Unit IV

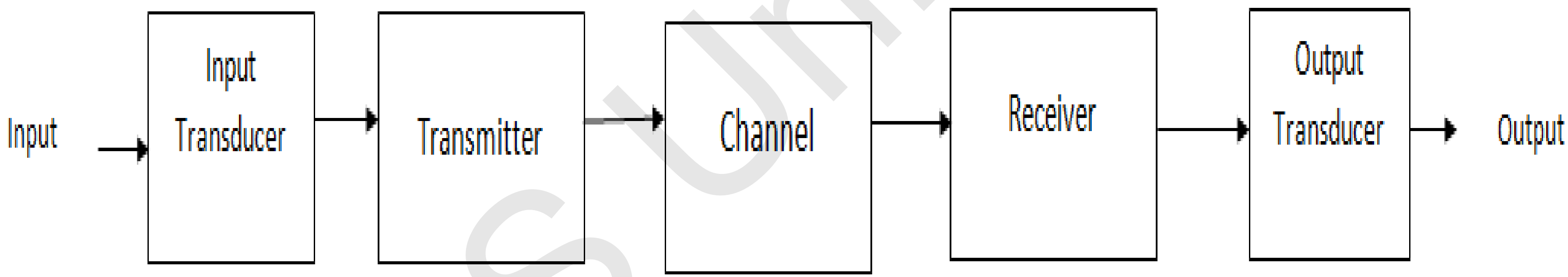
Communication Systems

At the end of this unit, student will be able to

- ❖ Understand the concepts of Communication systems
- ❖ learn the Modulation and Demodulation techniques.
- ❖ Understand the design concepts of cellular concepts

Electronic Communication systems

A communication system is composed of the following blocks



Input Transducer

Source: Analog or digital

Example: Speech, music, written text

Input Transducer: Converts the message produced by a source to a form suitable for the communication system.

Example:

Speech waves→Microphone→Voltage

Channel

- Physical medium that does the transmission
- Examples: Air, wires, coaxial cable, radio wave, laser beam, fiber optic cable
- Every channel introduces some amount of distortion, noise and interference

Receiver

- Extracts message from the received signal Operations:
  - Amplification,
  - Demodulation,
  - Filtering
- In an ideal transmission the receiver output is scaled and possibly delayed version of the message signal.
- In a Practical condition the received signal will have signal component disturbed by noise.

Examples: TV set, radio, web client

Output Transducer

- Transducers converts electrical signal into the form desired by the system

- Transducer can be active transducer and passive transducers based on whether a power source is required or not.

- Active transducer doesn't require any power source for their operations, these transducers work on the principle of energy conversion.

- Whereas passive transducer requires an external power source for their operation.

Modulation

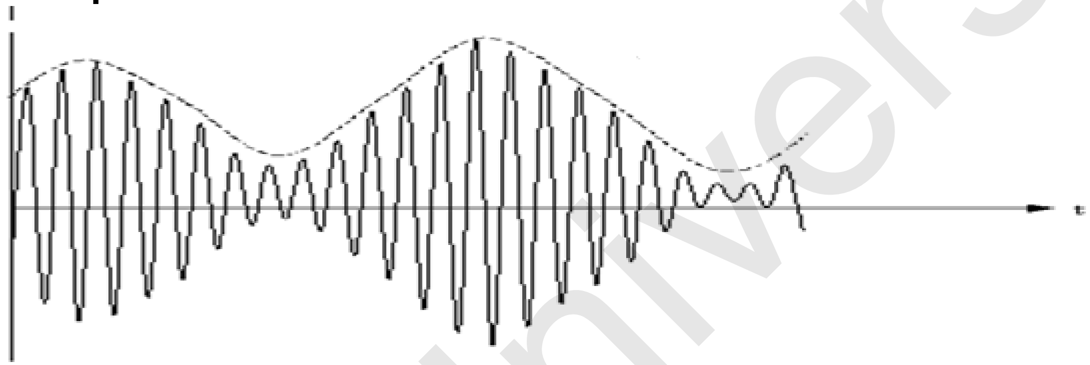
Modulation is a process of changing the carrier signal characteristics according to the message Signal

Types of Modulation:

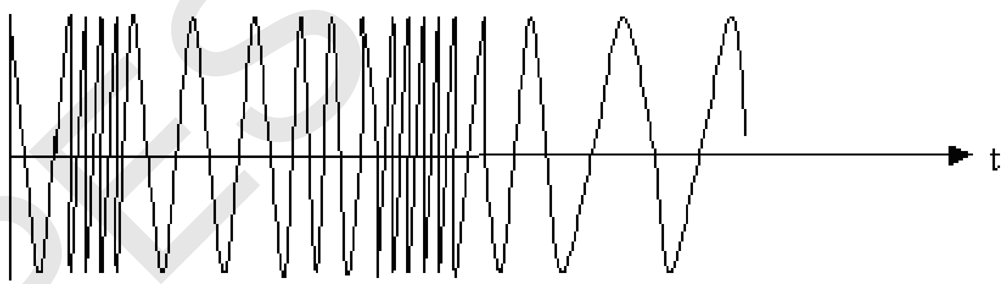
- Continuous Modulation : AM,FM
- Digital Modulation: ASK,PSK,FSK

