UNIT : X

COMMUNICATION SYSTEM

GIST OF THE UNIT:

Communication refers to the sending, receiving and processing of information by electrical means. A modern communication system involves

1. Sorting, processing and storing of information.
2. Actual transmission after filtering of noise.
3. Reception which may include processing steps, example- decoding, storage and interpretation

ELEMENTS OF A COMMUNICATION SYSTEM

Every communication system has three essential elements-transmitter, medium/channel and receiver. The block diagram shown in Fig. depicts the general form of a communication system.

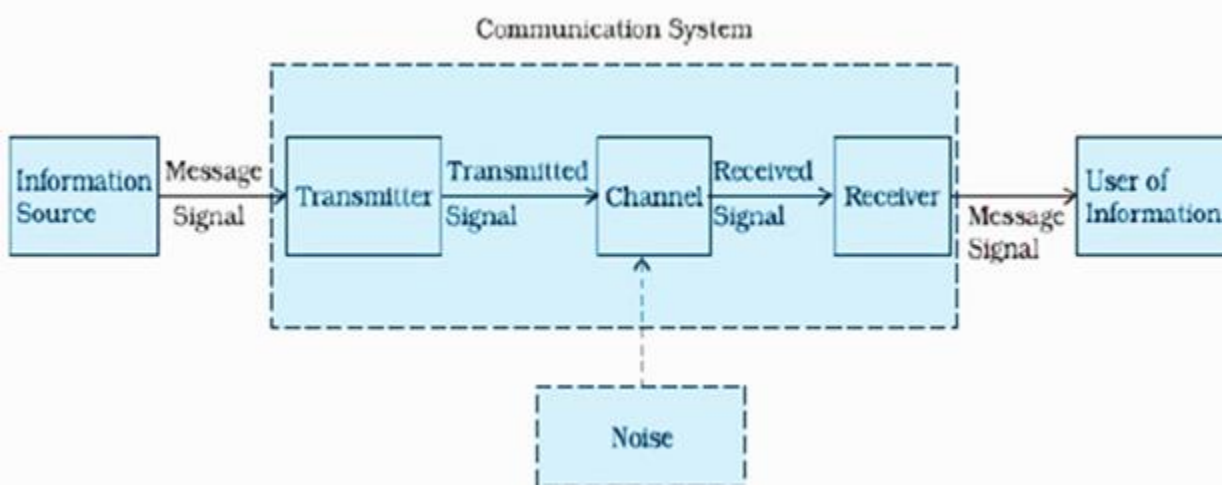


Fig-1

There are two basic modes of communication: point-to-point and broadcast.

Point-to-point communication mode: In this mode, communication takes place over a link between a single transmitter and a receiver. For example Telephony

Broadcast mode: In this mode, a large number of receivers corresponding to a single transmitter.

Radio and television are examples of broadcast mode of communication.

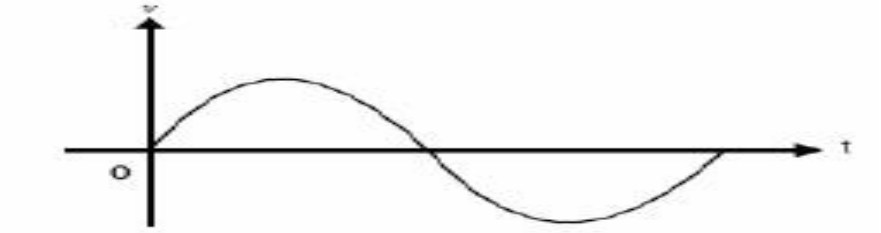
BASIC TERMINOLOGY USED IN ELECTRONIC COMMUNICATION SYSTEMS

(i) **Transducer**: Any device that converts one form of energy into another can be termed as a transducer. For example, a microphone converts a sound signal into an electrical signal.

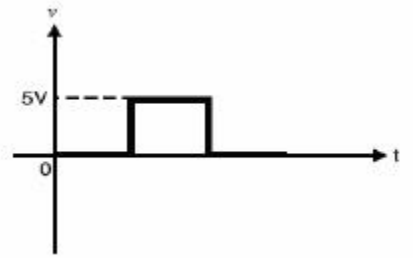
(ii**) Signal:** Information converted in electrical form and suitable for transmission is called a signal.

Signals can be either analog or digital.

Analog signal: Analog signals are continuous variations of voltage or current. They are essentially single-valued functions of time. Sine wave is a fundamental analog signal. All other analog signals can be fully understood in terms of their sine wave components. Sound and picture signals in TV are analog in nature.



