Module 1: Introduction to communication system

Definition :

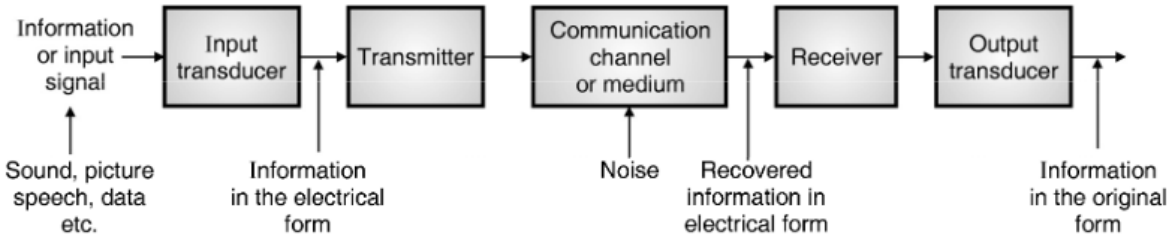
- A communication system is defined as a collection of individual communications networks, transmission systems, relay stations, communication channels and receivers interconnected to exchange meaningful information.

Block diagram :

- The block diagram of the simplest possible communication system is as shown in Fig. 1.2.1.
- As seen from the Fig. 1.2.1, the elements of a basic communication system are transmitter, a communication medium (channel) and the receiver.
- When the transmitted signal is travelling from the transmitter to the receiver over a communication channel, noise gets added to it.
- The elements of basic communication system are as follows :
  1. Information or input signal
  2. Input transducer
  3. Transmitter
  4. Communication channel or medium
  5. Noise
  6. Receiver
  7. Output transducer

Information or Input signal :

- The communication systems have been developed for communicating useful information from one place to the other.
- This information can be in the form of a sound signal like speech or music, or it can be in the form of pictures (TV signals) or it can be data information coming from a computer.



(D-1) **Fig. 1.2.1 : Block diagram of the basic communication system**

Input transducer :

- The information in the form of sound, picture or data signals cannot be transmitted as it is.
- First it has to be converted into a suitable electrical signal. The input transducer block does this job.
- The input transducers commonly used in the communication systems are microphones, TV camera etc.

Transmitter :

- The function of the transmitter block is to convert the electrical equivalent of the information to a suitable form.
- In addition to that it increases the power level of the signal. The power level should be increased in order to increase the range of transmitted signal.
- The transmitter consists of the electronic circuits such as amplifier, mixer, oscillator and power amplifier.

Communication channel or medium :

- The communication channel is the path used for transmission of electronic signal from one place to the other.
- The communication medium can be conducting wires, cables, optical fibre or free space. Depending on the type of communication medium, two types of communication systems will exist. They are :
  1. Wired communication or line communication
  2. Wireless communication or radio communication
- The radio communication systems use the free space as their communication medium.
- They do not need the wires for sending the information from one place to the other.
- The radio or TV broadcasting, satellite communication are the examples of the wireless communication.
- These systems transmit the signal using a transmitting antenna in the free space.
- The transmitted signal is in the form of electromagnetic waves. A receiving antenna will pick up this signal and feed it to the receiver.

- Radio communication can be used for the long distance communication such as from one country to the other or even from one planet to the other.

Noise :

- Noise is an unwanted electrical signal which gets added to the transmitted signal when it is travelling towards the receiver.
- Due to noise, the quality of the transmitted information will degrade. Once added, the noise cannot be separated out from the information.
- Hence noise is a big problem in the communication systems. (Especially analog communication systems).
- The noise can be either natural or manmade. The sources of natural noise are lightning or radiation from the sun and stars etc.
- The man made noise includes the noise produced by electrical ignition systems of the automobiles, welding machines, electric motors etc.
- Even though noise cannot be completely eliminated, its effect can be reduced by using various techniques.

Receiver :

- The process of reception is exactly the opposite process of transmission. The received signal is amplified, demodulated and converted into a suitable form.
- The receiver consists of electronic circuits like mixer, oscillator, detector, amplifier etc.

