# 14. COMMUNICATION SYSTEM

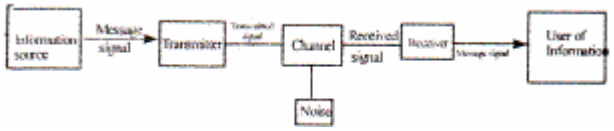
**SYNOPSIS : INTRODUCTION**

1. The exchange of information between a sender and receiver is called communication.
2. The arrangement of devices to transfere the information is called the communication system.

**I. Communication System**

1. A communication system consists of three essential parts.

   a) transmitter  b) medium or channel  c) receiver




2. If the information is communicated between two points, this method of communication is called to point mode.
3. If the information is communicated from one point to several points, this method of communication is called Broad casting mode.

**1. Message Signal**

The information converted into electrical form by a transducer, suitable for transmission is called message signal.

**a. Analog signal :** Any physical variable is converted into continuous variations for current or voltage. These changes are analogous to the changes of the information.

These changes are single valued functions of time.

**b. Digital signal :** The physical variables are converted into stepwise variations of current or voltages. Generally two steps of signals low level corresponds to zero and high level corresponds to 1.

**Transducers :** Any device that converts one form of energy into another form. An electrical transducer CONVERTS SOME physical variables into electrical variables or vice versa.

**Ex:** Microphone - converts sound into electrical variables.

Speaker - converts electrical variables into sound.

**2. Tranmitter:**

The transmitter processes the message and makes suitable for transmission through a channel.

3. **Noise:**

The unwanted signals which tend to disturb the transmission or processing of message signals are called Noise. These may generate inside or outside the system.

**4. Receiver:**

The receiver extracts the message from the received signals at the channel out put.

**5. Attenuation:**

The loss of strength of a signal while propagating through a medium is known as attenuation.

**6. Amplification:**

It is the process of increasing the amplitude ( and consequently the strength) of a signal using an electronic circuit called the amplifier. Amplification is necessary to compensate the attenuation of the signal in communication systems.

**7. Range :**

It is the largest distance between a source and destination up to which the signal is received with sufficient strength.

**8. Bandwidth :**

Bandwidth refers to the frequency range over which an equipment operates or the portion of the spectrum occupied by the signal.

**9. Modulation:**

The original low frequency message / information signal cannot be transmitted to long distances. Therefore, at the transmitter, information contained in the low frequency message signal is superimposed on a high frequency wave, which acts as a carrier of the information. This process is known as modulation.

**10. Demodulation :**

The process of retrieval of information from the carrier wave at the receiver is termed as demodulation. This is the reverse process of modulation.

**II. Band width of signals**

In general a signal is the compositionof number of frequencies. Hence the signal has a frequency range called band width

| **Analog signals Continuous Variation** | **Frequency** | **Bank width** |
|---|---|---|
| Voice message Telephonic communication | 300 Hz to 3100 Hz | 2800 Hz |
| Music | 20 Hz to 20 kHz | 20 kHz |
| Video Signals | 4.2 MHz | |
| TV Signals | | 6 MHz |
| Digital Signals Step wise Variation | As higher harmonics contribute less to signal wave | extends to GHz |

**III. Broadcasting mode of communication ... Propagation of em waves**

1) This type of communication is also called as the wireless communication.
2) The em waves (radio waves) are used for the transmission.
3) The radio waves from transmitting antenna reach the receiving antenna through ground or through atmosphere.
4) The earth atmosphere plays an important role in the propagation. Depending on the frequency of radio waves and the rages, three modes of propagation exist.
5) The three modes of propagations are
   a) Ground wave propagation
   b) Sky wave propagation and
   c) Space wave propagation

**IV. Layers of Atmosphere**

1) Sky wave propagation takes place with the help of the layers in the atmosphere.
2) The gaseous enevelope of the earth is called the earth's atmosphere.
3) There is no sharp boundary for the atmosphere.
4) The earth's atmosphere is divided into several layers; depending on the temperature variation.

