MODULE 5

Analog Communication Schemes
Modern communication system scheme
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Transmitter
Channel or Medium – Hardwired and Soft-wired
Noise
Receiver
Multiplexing
Types of communication systems
Types of modulation
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Concept of Radio wave propagation (Ground, space, sky)

Digital Modulation Schemes
Advantages of digital communication over Analog-Communication
ASK, FSK, PSK
Radio signal transmission
Multiple access techniques
Review questions

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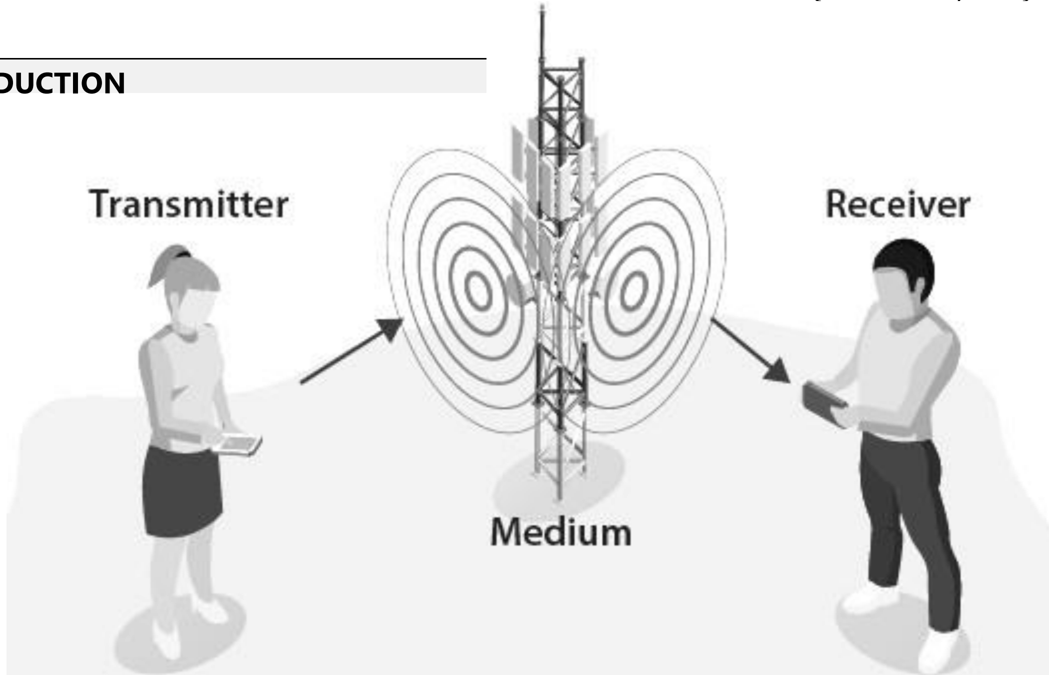
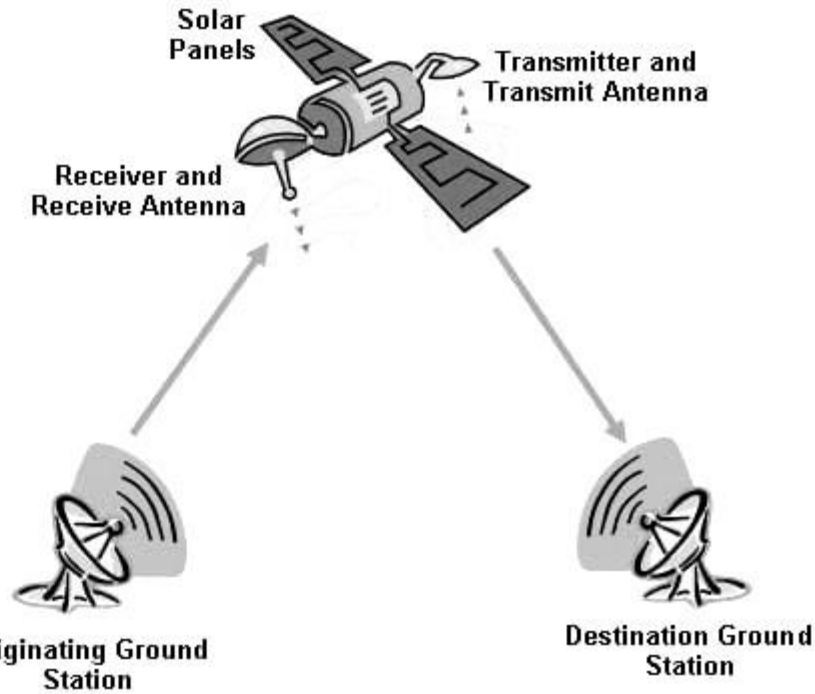
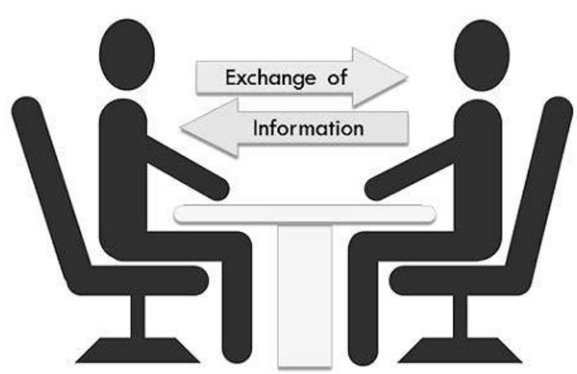
5.1 INTRODUCTION





Communication?

- Transfer of information from one point to other (or) Exchange of Information between two points.
- **Electronic Communication**: Sending data or Information using electronic devices. This allows rapid transfer of goods, money and ideas



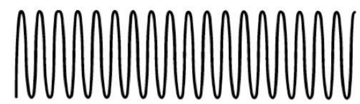
Need for Communication

- **Speedy transmission**: Requires only few seconds to communicate through electronic media due the technology available for quick transmission
- **Wide Coverage**: The whole world has become a global village and communication around the globe requires just a second
- **Low Cost**: Cost of an SMS is cheaper than sending a letter by post
- **Exchange of feedback**: Instant exchange of feedback
- **24/7 accessibility**: Can be accessed anytime

Message signal: The signal that consists information is called modulating signal. The modulating signal is usually of low-frequency signal. (20 Hz – 20 KHz)

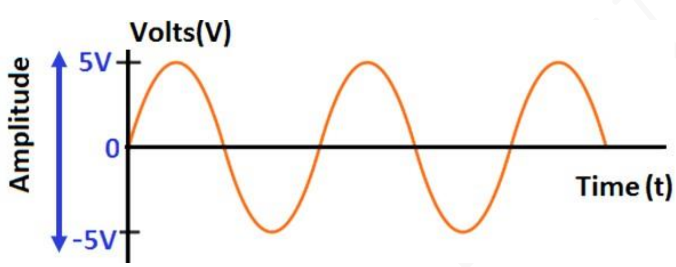
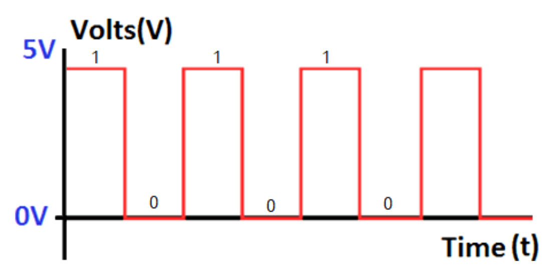
Carrier signal:

The signal which carries the information is called carrier signal. Carrier signal is a high frequency signal which does not contains any information. The purpose of this signal is just to carry the message signal. The range is in terms of Mega Hertz.



Type of Signals

Signals are functions that carry information. We use signals to convey information from place to place. In electronics, signals are mainly in the form of varying voltages. There are *two types* of signals.

Analog Signals	Digital Signals
	
Analog signal is continuous and time varying	Digital signal have two or more states (binary form)
Troubleshooting is difficult.	Troubleshooting is easy.
Easily affected by the noise.	These are stable and less prone to noise.
Analog signals use continuous values to represent the data, usually in the form of sine wave.	Digital signals use discrete values to represent the data, usually in the form of square wave.
Accuracy may be affected by noise.	Accuracy is immune from the noise.
Analog signals may be corrupted during data transmission.	Digital signals are not corrupted during data transmission.
Analog signals use more power.	Digital signals use less power.
Examples: Temperature, Pressure, Flow measurements, etc.	Examples: Motor Start, Trip, etc.
Components like resistors, Capacitors, Inductors, Diodes are used in analog circuits.	Components like transistors, logic gates, and micro-controllers are used in digital circuits.