Output transducers :

- The output transducer converts the electrical signal at the output of the receiver back to the original form i.e. sound or TV pictures etc.
- The typical examples of the output transducers are loud speakers, picture tubes, computer monitor etc.

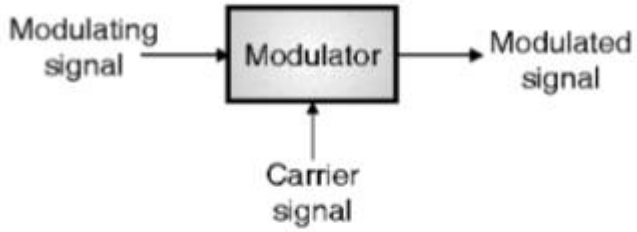
Module 3: Modulation

In the **Modulation** process, two signals are used namely the **modulating signal** and the **carrier.**

The modulating signal is nothing but the baseband signal or information signal while carrier is a high frequency sinusoidal signal.

Definition :

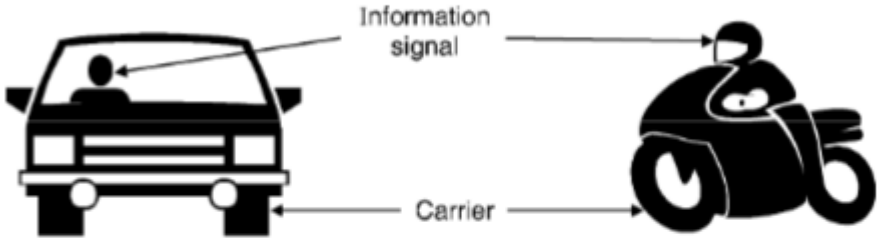
- Modulation is defined as the process in which some parameter of the carrier wave (such as amplitude, frequency or phase) is varied in proportion with the instantaneous magnitude of the modulating signal.



(D-8) Fig. 1.7.1 : Modulation

- The result of this process is called as the modulated signal. This modulated signal is then transmitted by the transmitter over a communication channel or medium.
- The receiver will **"Demodulate"** the received modulated signal and get the original information signal back. Thus demodulation is exactly opposite to modulation.
- In the process of modulation, the carrier wave actually acts as a **carrier** which carries the information signal (modulating signal) from the transmitter to receiver.

- This is similar to a situation in which a person travels in his car or on his bike from one place to the other.
- The person can be viewed as the modulating signal and the car or bike as the carrier as shown in Fig. 1.7.2.



(D-9) **Fig. 1.7.2 : Concept of modulation**

Frequency Translation in the Modulation Process :

- The baseband signal or modulating signal is a low frequency signal. For example the audio signal is present in the frequency range from 20 Hz to 20 kHz.
- But due to modulation, the same signal now gets translated to a higher frequency range.
- For example the Vividh Bharati FM pune station is tuned at 101 MHz, or AM Pune station is at 792 kHz.

1.8 Need of Modulation :

MU : Dec. 17, May 19, Dec. 19

University Questions

Q. 1 Define modulation and explain any two need of modulation. **(Dec. 17, 5 Marks)**

Q. 2 Write short note on need of modulation. **(May 19, 5 Marks)**

Q. 3 Explain need of modulation. Justify it with example. **(Dec. 19, 5 Marks)**

- A question may be asked as, when the baseband signals can be transmitted directly why to use the modulation ?
- The answer is that the baseband transmission has many limitations which can be overcome using modulation. It is as explained below.
- In the process of modulation, the baseband signal is "translated" i.e. shifted from low frequency side to high frequency side of the frequency spectrum.
- This frequency shift is proportional to the frequency of carrier.
- The modulation process is needed because it offeres the following advantages :

Advantages of modulation :

1. Reduction in the height of antenna
2. Avoids mixing of signals
3. Increases the range of communication
4. Multiplexing becomes possible
5. Improves quality of reception.