Types of Analog Modulation

- If the amplitude of the carrier is varied according to the message it is called as Amplitude modulation

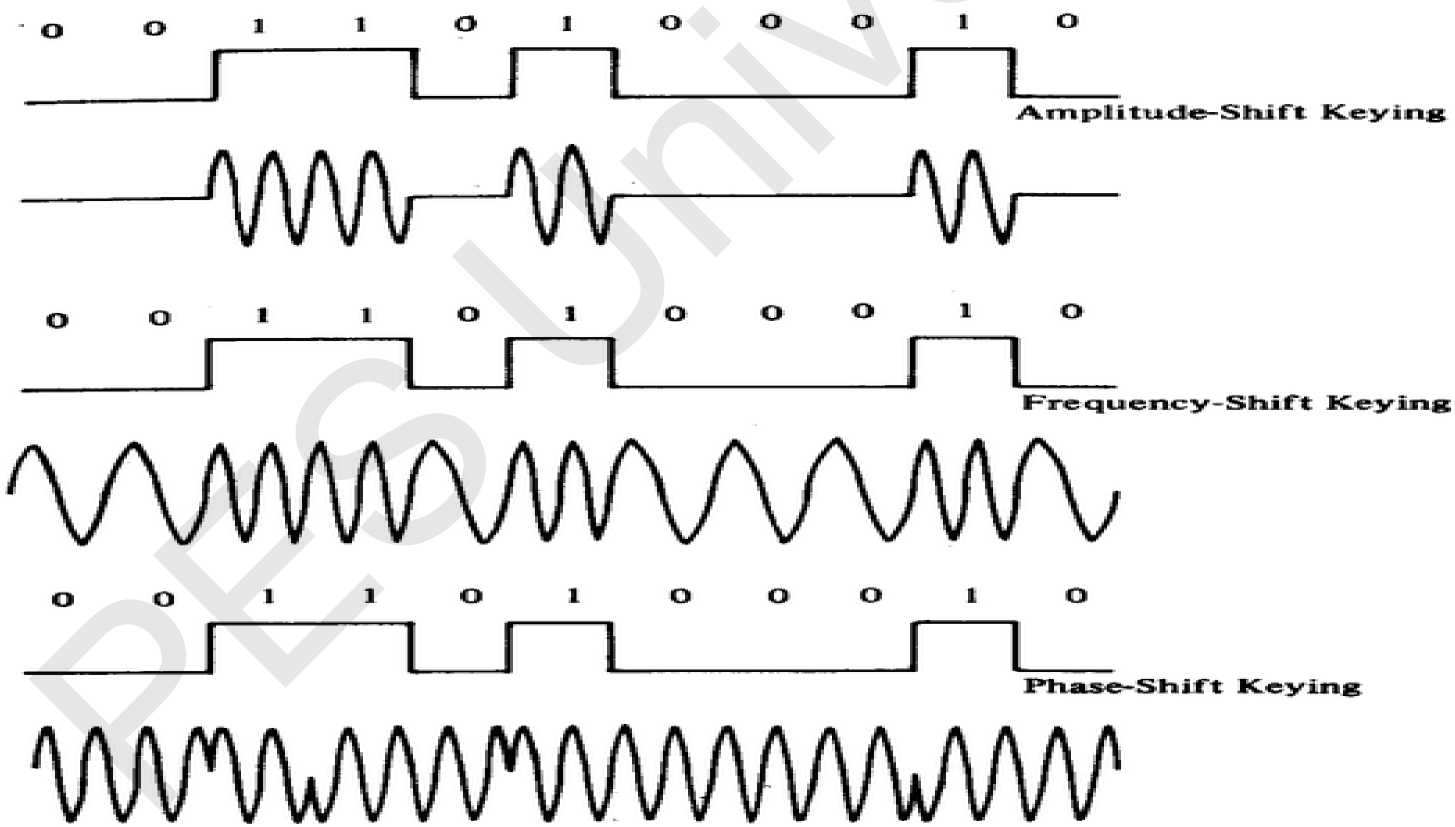


- If the frequency of the carrier is varied according to message it is called as Frequency Modulation.



Types of Digital Modulation

- In Digital Modulation the information will be in binary form i.e. 1s and 0s where as carrier will be continuous.
- The amplitude or phase of the carrier will be varied according to binary data.