Digital signal: Digital signals are those which can take only discrete stepwise values. Binary system that is extensively used in digital electronics employs just two levels of a signal. '0' corresponds to a low level and '1' corresponds to a high level of voltage/current.



(iii**) Noise:** Noise refers to the unwanted signals that tend to disturb the transmission and processing of message signals in a communication system. The source generating the noise may be located inside or outside the system.

(iv) **Transmitter:** A transmitter processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception.

(v) **Receiver**: A receiver extracts the desired message signals from the received signals at the channel output.

(vi) **Attenuation**: The loss of strength of a signal while propagating through a medium is known as attenuation.

(vii) **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 for the attenuation of the signal in communication systems.

(viii) **Range:** It is the largest distance between a source and a destination up to which the signal is received with sufficient strength.

(ix) **Bandwidth**: Bandwidth refers to the frequency range over which equipment operates or the portion of the spectrum occupied by the signal.

(x) **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.

(xi) **Demodulation**: The process of extracting the information from the carrier wave at the receiver is termed demodulation. This is the reverse process of modulation.

(xii) **Modulation Index**:$\mu = A_m/A_c$

is called modulation index, in practice; μ is kept ≤ 1 to avoid distortion.

(xiii) **Repeater:** A repeater is a combination of a receiver and a transmitter. A repeater, picks up the Signal from the transmitter, amplifies and retransmits it to the receiver sometimes with a change in Carrier frequency. Repeaters are used to extend the range of a communication system as shown in Fig. 2.

A communication satellite is essentially a repeater station in space.

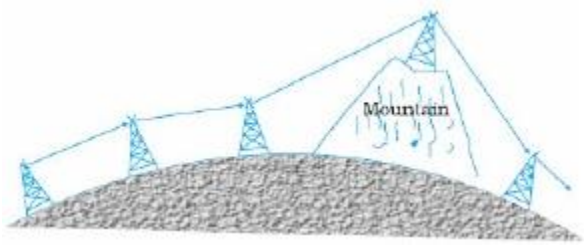


Fig.2

(xiv) **Antenna**: An antenna is basically a small length of a conductor that is used to radiate or receive electromagnetic waves. It acts as a conversion device.

BANDWIDTH OF SIGNALS

In a communication system, the message signal can be voice, music, and picture or computer data. Each of these signals has different ranges of frequencies. The type of communication system needed for a given signal depends on the band of frequencies which is considered essential for the communication process.

For speech signals, frequency range 300 Hz to 3100 Hz is considered adequate. Therefore speech signal requires a bandwidth of 2800 Hz (3100 Hz – 300 Hz) for commercial telephonic communication.

To transmit music, an approximate bandwidth of 20 kHz is required because of the high frequencies produced by the musical instruments. The audible range of frequencies extends from 20 Hz to 20 kHz.

Video signals for transmission of pictures require about 4.2 MHz of bandwidth. A TV signal contains both voice and picture and is usually allocated 6 MHz of bandwidth for transmission.

BANDWIDTH OF TRANSMISSION MEDIUM

Similar to message signals, different types of transmission media offer different bandwidths. The commonly used transmission media are wire, free space and fiber optic cable.

Coaxial cable is a widely used wire medium, which offers a bandwidth of approximately 750 MHz.

Such cables are normally operated below 18 GHz.

Communication through free space using radio waves takes place over a very wide range of frequencies: from a few hundreds of kHz to a few GHz. This range of frequencies is further subdivided and allocated for various services as indicated in Table

Optical communication using fibers is performed in the frequency range of 1 THz to 1000 THz (microwaves to ultraviolet). An optical fiber can offer a transmission bandwidth in excess of 100GHz.

SOME IMPORTANT WIRELESS COMMUNICATION FREQUENCY BANDS

Service	Frequency bands	Comments
Standard AM broadcast	540-1600 kHz	
FM broadcast	88-108 MHz	
Television	54-72 MHz 76-88 MHz 174-216 MHz 420-890 MHz	VHF(very high frequencies) TV UHF(ultra high frequencies) TV
Cellular Mobile Radio	896-901 MHz 840-935 MHz	Mobile to base station Base station to mobile
Satellite Communication	5.925-6.425 GHz 3.7-4.2 GHz	Uplink Downlink