5.1.1 Modern Communication System scheme

General form of a basic communication system is shown in the fig.5.1(a). Illustration of video communication system is shown in the fig. 5.1(b).

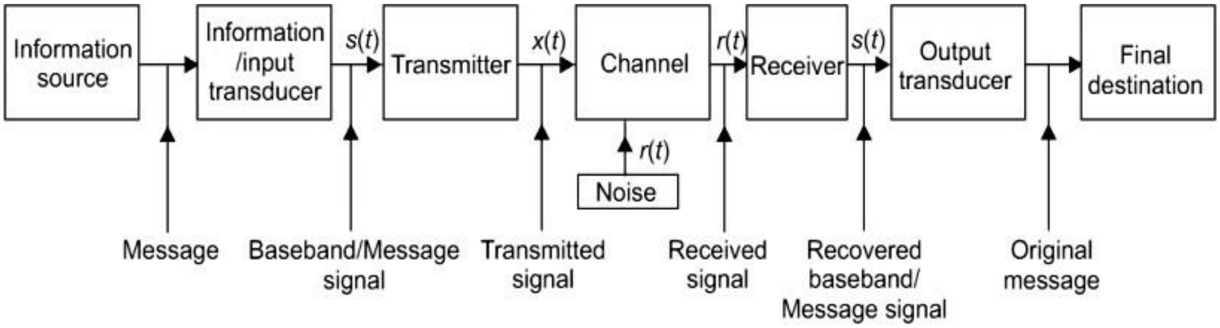


Fig.5.1(a) Illustration of Basic Communication System

Elements of Communication System

- Information source and transducer
- Transmitter
- Channel or medium / Noise
- Receiver
- Output transducer and final destination

A communication system transmits information from an ***information source (message)*** to a ***destination***.

- Examples: Voice, Live scenes (video), music, written text, and e-mail.

A *transducer is a device that* ***converts a physical signal*** *into its corresponding* ***electrical signal*** *and vice versa.*

Examples of input transducers: Sound - Microphone
Picture - Camera
Text - Keyboard
Temperature/Pressure - Sensor with transducer

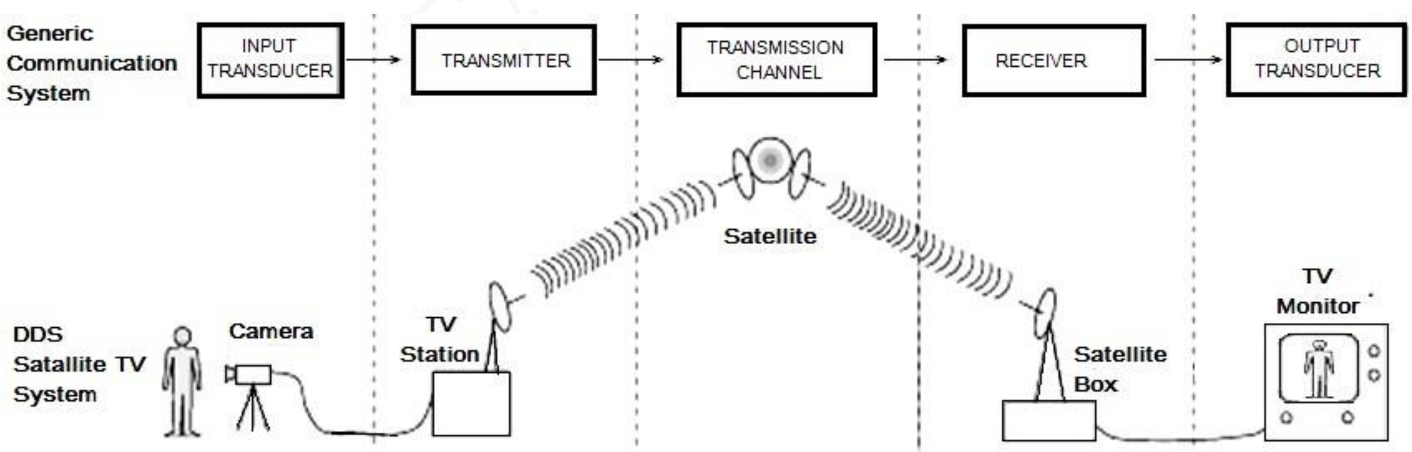


Fig.5.1(b) Illustration of video Communication System

(i) Information Source and Transducer

Message or information originates in the information source may be in the form of sound (human speech), picture (image source), words (text). However, out of these messages, only the desired message is selected and communicated.

A *transducer* is a device which converts one form of energy into another form. Generally, the input transducer converts the non-electrical signal (Ex: sound signal or light signal) into an electrical signal.
For example, in case of radio-broadcasting, a microphone converts the information or massage which is in the form of sound waves into corresponding electrical signal.

(ii) Transmitter

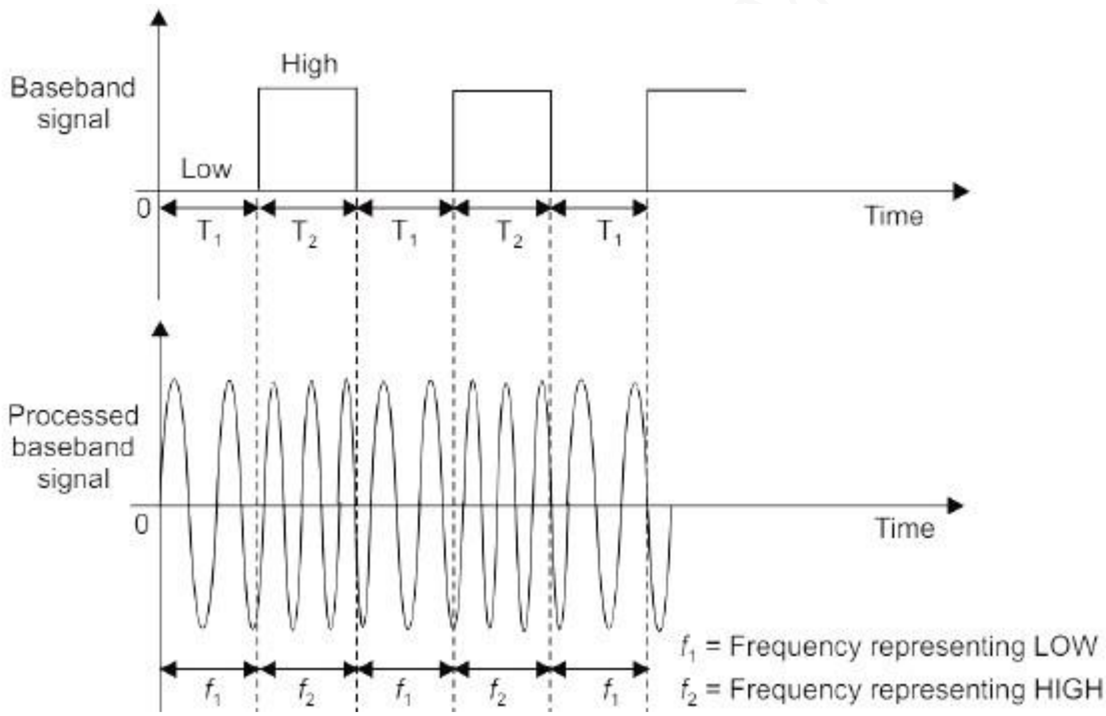
The base band signal (electrical form), output from the input transducer is applied to the input of the transmitter. The transmitter performs three operations: *filtering, amplification* and *modulation*. The nature of processing depends on the type of communication system.

There are two options for processing signals prior transmission

(i) The baseband signal, which lies in the low frequency spectrum, is translated to a higher frequency spectrum --- *carrier communication system*

In this process, *modulation* is the main function of the transmitter. In modulation, the message signal is superimposed upon the high-frequency carrier signal. As the original message signal cannot be transmitted over a longer distance because of their low frequency and amplitude, they are superimposed with high frequency carrier signal.

(ii) The baseband signal is transmitted without translating it to a higher frequency spectrum --- *baseband communication system.*



If the signal is to be transmitted through the space, then the transmitter will convert the electrical signals into radio waves. If the signal is to be transmitted through the fiber optic cable then the transmitter will convert the electrical signal into light or optical signal.