Reduction in height of antenna :

- For transmission of radio signals, the antenna height must be a multiple of ($\lambda/4$). Here λ is the wavelength. $\lambda = c/f$ where c is velocity of light and f is the frequency of the signal to be transmitted.
- The minimum antenna height required to transmit a baseband signal of f = 10 kHz is calculated as follows :

$$\text{Minimum antenna height} = \frac{\lambda}{4} = \frac{c}{4f}$$

$$= \frac{3 \times 10^8}{4 \times 10 \times 10^3}$$

$$= 7500 \text{ meters i.e. } 7.5 \text{ km}$$

- The antenna of this height is practically impossible to install.
- Now consider a modulated signal at f = 1 MHz. The minimum antenna height is given by,

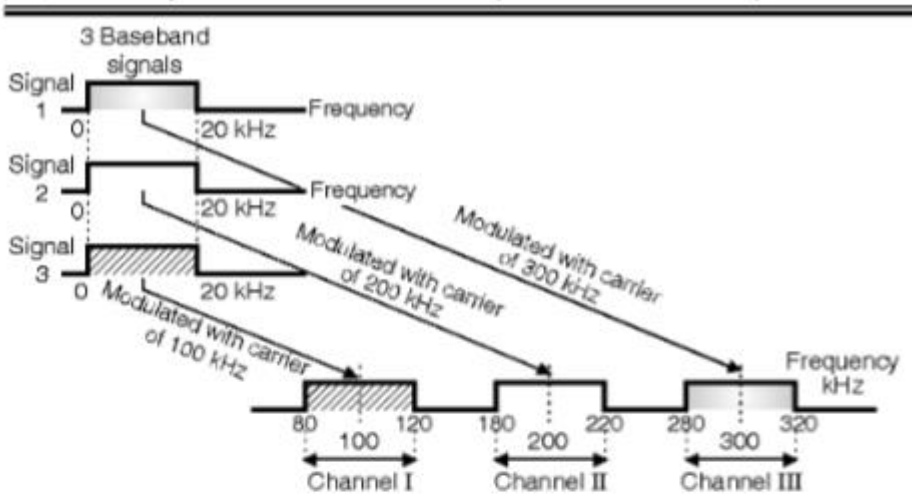
$$\text{Minimum antenna height} = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3 \times 10^8}{4 \times 10 \times 10^6}$$

$$= 75 \text{ meters}$$

- This antenna can be easily installed practically. Thus modulation reduces the height of the antenna.

Avoids mixing of signals :

- If the baseband sound signals are transmitted without using the modulation by more than one transmitter, then all the transmitted signal by multiple transmitters will be in the same frequency range i.e. 0 to 20 kHz.
- Therefore the signals from different stations get mixed together and a receiver cannot separate them from each other.
- So if each baseband sound signal is used to modulate a different carrier which corresponds to a different station then they will occupy different slots in the frequency spectrum (different channels).
- This is as shown in Fig. 1.8.1. Thus modulation avoids mixing of signals.



(D-10) Fig. 1.8.1 : Modulation avoids mixing of signals

Increases the range of communication :

- The frequency of baseband signals is low, and the low frequency signals cannot travel a long distance when they are transmitted. They get attenuated (suppressed) quickly.
- The attenuation reduces with increase in frequency of the transmitted signals, and they travel longer distance.
- The modulation process increases the frequency of the signal. Hence it increases the range of communication.

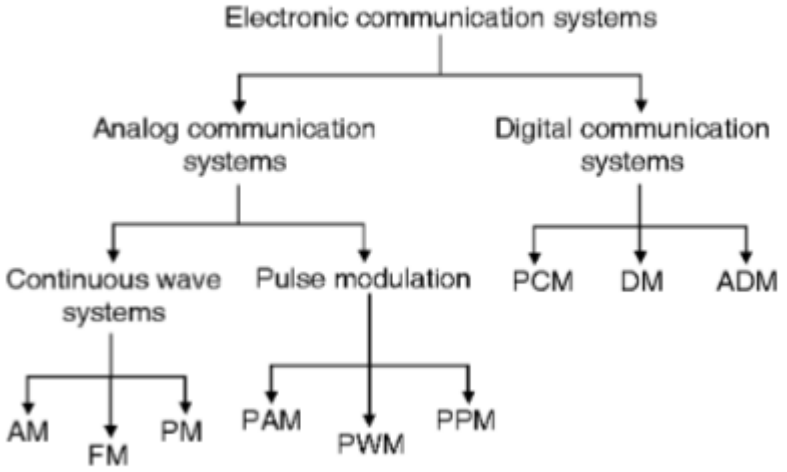
Multiplexing is possible :

- Multiplexing is a process in which two or more signals can be transmitted over the same communication channel simultaneously.
- This is possible only with modulation. The multiplexing allows the same channel to be used by many signals.
- So many TV channels can use the same frequency range, without getting mixed with each other. OR different frequency signals can be transmitted at the same time.