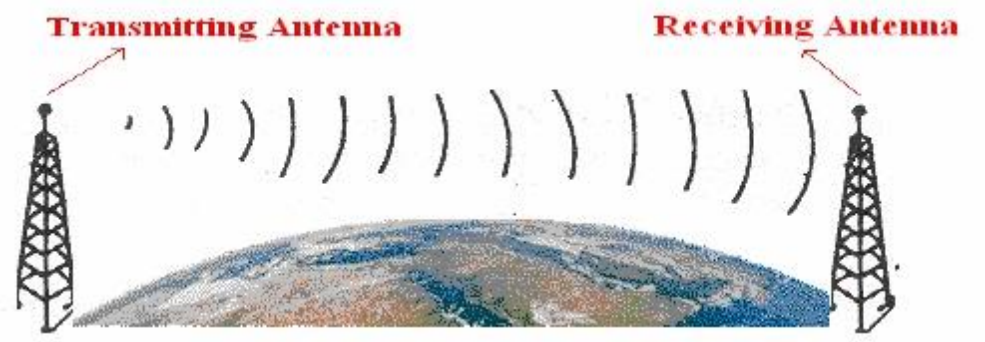
IONOSPHERE

The upper portion of atmosphere about 65 km to 400 km above the earth's surface is called ionosphere. The ionosphere is so called because of the presence of a large number of ions or charged particles. It extends from a height of ~ 65 Km to about 400 Km above the earth's surface.

PROPAGATION OF ELECTROMAGNETIC WAVES

Ground wave Propagation

In ground wave propagation, the radio waves (AM) travel along the surface of the earth. These waves are called ground waves or surface waves.



Ground wave propagation can be sustained only at low frequencies (~500 kHz to 1500 kHz).The

maximum range of ground wave propagation depends on two factors:

(i)The frequency of the transmitted wave

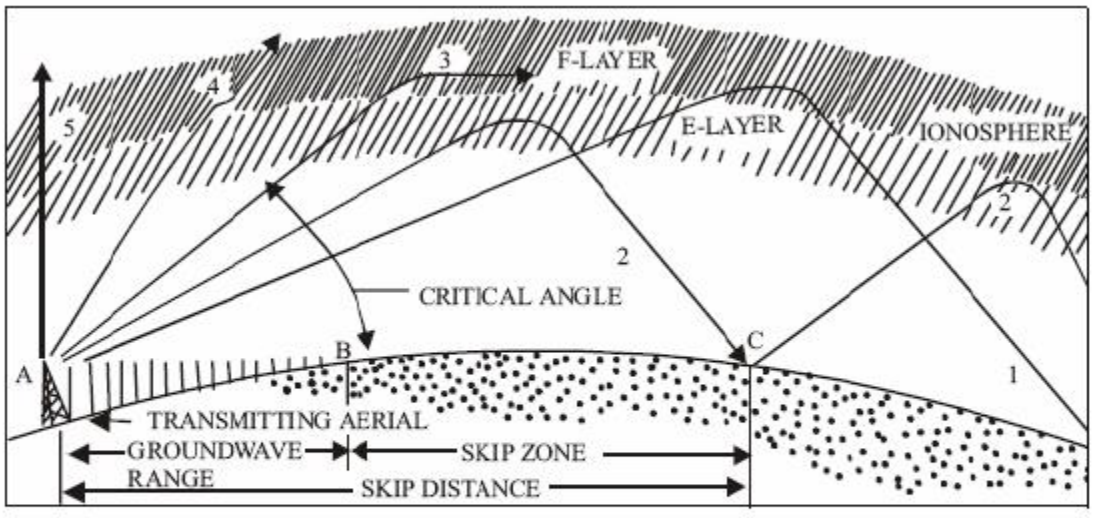
(ii)The power of the transmitter

Sky waves Propagation

In the frequency range from a few MHz up to 30 MHz, long distance communication can be

achieved by ionospheric reflection of radio waves back towards the earth. This mode of propagation

is called sky wave propagation and is used by short wave broadcast services.



(i) **Critical frequency.** The highest frequency above which the ionosphere no longer returns the sky

wave back to earth when transmitted in vertical direction is called critical frequency.

Above this frequency, the radio wave will penetrate the ionosphere and is not reflected by it. It is

given by $f_c = \sqrt{9(N_{max})}$, where N_{max} is maximum electron density of the ionosphere.

(ii) **Critical angle**. For a given frequency, the vertical angle above which the sky wave no longer

returns to earth but travels outward into space is called critical angle.

(iii) **Skip distance**. The distance between the transmitting aerial and the point where the sky wave is first received after returning to earth is called skip distance. In Fig 3 the ground distance AC is skip distance. The ground-wave range here is AB.

(iv) **Skip zone**. The ground distance BC is called skip zone. No signal can be picked up in the skip zone.