Typical Analog transmitter

Let *s(t)* be the baseband signal applied to the modulated stage as shown in the fig.5.1(c), to translate (modulate) it from low to high frequency spectrum. That means, *s(t)* is superimposed upon the high-frequency carrier signal *c(t),* which is generated by a high frequency carrier oscillator. The output of the modulated stage is called the *modulated signal,* and is designated as *x(t).* This signal is then applied to amplifier stage. The voltage of the modulated signal is amplified to drive the power amplifier stage. The *power amplifier* that amplifies the power of the modulated signal *x(t)* and thus it carries enough power to reach the receiver stage of the communication system. Finally, the signal is passed to the transmission medium or channel.

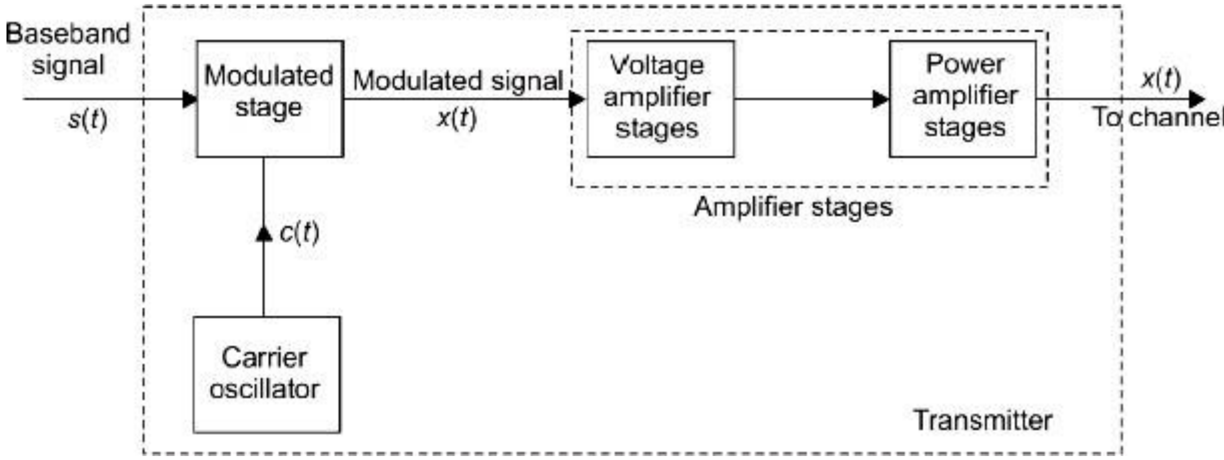


Fig.5.1(c) Block diagram of analog transmitter section

For example, in radio broadcasting the sound signal (message signal) is converted into the electrical signal (baseband signal), by the input transducer. Then, it is modulated with the radio frequency range carrier signals to produce radio signals. These radio signals are transmitted through electromagnetic waves (open space), referred to as radio waves.

Radio Frequency (RF) bands spread in the range between 30 kHz and 300 GHz. Transmission systems are operated in the RF spectrum range and its application in communication systems is tabulated in the table-5.1.

Table 5.1: **Frequency ranges and its application in communication systems**

Frequency Name	Frequency Range	Application
Super high frequencies	3GHz-30GHz	RADAR
Ultra high frequencies	300MHz-3GHz	Satellite communication, cellular phones
Very high frequencies	30MHz-300MHz	TV and FM
High frequencies	3MHz-30MHz	Commercial short wave broadcast
Medium frequencies	300kHz-3MHz	AM broadcast
Low frequencies	30kHz-300kHz	Navigation, submarine communication
Very low frequencies	3kHz-30kHz	Navigation, submarine communication
Voice frequencies	300Hz-3kHz	Navigation ,submarine, audio
Extremely low frequencies	30Hz-300Hz	Power transmission

***(iii)* Channel or medium**

The term channel means the medium through which the message travels from the transmitter to the receiver. The transmitted signal should have adequate power to withstand the channel noise. The channel characteristics also impose constraints on the bandwidth.

Depending on the physical implementations, one can classify the channels in the following two groups:

a) Hardwired channels (Manmade structure)

Transmission lines: It is a conductive medium consisting of two or more conductors through which electrical signal are transmitted from transmitting point to receiver point.

Example: i) *Twisted pair cables* used in telephony, in which two conductors are twisted together for the purposes of improving electromagnetic compatibility.

ii) *Coaxial cable* used in TV transmission, to carry high-frequency electrical signals with low losses.

Waveguide: consisting of a hollow, metal tube of uniform cross-section used for transmitting electro-magnetic waves. When signals entered the waveguides are reflected at the metallic walls and propagate at the other end. The energy is in the form of electric field and magnetic field which are perpendicular to each other.

Optical Fibre: consist of very thin hollow glass fibre through which signal is transmitted in the form of light energy.

b) Soft-wired channels (no physical link between transmitter and receiver)

Natural resources which can be used as the transmission medium for signals.

Example: Air or Open space and Sea water.

The signals are transmitted in the form of electromagnetic (EM) waves also called radio waves. Radio waves travel through open space at a speed equal to that of light ($c = 3 \times 10^8$ m/s)

***(iv)* Noise**

Noise is defined as unwanted electrical signal which do not have any useful information. Noise is a highly undesirable part of a communication system, and has to be minimized. When noise is mixed with the transmitted signal, it rides over it and deteriorates its waveform.

Noise calculation:

Signal to Noise Ratio (SNR) and Noise figure (F)

SNR is defined as the ratio of signal power (S) to the noise power (N), often expressed in decibels (dB).

$$SNR = \frac{P_{signal}\ \text{(Wanted component)}}{P_{noise}\ \text{(Unwanted component)}}$$

If P_s is signal power and P_n is noise power, then SNR expressed as S/N, is given as

$$\frac{S}{N} = \frac{P_s}{P_n}$$

If $P_s = V_s^2 R$ and $P_n = V_n^2 R$, then

$$\frac{S}{R} = \frac{P_s}{P_n} = \frac{V_s^2 R}{V_n^2 R}$$

where V_s is signal voltage and V_n is noise voltage.

In addition, it is assumed that both the signal and noise powers are dissipated in the same resistor R. Therefore, SNR can be expressed in terms of decibels (dB) as

$$\left(\frac{S}{N}\right)_{dB} = 10 \log_{10}\left(\frac{V_s^2}{V_n^2}\right)$$

$$\left(\frac{S}{N}\right)_{dB} = 20 \log_{10}\left(\frac{V_s}{V_n}\right)$$

For example, if, at a particular point in a circuit, the signal and noise voltages are given as 3.5 mV and 0.75 mV, respectively, SNR in dB is calculated as:

$$\left(\frac{S}{N}\right)_{dB} = 20 \log_{10}\left(\frac{3.5}{0.75}\right) = 13.38\ dB$$

Noise Factor, F $\quad \boxed{F = \frac{S_i / N_i}{S_o / N_o}} = \frac{\text{SNR at input}}{\text{SNR at output}}$

Noise Figure, NF $\quad \boxed{\begin{aligned} NF &= 10 \log F \\ &= 10 \log \frac{S_i / N_i}{S_o / N_o} \ (dB) \end{aligned}}$

(v) **Typical Analog Receiver**

The main function of the receiver is to reproduce the original message signal. This reproduction of the original signal is accomplished by a process known as the demodulation or detection.

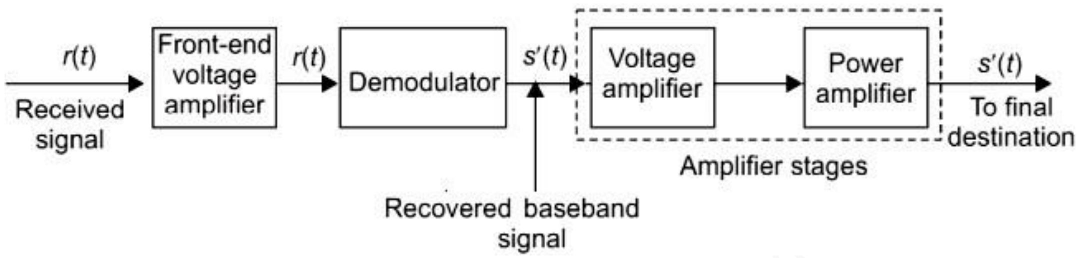


Fig.5.2 Block diagram of analog receiver section

Demodulation is the reverse process of modulation carried out in transmitter. Typical analog receiver section is shown in the fig.5.2. The signal received by the receiver is *r(t)*. Due to attenuation this received signal *r(t)* is a weak signal. A voltage amplifier amplifies to make strong enough for further processing. Next, this signal is applied to the demodulator. In demodulation, the baseband signal is separated from the high-frequency carrier signal. After recovering the original baseband signal *s'(t),* its voltage and power is amplified before send to the final destination block.