| | **Ground Wave Propogation** | **Sky Wave Propogation** | **Space Wave Propogation** |
|---|---|---|---|
| Channel | Ground | Layers of atmosphere | Line of sight communication |
| Method | Wave glides over the surface of earth diffraction effect | Due to reflection of radio waves from the layers having higher electron density | The radio waves travel from transmitting antenna to receiving antenna along a straight line |
| Frequency | Depends on power and frequency Less than 2 MHz | 3 MHz to 30 MHz | greater than 40 MHz |
| Uses | In medium wave Broad casting | Short wave broadcasting | FM broadcasting and Microwave links |
| Range | Depends on height of the Antenna and Curvature of earth | Depends on the angle of incidence on the ionosphere. 150 km to 3000 km | Due to curvature of the earth the waves are blocked at a point |
| Attenuation | Attenuation increases with frequency | | |

**5. Troposphere:**

a) The region extends from the surface to approximately 10 km above the surface.

b) This has large concerntration of water vapour.

c) The temper decreases upto 550C.

d) All climatic changes occur in this region

**6. Stratosphere:**

a) The region extend from 12 km to 50 km above the surface. The temperature remains constant upto 30 km

b) The upper part of thickness 20 km and 30 km to 50 km from the surface is caled ozone layer temperature increases is called ozone layer.

c) This layer absorbs a large portion of UV radiations from Sun.

**7. Mesosphere**

The layer between 50km to 80 km from the surface of earth is called Mesosphere temperature again decreases to - $73^0$C.

**8. Ionosphere :**

a) The region from a height of nearly 65 km to 400 km above the earth surface is called the Ionosphere. The temperature increases.

b) Ionosphere is mainly composed of free electrons and ions.

c) Ions are produced due to U.V. radiation and cosmic rays or X-ray.

**d) Different layers useful for Skywave propagation**

1) During day time ionosphere separated into three layers. D-layers, E layer and F-layer ($F_1$ & $F_2$)
2) D layer attenuates radio waves during day time.
3) The attenuation is maximum for lower frequencies.
4) Hence, HF waves are used for Sky wave propagation.
5) E layer of ionosphere reflects the radio waves of frequencies from 3 MHz to 30 MHz.
6) This reflection is similar to the total internal reflection of light.
7) This is used for a range upto 500 km.
8) The central part of E layer has maximum electron density. But it is less than the F layer.
9) Reflection takes place by E layer during day time.
10) This layer is highly variable in space and time.
11) F layer is the highly significant layer in the ionosphere.
12) During day time F layer splits into $F_1$ and $F_2$ layer.
13) $F_2$ layer has more electron density.
14) $F_2$ is stronger than $F_1$ layer in reflection.
15) The range is maximum for the $F_2$ layer. For reflection over 500 km range this layer is used.
16) Radio waves of frequency greater than 30 MHz penetrate through Ionosphere.
17) During night $F_1$ and $F_2$ layers combine and called F layer.
18) During night D and E layer disappear and the effective layer is only F layer.
19) **Kennely Heaviside layer**: At 110 km above the surface of earth the concentration of electrons is very large. This layer is called Kennely Heaviside layer.

a) The thickness of this layers is about a few km.

b) Beyond this layer the electron concentration decreases upto 250 km.

c) From 250 km to 400 km, a layer of large concentration of electrons called Apple ton layer exists.

d) Above appleton layer, ie above Ionosphere the temperature is $927.6^0$C.

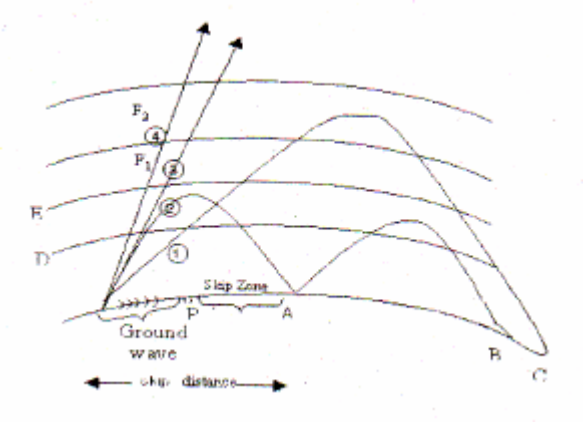
**V. Frequency Selection:**

**Frequencies used for transmission**

| Medium | |
|---|---|
| Wave | A.M. 0.54 MHz to 1.6 MHz |
| Broad cast | |
| Short wave | 1.6 MHz to 30 MHz or 40 MHz |
| Broad cast | Ionosphere reflected |
| FM Broad cast | 88 MHz to 108 MHz |
| TV Broad cast | VHF 54- 72 MHz |
| | 76 - 88 MHz |
| | UHF 174 - 216 MHz |
| | 420 - 890 MHz |
| Cellular Mobile | 896 MHz - 901 MHz to Base |
| | 840 MHz-935 MHz Base to mobile |
| Satellite | 5.925 - 425 GHz uplink |
| | 3.72 to 4.2 GHz down link |