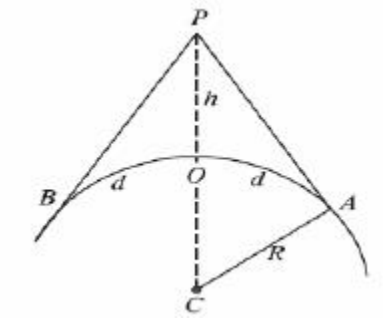
(v) **Fading.** It is the fluctuation in signal strength at the receiver end and it may be rapid or slow. It may be for all frequencies or for any particular frequency.

Space wave Propagation

Another mode of radio wave propagation is by space waves. A space wave travels in a straight line from transmitting antenna to the receiving antenna. Space waves are used for line-of-sight (LOS) communication as well as satellite communication. At frequencies above 40 MHz, communication is essentially limited to line-of-sight paths.

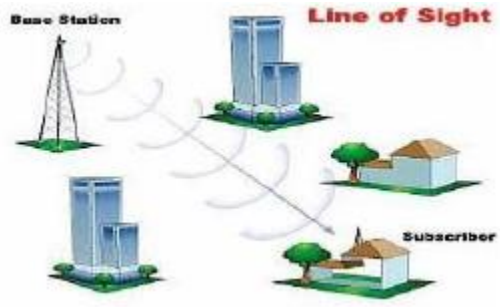
RANGE OF TV TRANSMISSION

The TV signals are in the 100–200 MHz range. Therefore, transmission of such signals via ground waves or sky waves is not possible. In such situations, we useline-of-sight transmission i.e., TV signals are transmitted by direct waves.



d= √2Rh

Thus the range of TV transmission depends upon the height of thetransmitting antenna. The greater the height of the antenna, thelarger is the range of TVtransmission. For this reason, TV broadcasts are made from talltransmitting antennas.Range of Space wave propagation between two antennas on earth's surface: Aspace wave travels in a straight line from transmitting antenna to receiving antenna i.e. it is a line ofsight (LOS) communication.



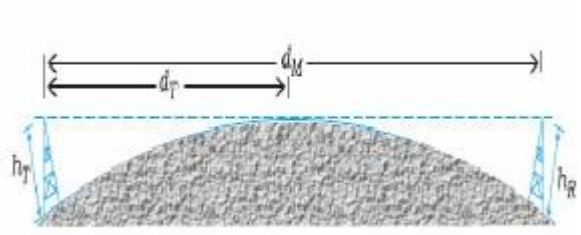


Fig.6

The maximum line-of-sight distanced between the two antennas having heights H_t and H_r above

the earth (see Fig.6) is given by

$d = \sqrt{2RHt} + \sqrt{2RHr}$

Television broadcast, microwave links and satellite communication are some examples of

Communication systems that use space wave mode of propagation.

MODULATION AND ITS NECESSITY

Most of the message, information or speech signals are of low frequency which cannot be transmitted to long distance.(Audio frequency signal's range 20Hz to 20kHz).This is because –

(i)For efficient radiation and reception, the transmitting antennas should have heights comparable to a quarter wavelength ($\lambda/4$) of frequency used.

(ii)Audio frequency range being so small, there would be so much overlapping and confusion.

(iii)Energy carried by low frequency audio waves is too small.

Effective power radiated by an antenna

A theoretical study of radiation from a linear antenna (length l) shows that the power radiated is proportional to $(l/\lambda)^2$. For a good transmission, we need high powers and hence this also points out

to the need of using high frequency transmission.

Modulation

For translating the original low frequency baseband message or information signal into high

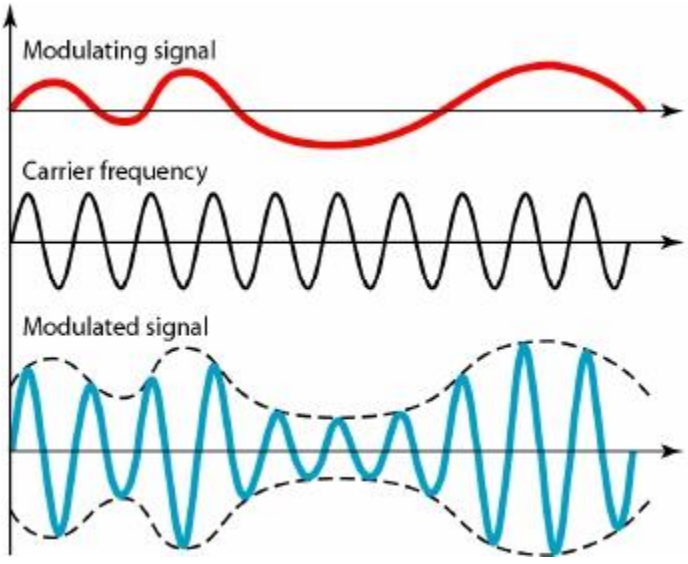
frequency wave before transmission such that the translated signal continues to possess the information contained in the original signal. In doing so, we take the help of a high frequency signal, known as the carrier wave, and a process known as modulation which attaches information to it.

