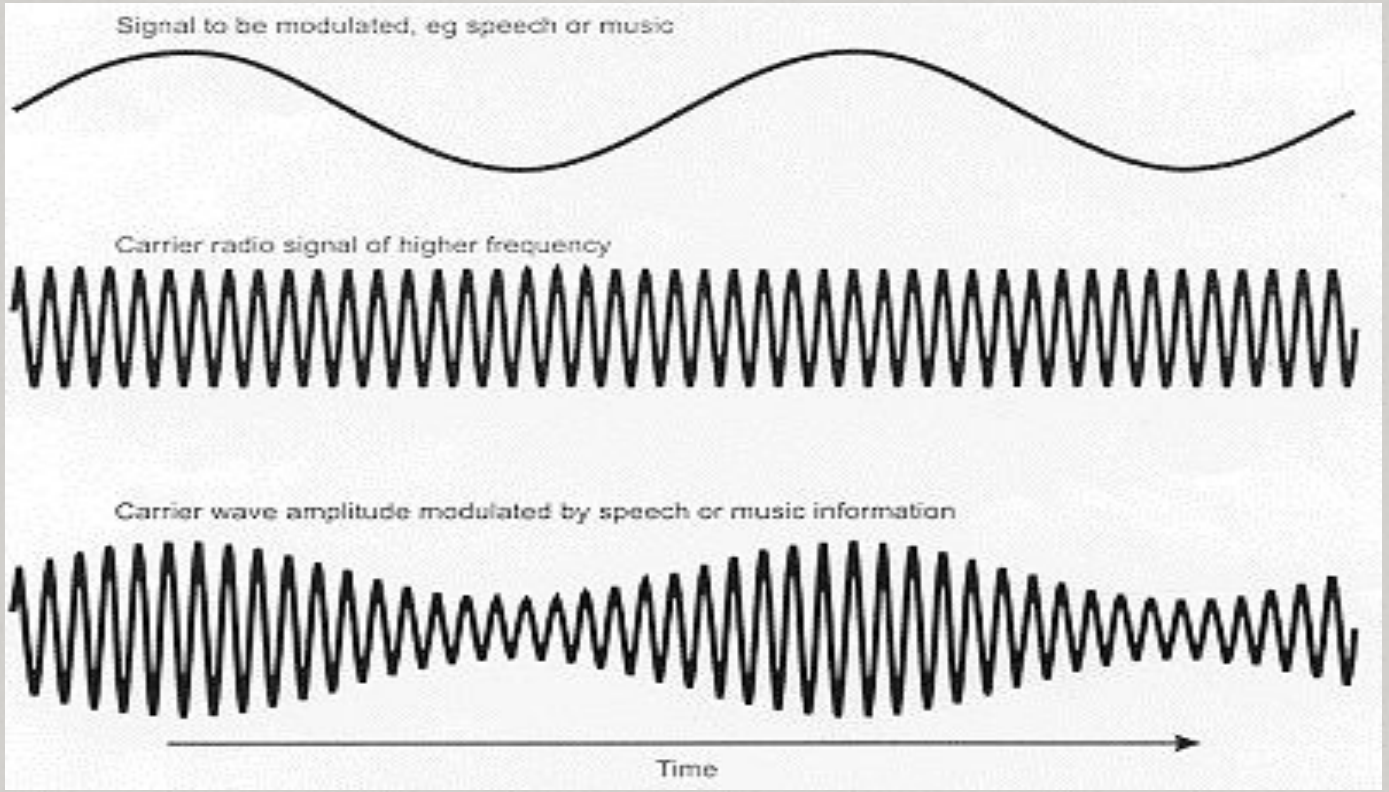
Wireless Communication Principles

3. Modulation

- A sinusoidal radio wave used for communication is referred to as a *carrier*.
- The carrier conveys no information on its own, but information can be superimposed on the carrier; this process is known as carrier *modulation.*
- Information is typically transmitted over a medium by superimposing an analog signal on a sinusoidal carrier using one of the following analog modulation techniques:

Wireless Communication Principles

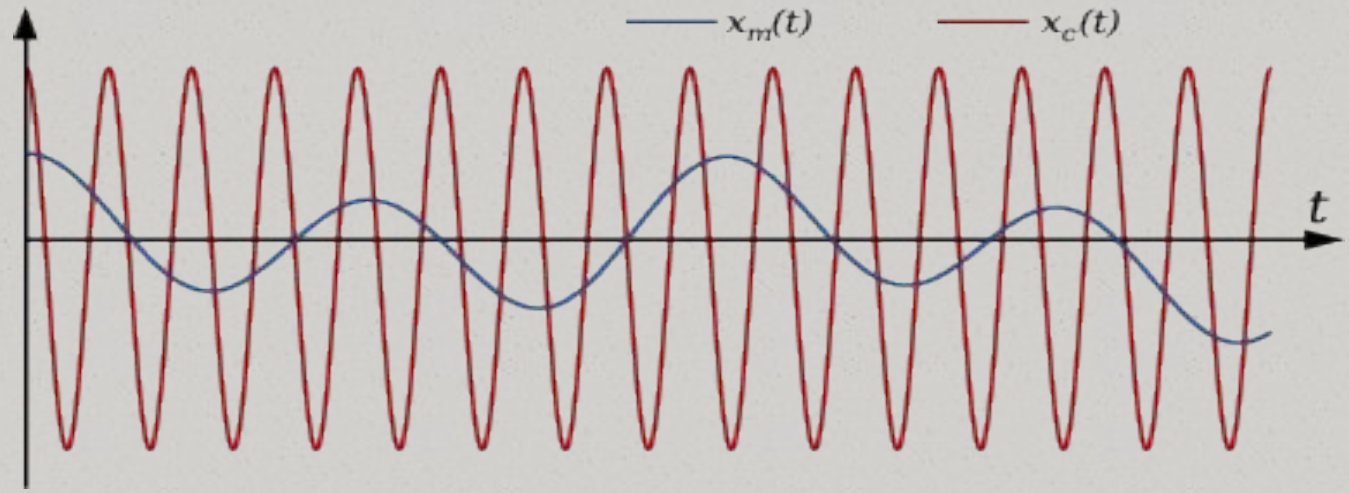
Amplitude Modulation (AM)



Wireless Communication Principles

Frequency Modulation (FM)