(vi) **Destination**

Destination is the final stage which is used to convert an electrical message signal into its original form. For example in radio broadcasting, the destination is a loudspeaker which works as a transducer that converts the electrical signal to original sound signal.

5.1.2 Types of Communication Systems

- **<u>Communication Systems based on Physical Infrastructure</u>**

Based on *physical infrastructure* there are two types of communication systems:

i) **Line communication systems**: Uses power lines to transfer data from one point to another point. There is a physical link, called a hardwire channel between the transmitter and the receiver inline communication systems. Example: Land line telephony, Cable TV

ii) **Radio communication systems**: information is carried across space using radio waves.
Example: Radio broadcasting

- **<u>Communication systems based on Signal specifications</u>**

A. <u>Based on Nature of baseband or information signal</u>

i) **Analog communication systems**: Exchange of information between two points through analog signals. Ex: Audio, video and pictures between two points using the analog signals.

ii) **Digital communication systems**: Exchange of information between two points through digital signals. Ex: Audio, HDTV

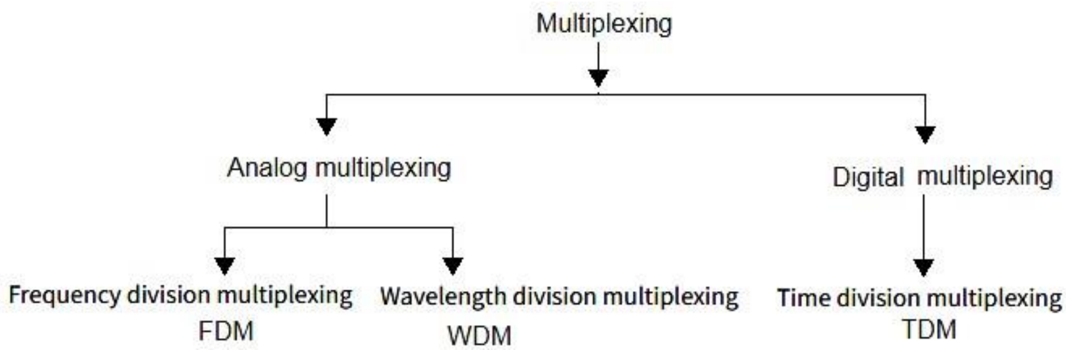
B. Based on Nature of the transmitted signal

i) **Baseband communication system**: Baseband signals are transmitted without translating (or amplified) to higher frequencies. Ex: Land line, fax, etc

ii) **Carrier communication system**: The baseband signal (low frequency) is mixed with high frequency carrier signal. Ex: Radio, voice messages and calls.

5.1.3 Multiplexing

Multiplexing is a process which allows more than one signal to be transmitted through a single channel.



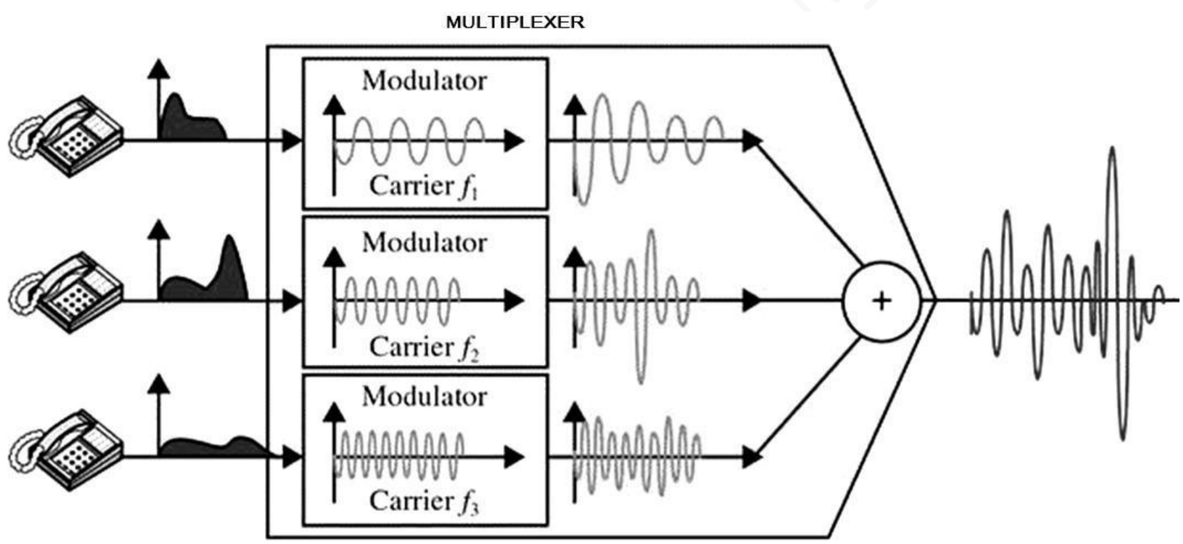
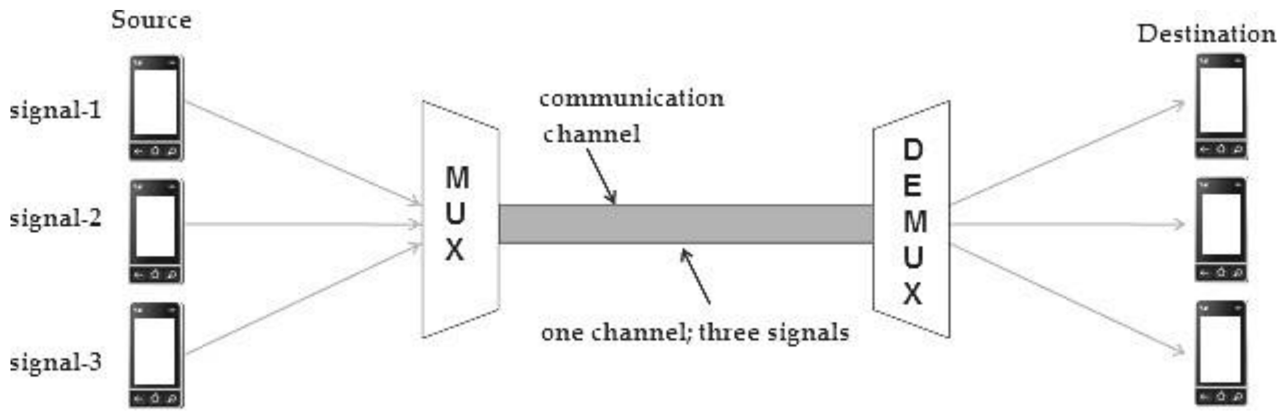


Fig. 5.3 multiplexing various baseband signals

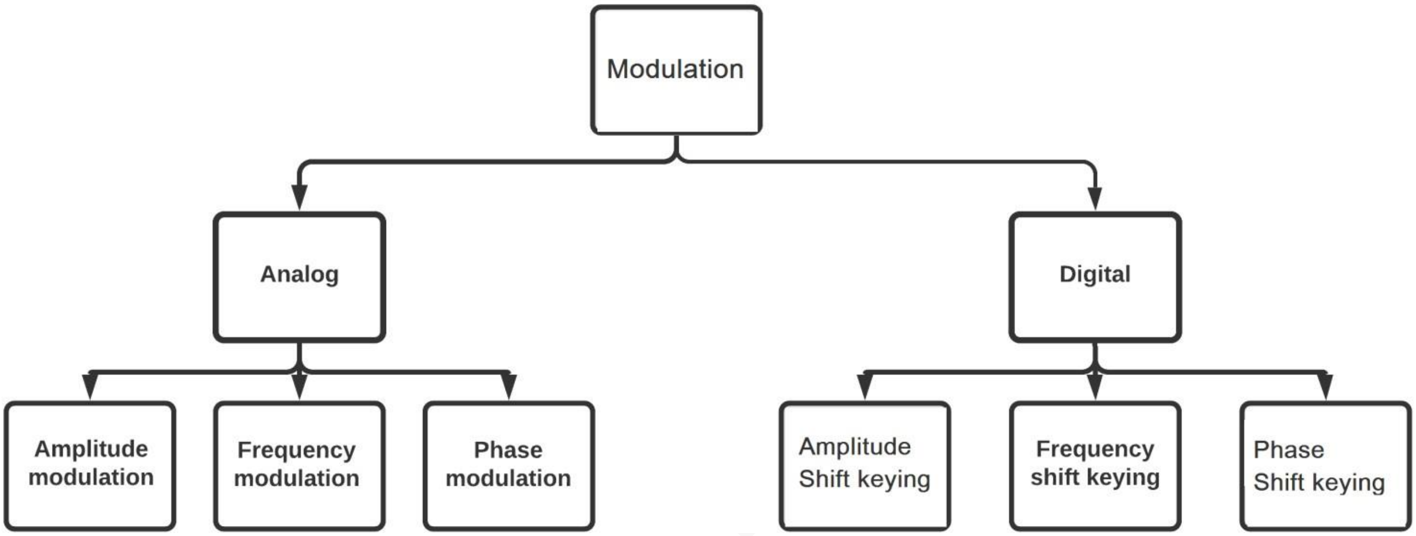
In multiplexing, each baseband signals are modulated with different carrier frequencies. At the transmitter they can be mixes and transmitted as shown in the fig.5.3. At the receiver end, all different transmitted signals can be easily separated by the known carrier frequencies by the process of de-multiplexing and demodulation.