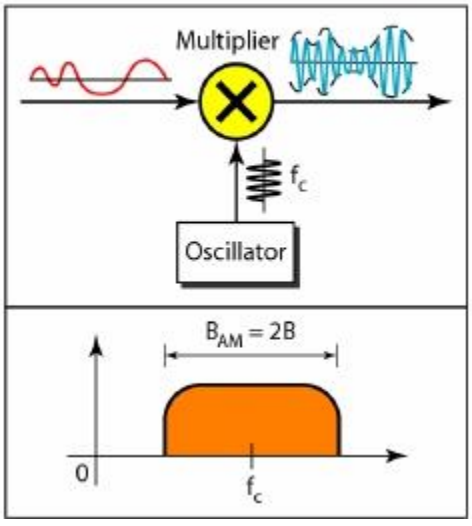
A sinusoidal carrier wave can be represented as c (t) = Ac sin (ωct + φ), Where c(t) is the signal strength (voltage or current), Ac is the amplitude ,ωc (= 2πνc) is the angular frequency and φ is the initial phase of the carrier wave.

During the process of modulation, any of the three parameters ,viz Ac ,ωc and φ, of the carrier wave can be controlled by the message or information signal. This results in three types of modulation: (i) Amplitude modulation (AM), (ii) Frequency modulation (FM) and (iii) Phase modulation (PM)

AMPLITUDE MODULATION

In amplitude modulation the amplitude of the carrier signal is varied in accordance with the information signal/modulating signal.A carrier signal is modulated only in amplitude value The modulating signal is the envelope of the carrierThe required bandwidth is 2B, where B is the bandwidth of the modulatingsignal



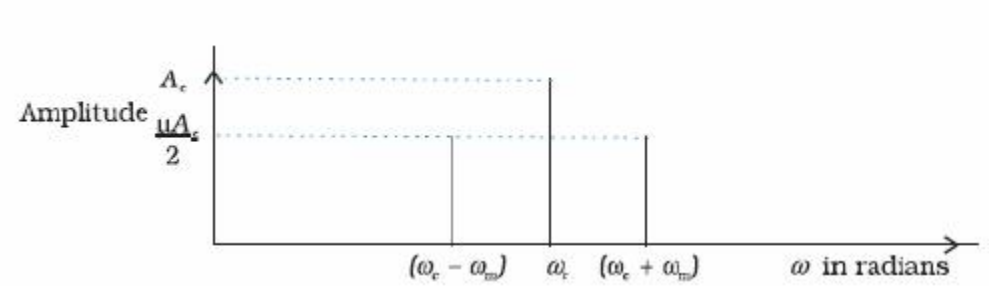


Here ωc –ωm and ωc +ωm are respectively called the lower side band (LSB) and upper side band

(USB) frequencies. The modulated signal now consists of the carrier wave of frequency ωc plus two

sinusoidal waves each with a frequency slightly different from, known as side bands. The frequency

spectrum of the amplitude modulated signal is shown in .

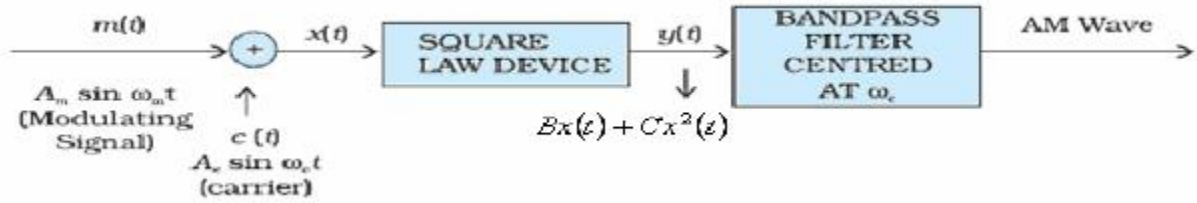


The difference between the highest and the lowest frequencies present in the A.M. wave is called its bandwidth.

PRODUCTION OF AMPLITUDE MODULATED WAVE

Amplitude modulation can be produced by a variety of methods. A conceptually simple method is

shown in the block diagram.