Medium and short wave Broad casting frequencies are called HF range

1) Higher frequencies are used for longer ranges.
2) The frequencies used during early morning late afternoon and early evening must be less than those used at mid day transmission for than those used at mid day transmission for the same range.
3) During later night still lower frequencies are to be used.




4) The radio waves which are radical on a small vertical angle along path 1 is reflected by $F_2$ layer and reach the ground at a larger distance.
5) The radio waves of path 2 having greater vertical angle than path 1 is reflected by E layer.
6) This has low range than path 1.
7) It can be reflected by the earth and it lands at B after second hop.
8) Using such hops the transmission can be made over the earth.
9) As the vertical angle increases they can not be reflected by they pass through the ionosphere.
10) The angle above which the radiations are not reflected by the ionospheric layer is called critical angle.
11) The critical angle depends on the density of ionisation.
12) However if the frequencies are greater than 30 MHz they pass through the ionosphere for any angle of incidence.
13) The distance from the transmitting tower 'O' to a point P is the Ground wave range.
14) From P, the point A at which the reflected ray from 'E' layer reaches the earth is called the skipzone. In this zone the reception is absent.
15) The distanc e'OA' is called the skip distance
16. **Drawbacks**

a) The density of ionisation of layers change hour to hour.

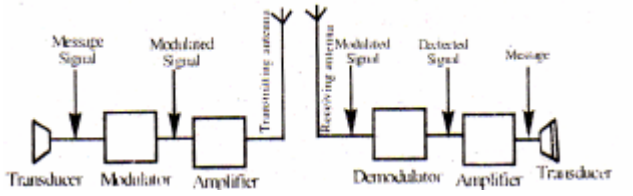
b) The height of the layers change daily

c) The height of layers change with season

d) Further it changes in the sunspot activity

e) Due to these changes made the propagation is least reliable as sudden fade outs and disappearances of signals occur so often.

VI. Working of Broadcast




1) Transducer converts the information in, to continuous electric variables in analog mode or step variables in digital mode.

2) Modulator super imposes the message signal on a carrier wave (Radio wave) which can be conveniently propagated with the velocity.

3) The modulated signal is amplified to a required level and radiated through Antenna called Transmitting antenna.

4) The propagating signal is intercepted by the Receiving antenna and picks up the modulated signal.

5) Demodulator detects the message signal and separates it from the carrier wave.

6) The message signal is amplified by the Amplifier to a required level.

7) The transducer converts the message signal into proper information.

**8) Antenna**

a) For the propagation, Antenna plays an important role.

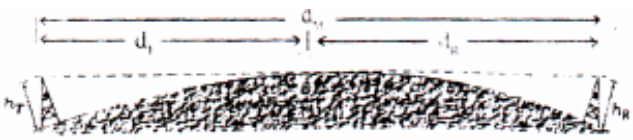
b) Different antenna's are designed for different wave lengths and different modes of propagation.

c) The linear size of the antenna must be the order of the wave length and for effective transmission its length must be $\frac{\lambda}{4}$ .

For transmission the em waves of base band range (AF range) cannot be used directly because of its wave length.

1. The audio frequency range is <20 KHz/
2. The wave length $\lambda = \frac{C}{f} = \frac{3\times10^8}{20\times10^3} = 15\times10^3 m = 15km$
3. The length of the Antena must be equal to $\frac{\lambda}{4}$.
4. For effective transmission of AF range radio waves. The length of Antenna must be $\frac{1500}{4}$ = 3750m, which is not feasible.
5. Hence the higher frequenceis are opted for the transmission.
6. If the frequency of transmission is high the height of the antenna is of reasonable lengths.
7. Thus the HF transmission is prefered.
8. The HF rang eis 3MHz to 30 MHz.
9. So the message contained byt eh base band signal is to be translated to a high radio frequencies before transmission.