Due to multiplexing it is possible to increase the number of communication channels so that more information can be transmitted where it makes the communication system economical. The typical applications of multiplexing are telephone, satellite communication etc.

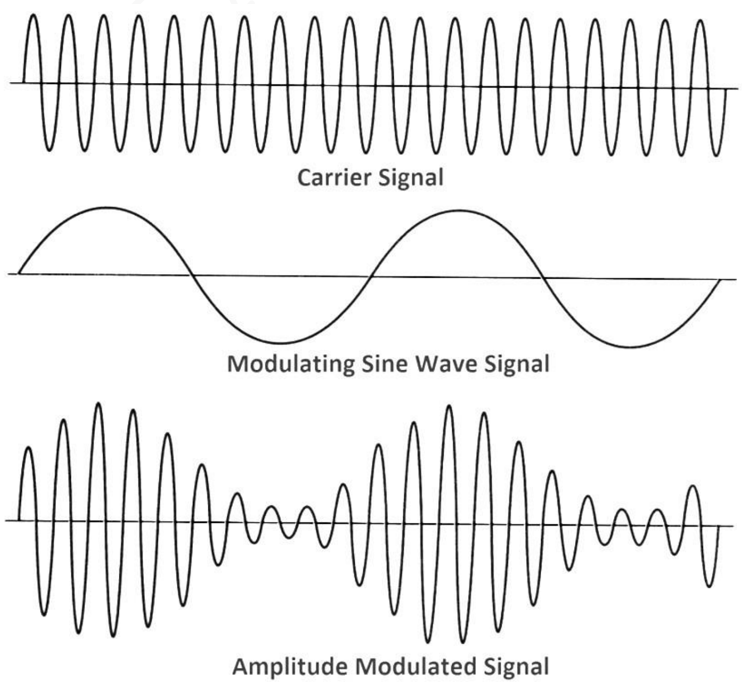
5.1.4 Types of Modulation

Modulation is the process in which any one of the parameters (amplitude, frequency or phase) of the high frequency carrier signal is varied according to the instantaneous values of the low frequency message signal, keeping other parameters constant.



Analog modulation is typically used for AM, FM radio, and short-wave broadcasting. Digital modulation involves transmission of binary signals (0 and 1).

Amplitude Modulation (AM) is the process in which the amplitude of the carrier signal is varied according to the instantaneous values of the message signal, where as the frequency and phase are kept constant. It is as shown in the below figure.



The first figure is the carrier wave, which is a high frequency signal and contains no information. Denoted as

$$c(t) = A_c \cos(2\pi f_c t)$$

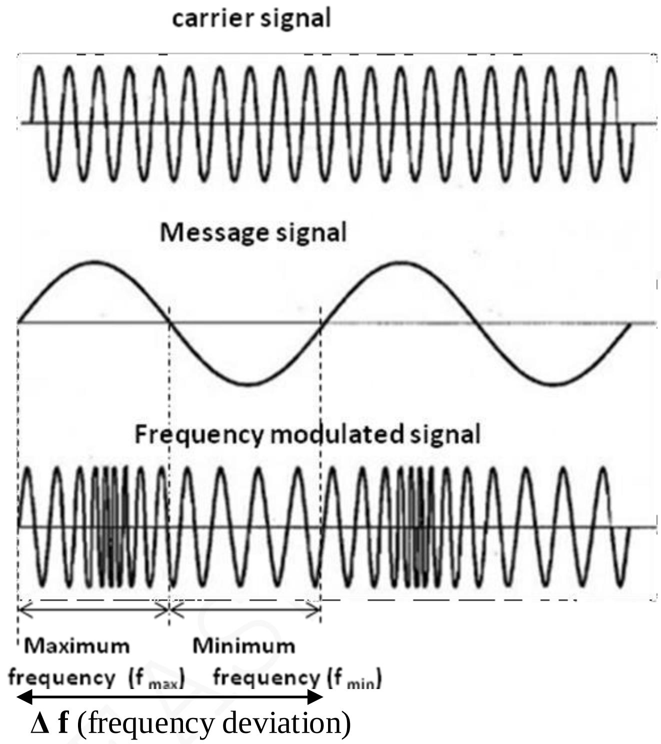
The next one is the modulating wave, which is the message signal; (low frequency signal) contains information. Denoted as $m(t) = A_m \cos(2\pi f_m t)$

The last one is the resultant amplitude modulated wave. Mathematically, AM is denoted as

$$V_{AM} = V_c \sin \omega_c t + \frac{m_a V_C}{2} \cos (\omega_c - \omega_m) t - \frac{m_a V_C}{2} \cos (\omega_c + \omega_m) t$$

In AM, most of the transmitted power is wasted in carrier, but used for longer distance communication.

Frequency Modulation is defined as a process in which the frequency of the carrier is varied in accordance with the instantaneous values of the message signal, where as the amplitude and phase are kept constant.



Mathematically, FM wave is denoted as $S(t) = A \sin [2\pi f_c t + m_f \sin (2\pi f_m t)]$

Modulation index (depth of modulation) $m_f = \frac{\Delta f}{f_m}$

Carrier Swing = $f_{(max)} - f_{(min)} = 2\Delta f$

In FM, all the transmitted power is useful, but used for short distance communication.

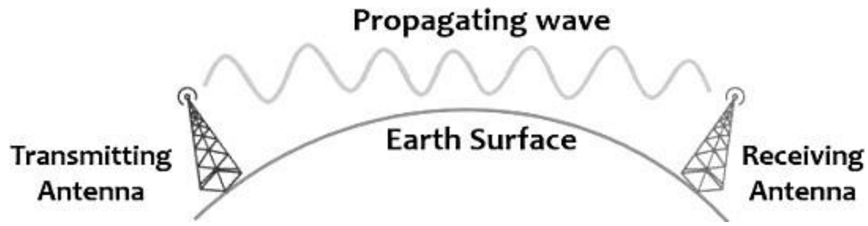
5.2 Radio Wave Propagation/Modes of EM wave Propagation

Radio waves exhibit the properties of light with the velocity 3×10^8 m/s. These are electromagnetic (EM) waves that consist of electric and magnetic field components, traversed perpendicular to one another in nature. Radio signals can travel from one end to another over vast distances. Since these are EM waves, they exhibit properties (like light waves) such as reflection, refraction, diffraction, absorption, polarization and scattering.

Radio propagation is the way of transmitting radio signals in different ways:

i) Ground or surface wave

Ground waves can be used for radio communication. Ground wave transmission is very reliable irrespective of the atmospheric conditions.



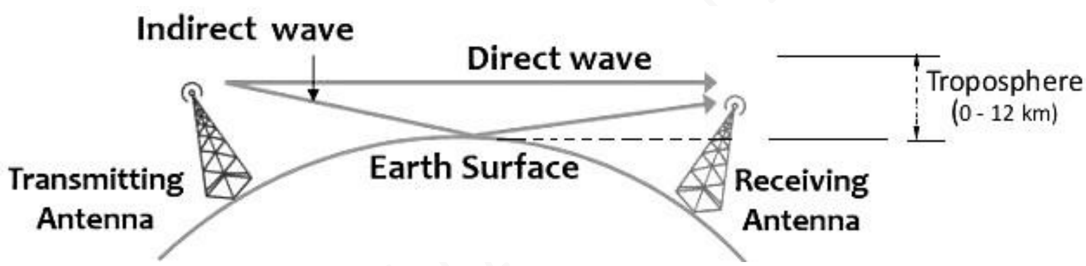
Frequency range: 30 kHz to 3 MHz
Transmission distance: 100 to 1000 km
Example: AM radio broadcast in the medium frequency band cover local areas.

ii) Space or tropo-spheric wave

In space wave (or line of sight propagation), radio waves move in the earth's troposphere within about 12 KM over the surface of the earth. *Frequency range*: 3MHz to 30 MHz. *Example*, TV Transmission. The space wave is made up of two components:

(a) a *direct or line-of- sight wave* from the transmitting antenna *to* the receiving antenna and

(b) an *indirect or ground-reflected* wave traversing form the transmitting antenna to ground and reflected to the receiving antenna.



iii) Sky wave

Radio waves transmitted from the transmitting antenna to the receiving antenna after reflection from the ionosphere (the earth's upper atmosphere) as shown in the fig.5.4.