Improves quality of reception :

- With Frequency Modulation (FM), and the digital communication techniques like PCM, the effect of noise is reduced to a great extent. This improves quality of reception.

- The electronic communication systems are classified into two categories namely :
  1. Analog communication systems.
  2. Digital communication systems.



(D-6) **Fig. 1.9.1 : Classification based on analog or digital communication**

1.9.1 Analog Communication :

Definition :

- The modulation systems or techniques in which one of the characteristics of the carrier is changed in proportion with the instanteous value of modulating signal is called as analog modulation system.
- If the carrier is sinusoidal then it's amplitude, frequency or phase is changed in accordance with the modulating signal to obtain AM, FM or PM respectively.
- These are continuous wave modulation systems.
- Analog modulation can be pulsed modulation as well. Here the carrier is in the form of rectangular pulses.
- The amplitude, width (duration) or position of the carrier pulses is varied in accordance with the modulating signal to obtain the PAM, PWM or PPM outputs.

Examples of Analog Modulation :

- Following are the examples of analog modulation systems :
    1. Amplitude Modulation (AM)
    2. Frequency Modulation (FM)
    3. Phase Modulation (PM)
    4. Pulse Amplitude Modulation (PAM)

1.9.2 Digital Communication :

Definition :

- The modulation system or technique in which the transmitted signal is in the form of digital pulses of constant amplitude, constant frequency and phase is called as digital modulation system.

Examples :

- Pulse Code Modulation (PCM), Delta Modulation (DM), Differential PCM (DPCM) and Adaptive Delta Modulation (ADM) are the examples of digital modulation.
- In the PCM and DM, a train of digital pulses is transmitted by the transmitter.
- All the pulses are of constant amplitude, width and position. The information is contained in the combination of the transmitted pulses.

Advantages of Digital Communication :

- Some of the advantages of digital communication are as follows :

1. Due to the digital nature of the transmitted signal, the interference of additive noise does not introduce many errors. So digital communication has a better noise immunity.
2. Due to the channel coding techniques used in digital communication, it is possible to detect and correct the errors introduced during the data transmission.
3. Repeaters can be used between transmitter and receiver to regenerate the digital signal. This improves the noise immunity further.
4. Due to the digital nature of the signal, it is possible to use the advanced data processing techniques such as digital signal processing, image processing, data compression etc.
5. TDM (Time Division Multiplexing) technique can be used to transmit many voice channels over a single common transmission channel.
6. Digital communication is useful in military applications where only a few permitted receivers can receive the transmitted signal.
7. Digital communication is becoming simpler and cheaper as compared to the analog communication due to the invention of high speed computers and Integrated Circuits (ICs).

Disadvantages of Digital Communication :

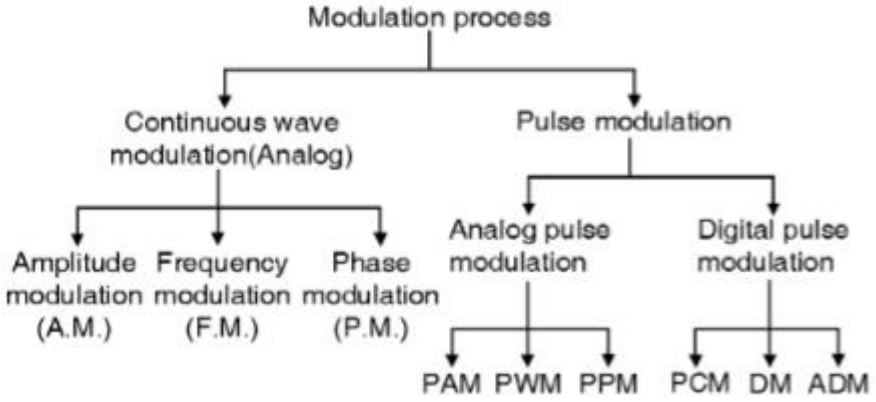
- Some of the important disadvantages of digital communication are :
  1. The bit rates of digital systems are high. Therefore they require a larger channel bandwidth as compared to analog systems.
  2. Digital modulation needs synchronization in case of synchronous modulation.