DETECTION OF AMPLITUDE MODULATED WAVE

The transmitted message gets attenuated in propagating through the channel. The receiving antenna

is therefore to be followed by an amplifier and a detector. In addition, to facilitate further

processing, the carrier frequency is usually changed to a lower frequency by what is called an

intermediate frequency (IF) stage preceding the detection. The detected signal may not be strong

enough to be made use of and hence is required to be amplified.

Detection is the process of recovering the modulating signal from the modulated carrier wave. We

just saw that the modulated carrier wave contains the frequencies and ωc ±ωm.

All possible formulae

1. Modulation factor ,μ = $\frac{Am}{Ac}$ or μ = $\frac{Am}{Ac}$ X 100 %
2. If A_{max} and A_{min} are the maximum and minimum amplitudes of the carrier wave,then

$$\mu = \frac{Amax - Amin}{Amax + Amin} \text{ X } 100\%$$

3. Modulating Voltage, m (t) = $Am\text{Sin}\omega_m t$
4. Carrier Voltage, , c (t) = $Ac\text{Sin}\omega_c t$
5. Instantaneous voltage of A.M wave is

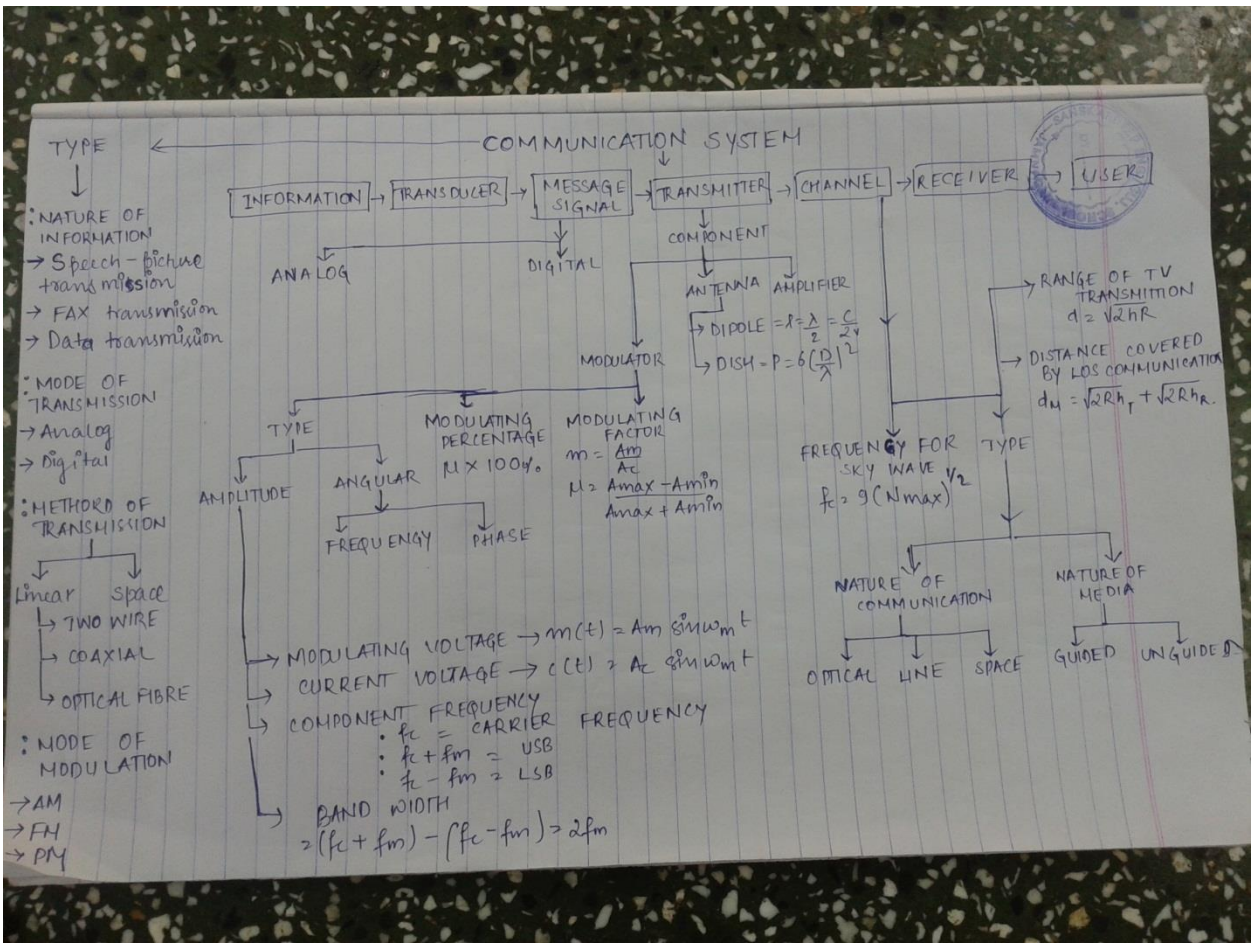
$C_m(t) = A_c(1 + \mu \text{Sin}\omega_m t)\text{Sin}\omega_c t = Ac\text{Sin}\omega_c t - \frac{\mu Ac}{2}\cos(\omega_c + \omega_m)t + \frac{\mu Ac}{2}\cos(\omega_c - \omega_m)t$