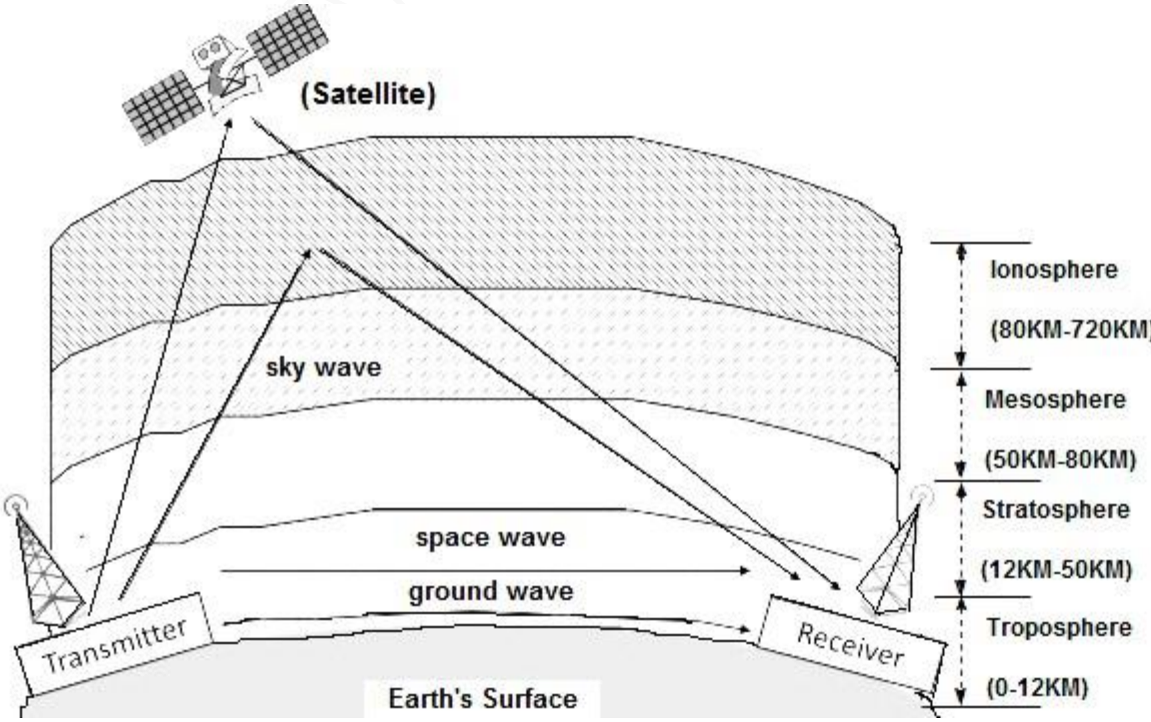


Fig.5.4 Radio wave propagation

Sky wave is responsible for short wave transmission around the globe via successive reflections at the ionosphere and the earth's surface.

Ionosphere - The ionized region extending about 80 KM above the earth's surface. In ionosphere radiation from the sun ionizes atoms and molecules that liberate electrons and ions from molecules. The propagation of radio wave through the ionosphere is affected by the electrons and ions. The effect of the electrons on the propagation is much greater than that of the ions since the electronic mass is much less than the ionic mass.

Advantages of sky wave propagation

1. It supports *large distance propagation*.
2. The *frequency range* of operation is considerably *high*.
3. *Attenuation* due to atmospheric conditions is *less*.

Disadvantages of sky wave propagation

1. Long-distance propagation requires *large-sized antennas*.
2. Due to the presence of the ionosphere near and far during night and day respectively there exist *variation in signal transmission in day and night.*

Applications

Sky wave propagation is widely used in mobile and satellite communications.

5.3 DIGITAL MODULATION SCHEMES

5.3.1 Advantages of Digital Communication over Analog Communication

Most of the real time signals are analog in nature (speech, video, temperature, etc). Digital signals are obtained from analog domain by the techniques viz, sampling, quantization and encoding. As the signals are digitized, there are many advantages of digital communication over analog communication, as listed below −

- Digital communication is lossless transmission.
- Internet and cyberspace could not exist without digital communication.
- Digital communication is fast, easier and cheaper.
- Digital communication system is more immune to noise, hence signal distortion is less.
- Digital circuits are more reliable (performance is better) and consume less power.
- Digital circuits are easy to design and cheaper than analog circuits.
- The hardware implementation is more flexible, easy to implement, less expensive, because of the advancement in the IC technology, powerful microprocessors, bigger memory devices etc.
- The occurrence of cross-talk is very rare in digital communication.
- Encryption allows the better security of data.
- Compression allows data to reduce to lesser in size; hence it can save and retrieve more conveniently.
- The probability of error occurrence is reduced due to error detecting and error correcting codes. In turn, it provides extreme accuracy and fidelity.
- Spread spectrum technique is used to avoid signal jamming.
- Multiplexing is quite easy (combining several digital signals using Time Division Multiplexing is easier).
- Better voice quality over a long distance and an increased level of efficiency.
- Deliver more information with greater portability - a lot of data is sent from one computer to another is faster.
- Simple to use - digital devices are easy to use with flexible features.

- Digital communication enables use of wide band channels such as geostationary satellites, optical fibre cables, co-axial cables etc.
- Greater dynamic range due to use of repeaters.
- It facilitates video conferencing and audio conferencing that saves time, money and effort in real time applications.
- Digital communication is excellent in techniques like image processing, video processing, data compression, channel coding and equalization etc.
- Digital signals can easily be stored, mixed, recording, review and retrieved in an accurate and with less expensive.
- In digital circuits, noise, temperature and other parameter fluctuations have a minimal influence.

5.3.2 Modulation Schemes

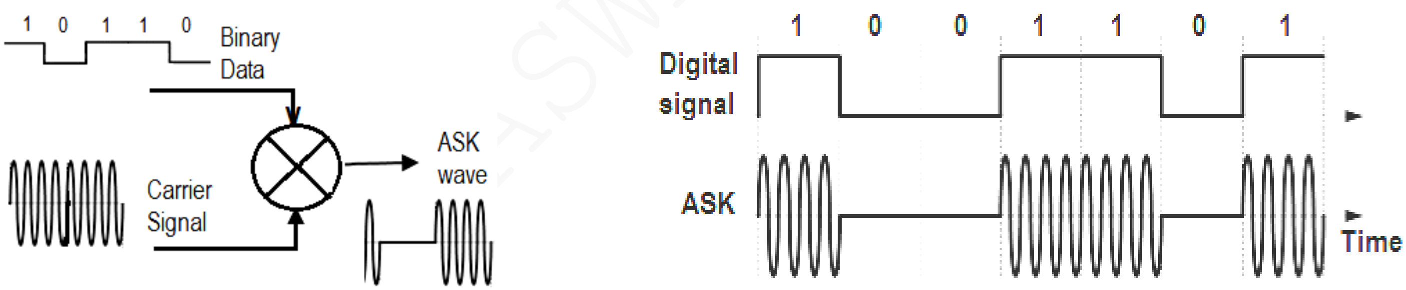
In digital communications, the modulating signal consists of binary data. When it is required to transmit digital signals, the amplitude, frequency or phase of the sinusoidal carrier is varied in accordance with the incoming digital data.