Applications of Digital Communications :

1. Long distance communication between earth and space ships.
2. Satellite communication.
3. Military communications which needs coding.
4. Telephone systems.
5. Data and computer communications.

1.10 Different Types of Modulation Systems :

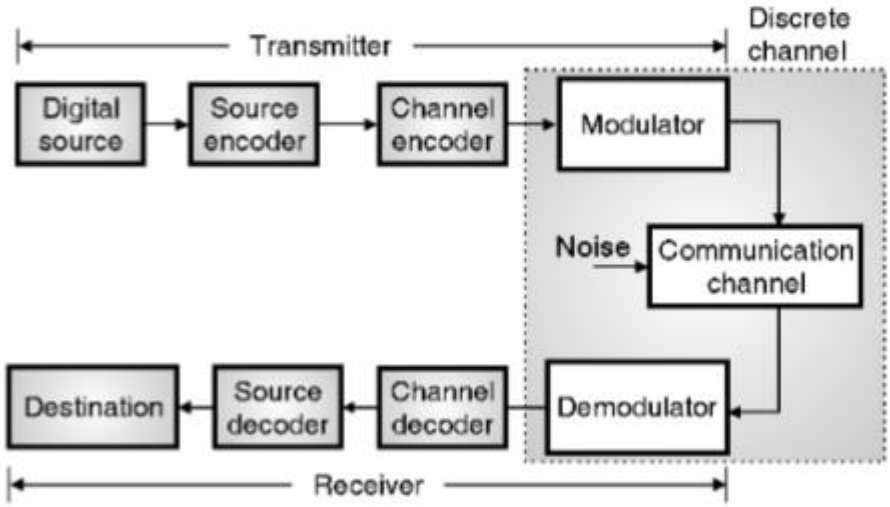
- We can classify the modulation techniques into two categories :
  1. Continuous wave modulation.
  2. Pulse modulation.
- The classification of modulation techniques is shown in Fig. 1.10.1.



(D-1304) **Fig. 1.10.1 : Classification of modulation process**

Block diagram :

- Fig. 1.12.1 shows the block diagram of a digital communication system.
- In this diagram three basic signal processing operations have been included. They are :
  1. Source coding
  2. Channel coding and modulation.



(E-3) Fig. 1.12.1 : Digital communication system

- The source of information is assumed to be digital. If it is analog then it must be converted first to digital.

Source coding :

- In source coding the source encoder converts the digital signal generated at the source output into another signal in digital form.

- Source encoding is used to reduce or eliminate redundancy for ensuring an efficient representation of the source output.
- Different source coding techniques are PCM, DM, ADM etc.
- The conversion of signal from one form to the other is called as mapping. Such a mapping is usually one as to one.
- Due to elimination of redundancy the source coding provides an efficient representation of the source output.

Channel coding :

- Channel encoding is done to minimize the effect of channel noise.
- This will reduce the number of errors in the received data and will make the system more reliable. Channel coding technique introduces some redundancy.
- The channel encoder maps the incoming digital signal into a channel input.

Modulation :

- Modulation is used for providing an efficient transmission of the signal over the channel.
- The modulator can use any of the CW digital modulation techniques such as ASK (amplitude shift keyings), FSK (frequency shift keying) or PSK (phase shift keying).
- The demodulator is used for demodulation.

1.12.1 Advantages of Digital Communication :

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2. Due to the channel coding techniques used in digital communication, it is possible to detect and correct the errors introduced during the data transmission.
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4. Due to the digital nature of the signal, it is possible to use the advanced data processing techniques such as digital signal processing, image processing, data compression etc.
5. TDM (Time Division Multiplexing) technique can be used to transmit many voice channels over a single common transmission channel. Thus digital telephony is possible to achieve.
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