Need for Modulation

- Modulation increases the distance over which the signal can be transmitted faithfully
- Modulation reduces the height of the antenna.
- Modulation avoid Mixing of signals
- Modulation will reduce noise and interference.
- Modulation for multiplexing
- Modulation helps to adjust bandwidth.

Demodulation

- The process of recovering the message from the modulated signal is called demodulation
- Two types of demodulation
  - Coherent
  - Non coherent
- In coherent technique a local oscillator is tuned to frequency of carrier to get back the message.
- Non-Coherent does not use any Local oscillator

Applications

Application	Frequency Band
AM Radio	0.54-1.6 MHz
TV	54-88 MHz 174-216 MHz
FM Radio	88-108 MHz
Cellular mobile radio	806-901 MHz

The Cellular Concept - System Design Fundamentals

Introduction

- Goals of a Cellular System
  - High capacity
  - Large coverage area
  - Efficient use of limited spectrum
- Large coverage area - Bell system in New York City had early mobile radio
  - Single Tx, high power, and tall tower
  - Low cost
  - Large coverage area - Bell system in New York City had 12 simultaneous channels for 1000 square miles
  - Small # users
  - Poor spectrum utilization
- What are possible ways we could increase the number of channels available in a cellular system?

- Cellular concept
  - Frequency reuse pattern

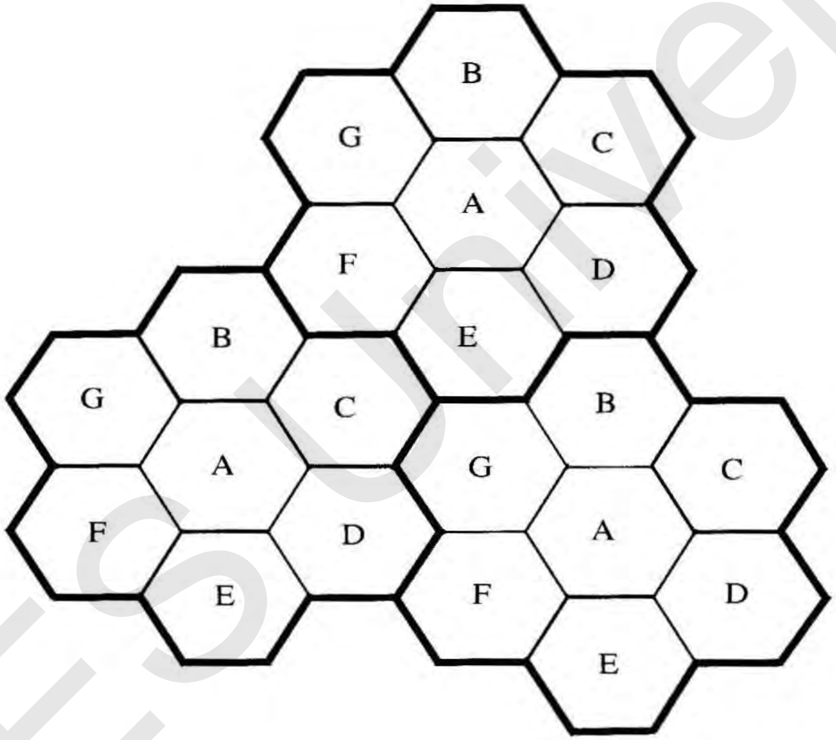


Figure 3.1 Illustration of the cellular frequency reuse concept. Cells with the same letter use the same set of frequencies. A cell cluster is outlined in bold and replicated over the coverage area. In this example, the cluster size, N, is equal to seven, and the frequency reuse factor is 1/7 since each cell contains one-seventh of the total number of available channels.

- Cells labeled with the same letter use the same group of channels.
- Cell Cluster: group of *N* cells using complete set of available channels
- Many base stations, lower power, and shorter towers
- Small coverage areas called “cells”
- Each cell allocated a % of the total number of available channels
- Nearby (adjacent) cells assigned different channel groups
  - to prevent interference between neighboring base stations and mobile users

- Same frequency channels may be reused by cells a “reasonable” distance away
  - reused **many** times as long as interference between same channel (co-channel) cells is < acceptable level
- As frequency reuse↑ ⟶ # possible simultaneous users↑⟶ # subscribers ↑⟶ but system cost ↑ (more towers)
- To increase number of users without increasing radio frequency allocation, reduce cell sizes (more base stations) ↑⟶ # possible simultaneous users ↑
- The cellular concept allows all mobiles to be manufactured to use the same set of freqencies
- ***** A fixed # of channels serves a large # of users by reusing channels in a coverage area *****

- Cells
  - base station antennas designed to cover specific cell area
  - hexagonal cell shape assumed for planning
    - simple model for easy analysis → circles leave gaps
    - actual cell “footprint” is amorphous (no specific shape)
      - where Tx successfully serves mobile unit
  - base station location
    - cell center → omni-directional antenna (360° coverage)
      - not necessarily in the exact center (can be up to *R/4* from the ideal location)

- cell corners → sectored or directional antennas on 3 corners with 120° coverage.
  - very common
  - Note that what is defined as a “corner” is somewhat flexible → a sectored antenna covers 120° of a hexagonal cell.
  - So one can define a cell as having three antennas in the center or antennas at 3 corners.