Digital modulation schemes are classified as

i) Amplitude Shift Keying (ASK)
ii) Frequency Shift Keying (FSK)
iii) Phase Shift Keying (PSK)

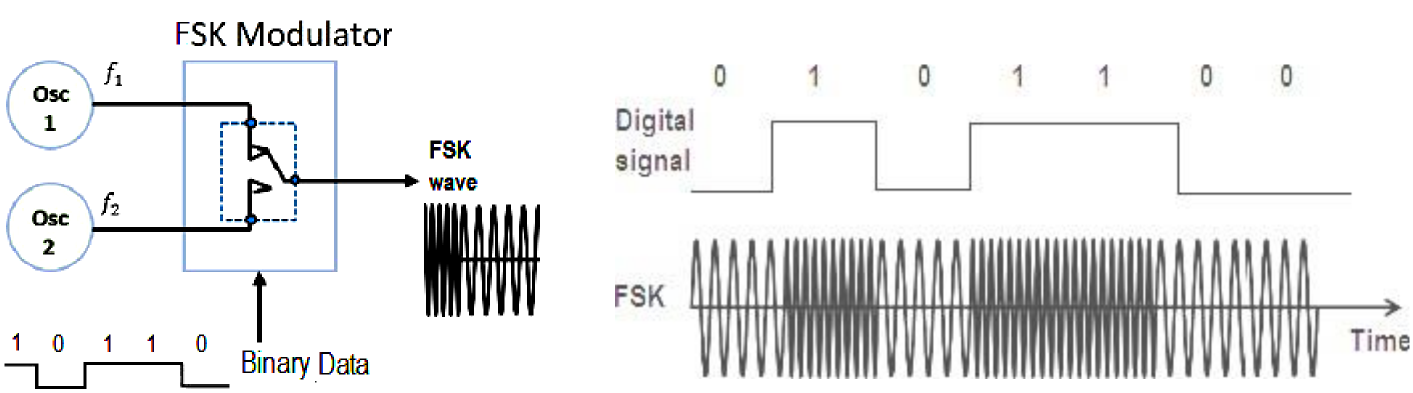
ASK (Amplitude Shift Keying)

ASK represents digital data as variations in the amplitude of a carrier wave. ASK signal can be generated when the incoming binary data and the sinusoidal carrier are applied to a product modulator as inputs. See the figure given below.



FSK (Frequency Shift Keying)

In this technique digital signal is transmitted by switching between low frequency and high frequency in order to represent 0's and 1's. The simplest FSK is Binary FSK (BFSK). It uses a pair of discrete frequencies to transmit binary (0s and 1s) information. See below figure.

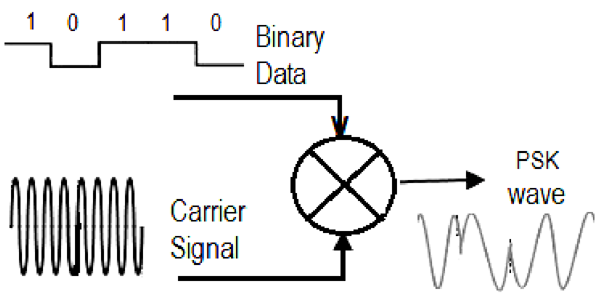


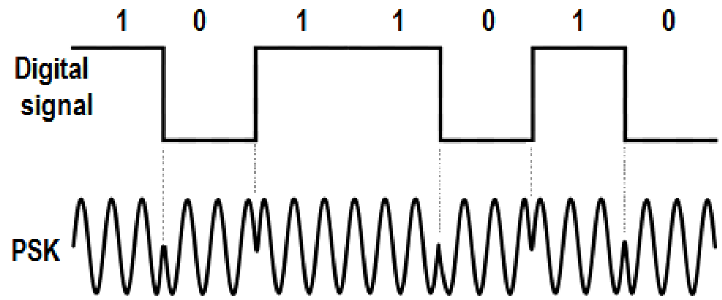
Phase Shift Keying (PSK)

The simplest form of PSK is binary phase shift keying (BPSK). In this case, the carrier phase is shifted between two different phases (typically 0° and 180°) depending on whether 0-bit or 1-bit is being transmitted. For example:

0-bit: the symbol transmitted is $Vc \cos(2\pi f_c t)$

1-bit: the symbol transmitted is $Vc \cos(2\pi f_c t + 180°) = -Vc \cos(2\pi f_c t)$





5.4 Radio signal Transmission

From the fig.5.5, the wireless transmitter accepts four different binary streams of bits (00, 10, 11 and 01) from the application software. Further, these bits encoded on to a radio wave, known as a carrier by adjusting its amplitude or phase. Transmitter operates in two stages. In the first stage, *quadrature phase shift keying* (QPSK) modulator accepts the incoming binary bits and convert it to symbols that represents the amplitude and the phase. Then, the symbols are passed over the analog transmitter, which generates the radio wave.

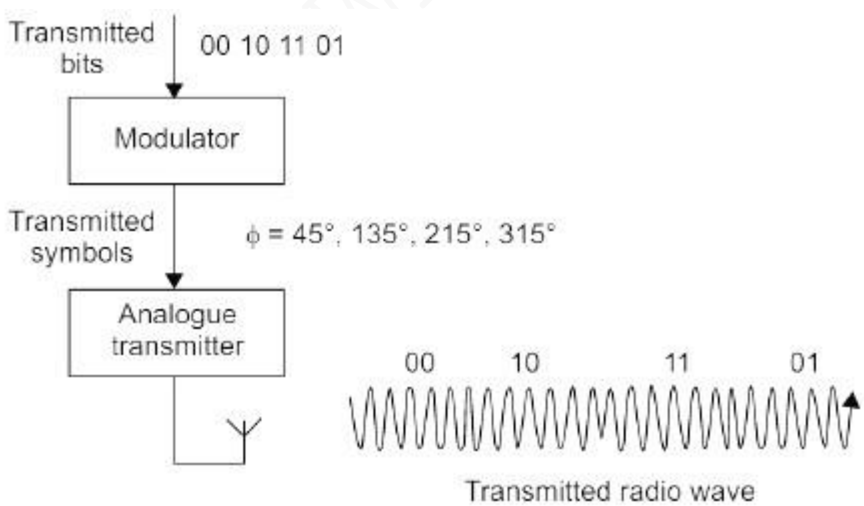


Fig.5.5 Wireless communication transmitter

QPSK modulator takes two bits at a time and transmits them using a radio wave. Four different binary states have phases of 45^o, 135^o, 225^o, and 315^o as shown in the fig.5.5.

The distance of each state from the origin represents the amplitude of the transmitted wave, while angle measured anti-clockwise from x-axis represents the phase as shown in the constellation diagram fig.5.6(b).

Each symbol is conveniently represented by two components: *in-phase* (I) and *quadrature* (Q).

$$I = a \cos \Phi \text{ (real part)}$$

$$\text{and } Q = a \sin \Phi \text{ (imaginary part)}$$

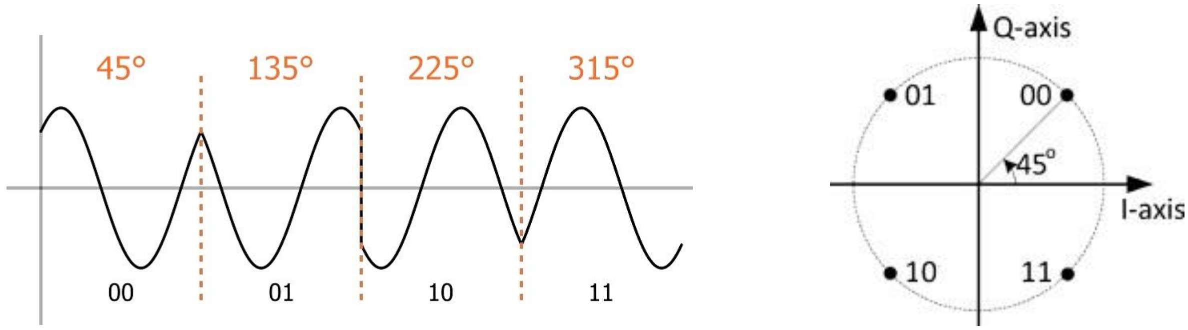


Fig.5.6 (a) QPSK representation **(b) QPSK constellation diagram**

> **Note:** Radio works by transmitting and receiving electromagnetic waves. Radio signal uses specific radio frequency AM is expressed in kilo Hertz, while FM radio is expressed in mega Hertz.