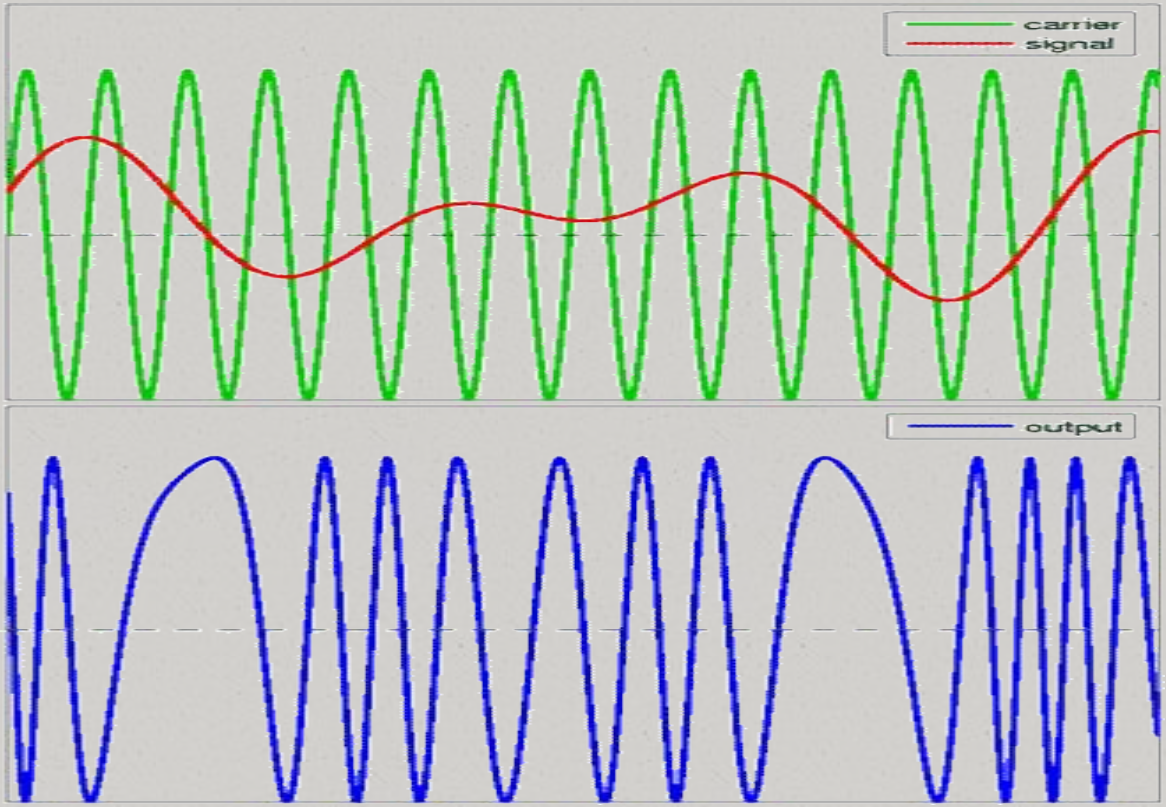
- Frequency Modulation conveys information over a carrier by varying its frequency.



Wireless Communication Principles

Phase Modulation (PM)

- Phase Modulation represents information as variations in the instantaneous phase of a carrier.



Wireless Communication Principles

3. Modulation

- Modulation can also be used to transmit information at higher frequencies.
- This is helpful because low-frequency analog signals cannot be effectively transmitted over free space.
- An example of modulation is a DJ's voice (in the 3- 4 KHz audio frequency range) being superimposed on a 96 MHz carrier wave using frequency modulation (the voice would then be received on a radio).

Wireless Communication Principles

3. Modulation

- Modulation can also be used to represent a digital message as an analog waveform. This is known as keying.
- There are several keying techniques:
  - Amplitude-shift keying (ASK)
  - Frequency-shift keying (FSK)
  - Phase-shift keying (PSK)
- Bluetooth, for example, uses phase-shift keying to exchange information between devices.

Wireless Communication Principles

3. Modulation

- A *modem* (modulator and demodulator) is a commonly used device which converts an outgoing digital bit stream from a device into an analog signal for transmission and converts the incoming received analog signal into a digital bit stream for further processing.