II. Handoff Strategies

- Handoff: when a mobile unit moves from one cell to another while a call is in progress, the MSC must transfer (handoff) the call to a **new** channel belonging to a **new** base station
  - new voice *and* control channel frequencies
  - very important task → often given higher priority than new call
    - It is worse to drop an in-progress call than to deny a new one

- choose a (handoff threshold) > (minimum useable signal level)
  - so there is time to switch channels before level becomes too low
  - as mobile moves away from base station and toward another base station

III. ROAMING

- A mobile may move into a different system controlled by a different MSC
  - Called an *intersystem handoff*
  - What issues would be involved here?

- Prioritizing Handoffs
  - Issue: Perceived Grade of Service (GOS) – service quality as viewed by users
    - "quality" in terms of dropped or blocked calls (not voice quality)
    - assign higher priority to handoff vs. new call request
    - a dropped call is more aggravating than an occasional blocked call

- Guard Channels
  - % of total available **cell** channels exclusively set aside for handoff requests
  - makes fewer channels available for new call requests
  - a good strategy is dynamic channel allocation (not fixed)
    - adjust number of guard channels as needed by demand
    - so channels are not wasted in cells with low traffic

- Queuing Handoff Requests
  - use time delay between handoff threshold and minimum useable signal level to place a blocked handoff request in queue
  - a handoff request can "keep trying" during that time period, instead of having a single block/no block decision
  - prioritize requests (based on mobile speed) and handoff as needed
  - calls will still be dropped if time period expires

IV. Practical Handoff Considerations

- Problems occur because of a large range of mobile velocities
  - pedestrian vs. vehicle user
- Small cell sizes and/or micro-cells → larger # handoffs
- MSC load is heavy when high speed users are passed between very small cells

- Umbrella Cells
  - Fig. 3.4, pg. 67
  - use different antenna heights and Tx power levels to provide large **and** small cell coverage
  - multiple antennas & Tx can be co-located at single location if necessary (saves on obtaining new tower licenses)
  - large cell → high speed traffic → fewer handoffs
  - small cell → low speed traffic
  - example areas: interstate highway passing thru urban center, office park, or nearby shopping mall

- Typical handoff parameters
  - Analog cellular (1st generation)
    - threshold margin $\Delta \approx$ 6 to 12 dB
    - total time to complete handoff $\approx$ 8 to 10 sec
  - Digital cellular (2nd generation)
    - total time to complete handoff $\approx$ 1 to 2 sec
    - lower necessary threshold margin $\Delta \approx$ 0 to 6 dB
    - enabled by mobile assisted handoff

- benefits of small handoff time
  - greater flexibility in handling high/low speed users
  - queuing handoffs & prioritizing
  - more time to "rescue" calls needing urgent handoff
  - fewer dropped calls → GOS increased
- can make decisions based on a wide range of metrics other than signal strength
  - such as also measure interference levels
  - can have a multidimensional algorithm for making decisions

- MSC dynamically decides which signal is best and then listens to that one
  - Soft Handoff
  - passes data from that base station on to the PSTN
- This choice of best signal can keep changing.
- Mobile user does nothing for handoffs except just transmit, MSC does all the work
- Advantage unique to CDMA systems
  - As long as there are enough codes available.

V. Co-Channel Interference

- Interference is **the** limiting factor in performance of **all** cellular radio systems
- What are the sources of interference for a mobile receiver?
- Interference is in both
  - voice channels
  - control channels

- Let us look at CCI
- Frequency Reuse
  - Many cells in a given coverage area use the same set of channel frequencies to increase system capacity (*C*)
  - Co-channel cells → cells that share the same set of frequencies
  - VC & CC traffic in co-channel cells is an interfering source to mobiles in Several different cells

- Possible Solutions?

1) Increase base station Tx power to improve radio signal reception? __
   - this will also increase interference from co-channel cells by the same amount
   - no net improvement
2) Separate co-channel cells by some minimum distance to provide sufficient isolation from propagation of radio signals?
   - if all cell sizes, transmit powers, and coverage patterns ≈ same ⟶ co-channel interference is independent of Tx power