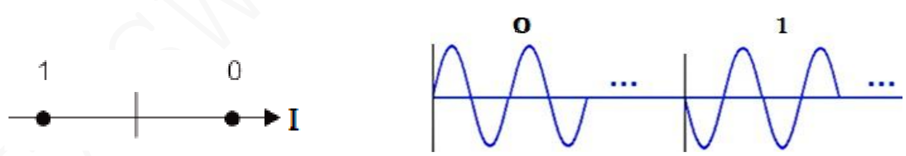
LTE Modulation scheme

LTE (Long Term Evolution) is a standard for wireless broadband communication for mobile devices (marketed as 4G). LTE uses four modulation schemes together as given below and shown in the fig.7

i) Binary Phase Shift Keying – BPSK
ii) Quadrature Phase Shift Keying - QPSK
iii) 16 Quadrature Amplitude Modulation -16 QAM
iv) 64 Quadrature Amplitude Modulation – 64 QAM

i) BPSK sends one bit at a time using two states (0 and 1) representing phases of 0^o and 180^o or signal amplitudes of +1 and -1

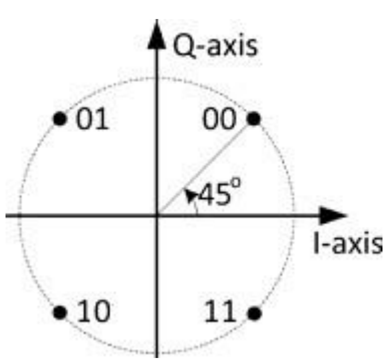
BPSK (1 bit per symbol)



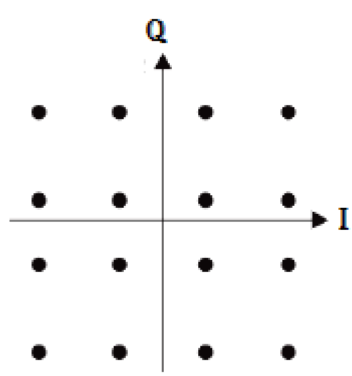
ii) QPSK sends two bits at a time using 4 states (00, 01, 10 and 11) to represent amplitude and phase by 45^o, 135^o, 225^o, and 315^o

iii) 16 - QAM sends four bits at a time using 16 states to represent amplitude and phase.

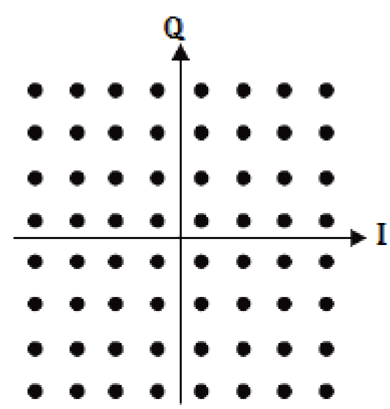
iv) 64 - QAM sends six bits at a time using 64 states to represent amplitude and phase.



QPSK (2 bits per symbol)



16-QAM (4-bits per symbol)



64-QAM (6-bits per symbol)

Fig. 7 LTE Modulation scheme

5.5 Multiple Access Techniques

Multiple access is a technique to provide communication service to multiple users over a single channel. It allows multiple mobile users share the allotted spectrum in the most effective manner. There are three types.

1) Frequency Division Multiple Access (FDMA)

Available frequency band is split into smaller frequency channels, and different channels are assigned to different users at same time. The carriers are separated by guard bands, which avoid the interference between the users.

2) Time Division Multiple Access (TDMA)

Various users can transmit at the same frequency band at different times. Every user is permitted to transmit only in specific time slots using a common frequency band.

GSM uses a combination of both TDMA and FDMA techniques.LTE uses orthogonal FDMA techniques.

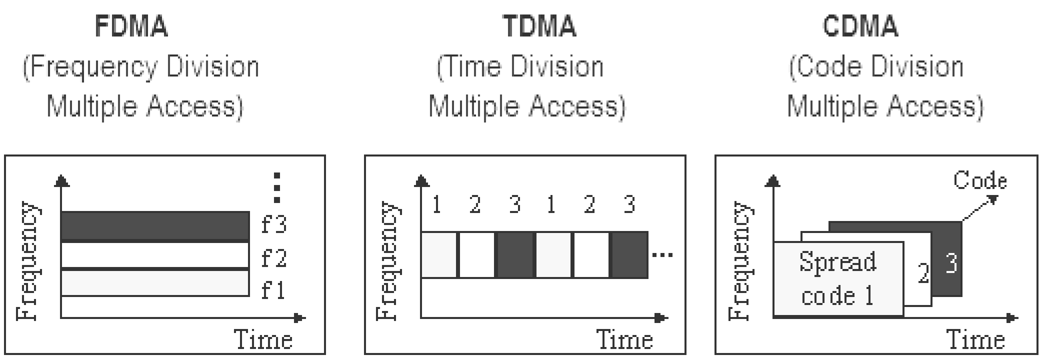


Fig.8 Multiple Access Techniques

3) Code Division Multiple Access (CDMA)

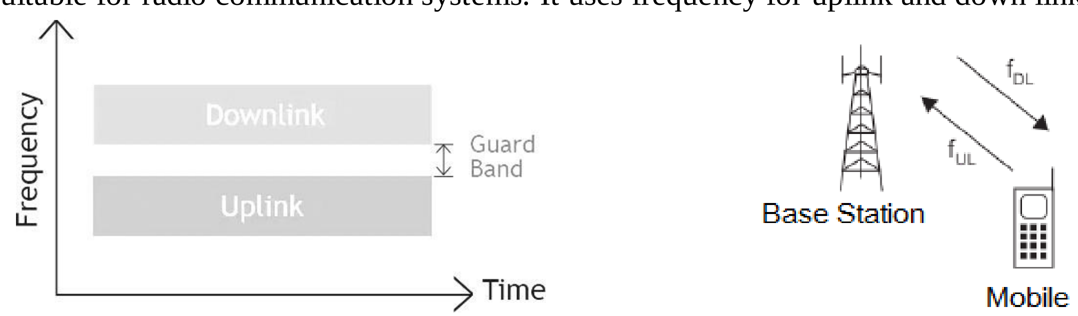
Mobiles receive signals on the same carrier frequency and at the same time. But the signals are labeled by the use of codes, which allows a mobile to separate its own signal from the others.

CDMA is the common platform on which 3G technologies are built.

FDD and TDD Modes

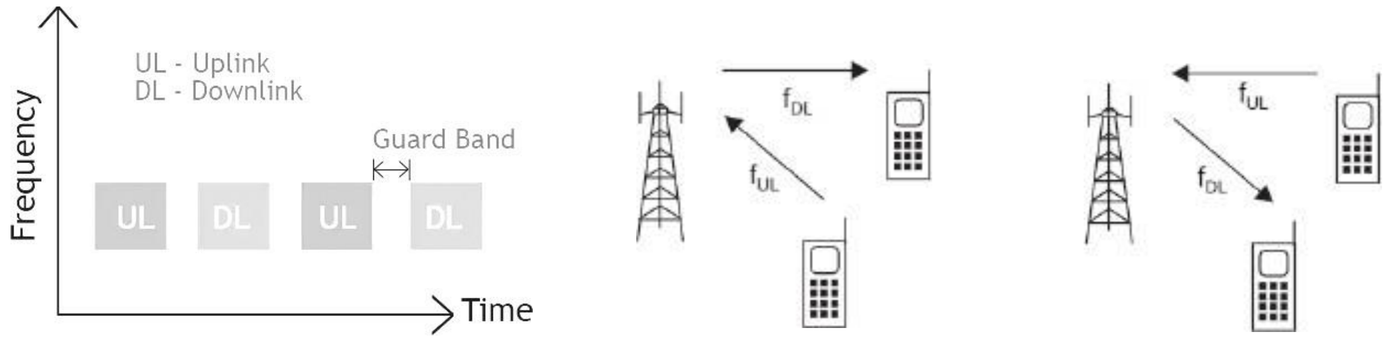
Duplexing: Allows users to send information simultaneously to the base station, while receiving information from the base station. The wireless telephony applies duplexing technique where talking and listening is enabled at a time.

Frequency Division Duplexing (FDD): Base station and mobile will transmit and receive at the same time, but using different carrier frequencies. FDD uses two separate frequency bands for every user. A sufficient guard band needs to separate the transmitting and receiving channels, so they do not interfere with one another. FDD is suitable for radio communication systems. It uses frequency for uplink and down link.



Down link: Base Station to mobile; **Uplink**: Mobile to Base Station]

Time Division Duplexing (TDD)- Base station and mobile will transmit and receive on the same carrier frequency but at different times. Time slots could be dynamically allocated separated by a guard band. A guard period ensures that UL and DL transmissions do not collide. TDD is more suitable for fixed wireless systems. It uses time for uplink and down link.



Review Questions

1. Describe the blocks of the basic communication system.
2. Define the following terms: i) Carrier communication system ii) Baseband communication system with neat and suitable waveforms.
3. Define and explain SNR, Noise Figure, channel types.
4. What is modulation? Define AM and FM. Explain types of analog modulation with the help of waveforms.
5. With suitable waveforms explain digital modulation schemes.
6. Present the architecture of a wireless communication transmitter and its modulation scheme QPSK with waveforms and constellation diagrams.
7. Discuss the transmission modes used in mobile communication system.
8. Discuss the various Multiple Access Techniques used in cellular network.