Wireless Communication Principles

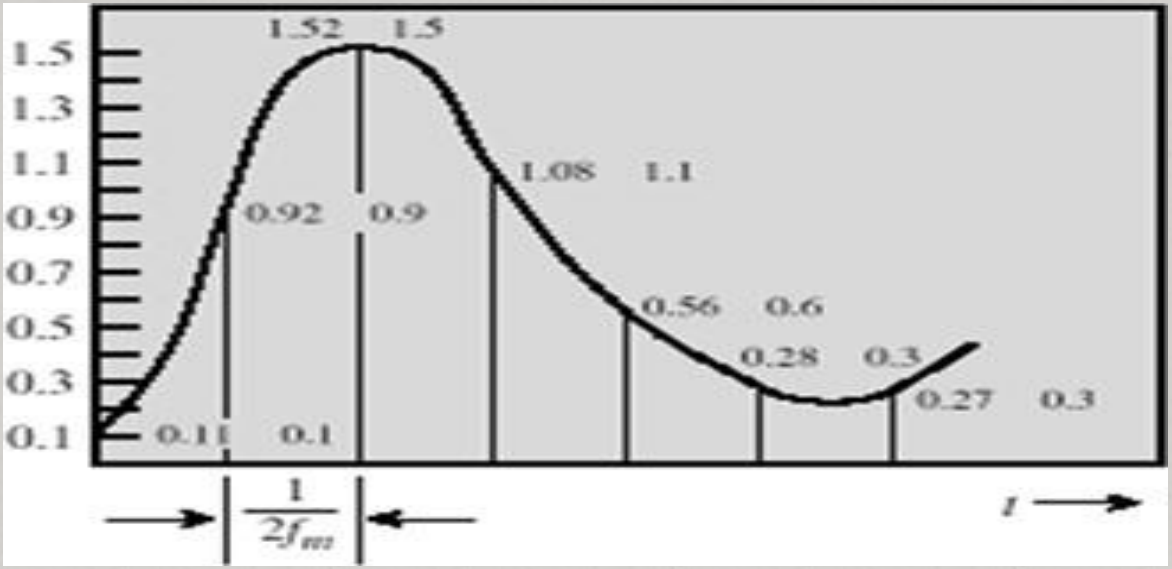
4. Pulse Code Modulation

- PCM is the most commonly used technique in digital communications for a *digital representation of an analog signal.*
- It is used for speech/audio encoding in telephony systems as well as digital storage systems such as CDs.
- The Nyquist limit is exercised by Pulse Code Modulation (PCM) techniques which use a sampling rate twice that of the original signal frequency.

Wireless Communication Principles

4. Pulse Code Modulation

- The analog samples are referred to as pulse amplitude modulation (PAM) samples.

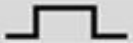


Wireless Communication Principles

4. Pulse Code Modulation

- The digital signal consists of block of *n* bits, where each *n*-bit number is the amplitude of a PCM pulse.

Digit	Binary Equivalent	PCM waveform
0	0000	
1	0001	
2	0010	
3	0011	
4	0100	
5	0101	
6	0110	
7	0111	

Digit	Binary Equivalent	PCM waveform
8	1000	
9	1001	
10	1010	
11	1011	
12	1100	
13	1101	
14	1110	
15	1111	

Pulse Code Modulation

Wireless Communication Principles

5. Multiplexing

- Multiplexing is a technique which makes it possible to combine several logical channels (each capable of supporting an independent connection) into the same physical channel or line.
- Multiple signals or messages may be transmitted through multiplexing.
- The objective of multiplexing is to reduce costs by better utilising the capacity of a line.

Wireless Communication Principles

5. Multiplexing

Time Division Multiplexing / Time Division Multiple Access:

- In TDM, each logical channel is allocated a time slot to transmit over a shared physical channel.
- TDM requires special multiplexing/demultiplexing hardware (MUX) at either end of the line.
- Because the channels are spread across time, some means of initial synchronization is also needed.

Wireless Communication Principles

Frequency Division Multiplexing:

- In FDM, the available bandwidth of the line is divided into a number of partitions, each of which is used as a separate logical channel.
- Radio and TV broadcasting represent the oldest examples of FDM.
- To avoid neighbouring channels from interfering with one another, the extreme ends of the channel frequencies are left unused to provide a gap.

Wireless Communication Principles

5. Multiplexing

Code Division Multiplexing / Code Division Multiple Access:

- In CDM, the available bandwidth and time slot are simultaneously used by all users; each user is assigned a different orthogonal or semi-orthogonal code to modulate the signal (e.g. spread spectrum).

Wireless Communication Principles

5. Multiplexing

Each of the above techniques has its own advantages and disadvantages, which are given below:

- TDM: It is spectrum efficient as only one carrier is used and full bandwidth is available to each user at any given time. Since precise synchronization is necessary, it is not very easy to be implemented.

Wireless Communication Principles

5. Multiplexing

- FDM: It is not the most spectrum efficient (bandwidth is wasted if traffic is not uniform) and is also complex to be implemented.
- CDM: It is the most power and spectrum efficient and can support a large number of users even at low power levels. Signal demodulation is complex.