**Two antennas:**



(a) The distance between transmitting antenna and the horizon $D_1 = \sqrt{2Rh_t}$ , .

Where $h_1$ = height of transmitting antenna

R = Radius of the earth

(b) The distance between receiving antenna and the horizon $D_r = \sqrt{2Rh_r}$ .

Where $h_1$ = height of transmitting antenna

10. The maximum distance between the transmitting antenna and receiving antenna $D_m$.

11. The maximum distance $D_m = D_r + D_t$.

**Single antenna**

12. The radius "d" of the area covered by a single transmitting tower of height h is given by d = $\sqrt{2R_eh}$ . Where $R_e$ is the radius of the Earth.

13. If the Population density around the tower is given, the number of persons covered by the tower is

= (Area covered by the tower) x Population density

No. of persons covered $\pi d^2 \times$ = Population density.

14. If the Antenna is vertical. vertically polarised EM wave is radiated.

Ex: TV Broad cast.

Microwave links.

Satellite communication

**Modulation**

1. The message signals are also called base band signals which are in AF range (less than 20 kHz).

a) These AF signals can not be transmitted to a long distances because of attenuation (loss of energy).

b) For the transmission of AF range signals, the linear size (1) of the antenna should be large.

c) The effective power radiated by the transmitte is proportional to $(1/\lambda)^2$ . Hence the size of the antenna is about 75 km which is not feasible.

d) When many transmitters are radiating base band signals simultaneously, they mix up and it is difficult to distinguish the required signal.

2. The solution for the long distance transmission is the selection of the HF transmission.

3. As HF radio waves are prefered for transmission, the message contained by the base band signal is to be translated on to a HF em wave.

4. Messages are convered into electrical variations by a transducer.

5. These electrical variations are called signal.

6. The sound waves are converted into electrical variations (either voltage or current) by the microphone (transducer)

7. The signal wave is called modulating wave.

8. The electrical variations are super imposed on the RF em wave called carrier wave (CW).

9. The resultant wave is called Modulated wave.

10. The process is called Modulation.

11. During modulation on eof the characterstics of the RF wave (CW) is to be changed in accordance with signal.

12. Modulation is of three types

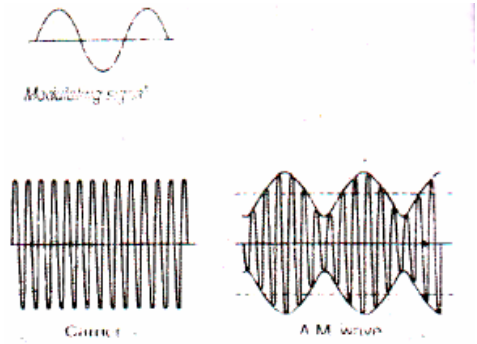
    a) Amplitude modulation

    b) Frequency modulation

    c) Phase modulation

**Amplitude Modulation:**

1. The amplitude of CW varies in accordance with the amplitude variations of the modulating signal. However the frequency and phase of CW wave remain same.

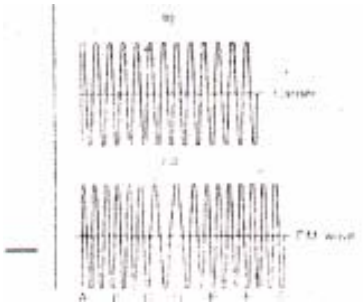


2. The amplitude of carrier wave increases in accordance with the increase of the amplitude of the signal in the positive half cycle and decreases with the amplitude of the signal in the negative half cycle.

**Frequency Modulation**

3. The frequency of the CW changes in accordance with the amplitude variation of the signal.

4. The amplitude of the modulated wave does not change.



**Phase Modulation**

1. The pahse of the CW is changed in accordance with the amplitude variations of the signal.

2. The amplitude and frequency of CW do not change.

3. The modulated wave appears similar to the FM wave.

4. If differs from FM wave in the definition and the modulation factor.

**Demodulation**

1. The process of extracting the message from the modulated wave is called demodulation.

2. This consists of detection and amplification of signal.

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