6. Component frequencies of A.M wave are:
   (a) Carrier frequency = f_c
   (b) USB = $f_c + f_m$
   (c) LSB = $f_c - f_m$
7. Bandwidth = (fc + fm) – (fc – fm) =2 fm
8. Length of dipole antenna l = $\frac{\lambda}{2} = \frac{c}{2v}$
9. Number of channels = $\frac{Total\ bandwidth\ of\ channel}{bandwidith\ needed\ per\ channel}$
10. Critical frequency for sky wave propogation $f_c = 9(N_{max})^{1/2}$

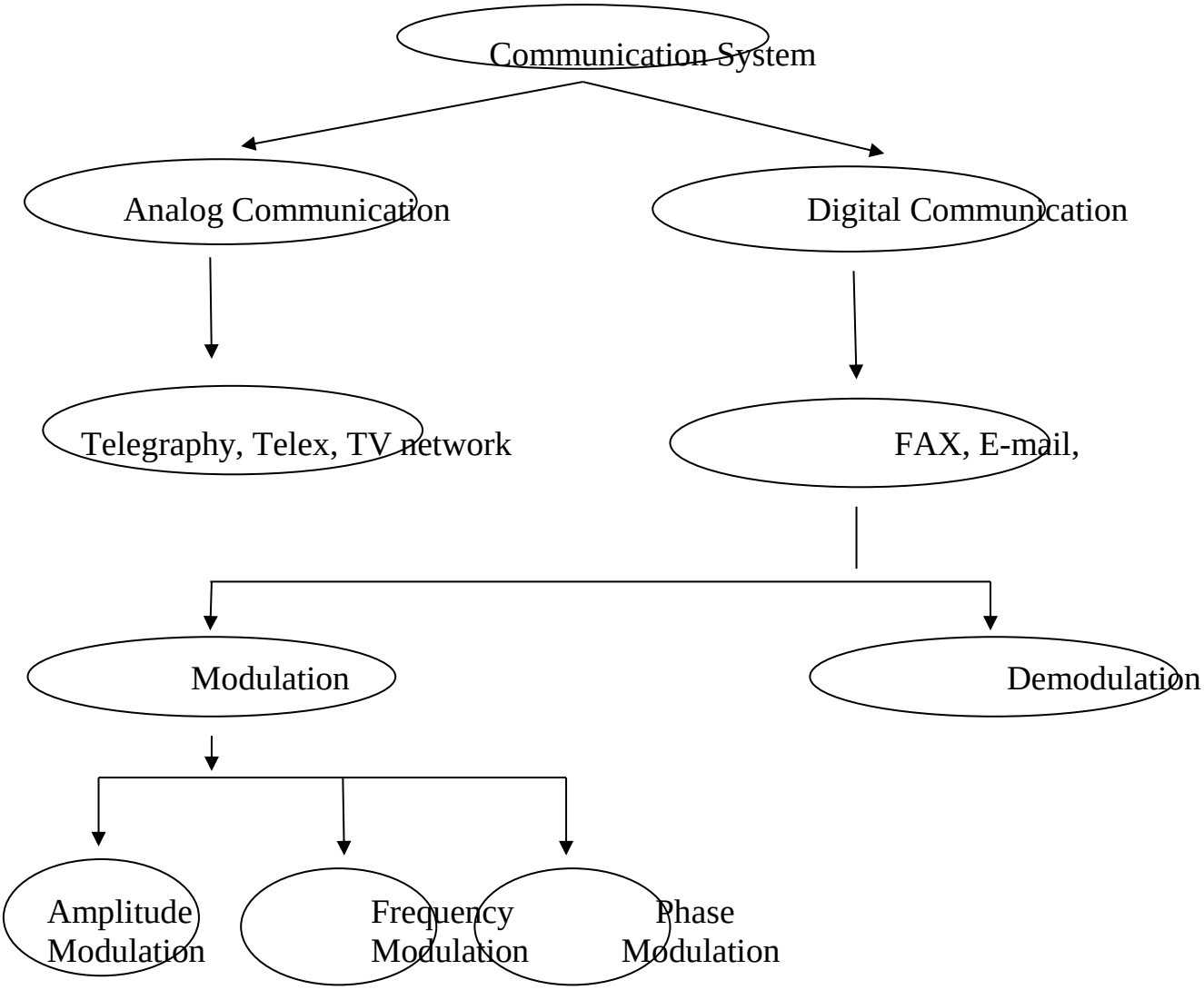
11. The range of TV transmission $d = \sqrt{2hR}$ Where h = height of antenna, R= Radius of Earth
12. Population Covered = population density X Area
13. Maximum distance covered in LOS communication:

$$d_M = d_T + d_R = = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

CONCEPT MAP



Mind Map


Communication System
Analog Communication
Digital Communication
Telegraphy, Telex, TV network
FAX, E-mail,
Modulation
Demodulation
Amplitude Modulation
Frequency Modulation
Phase Modulation

Modulation Index

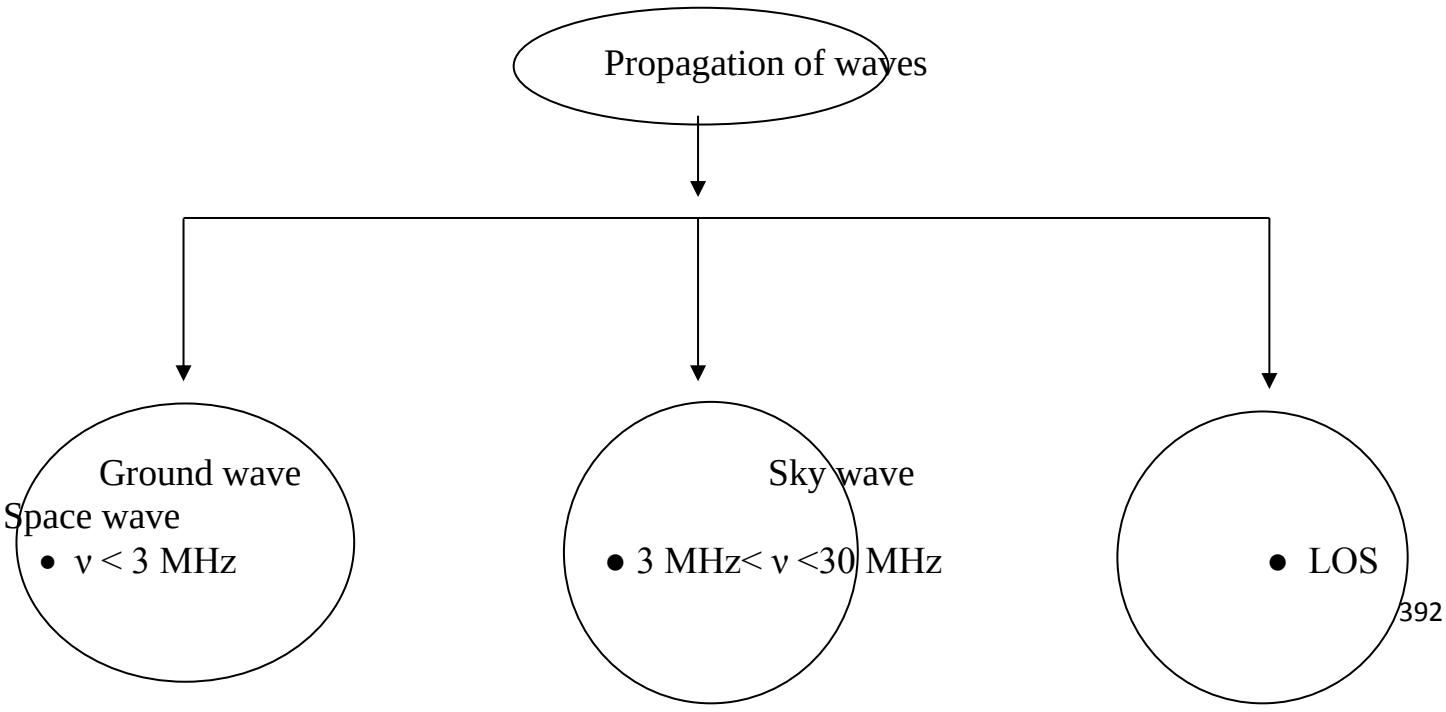
$\mu = \frac{A_m}{A_c} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$

Bandwidth

= USB – LSB

= $(f_c + f_m) – (f_c - f_m)$

= $2 f_m$



- Directly on the Surface of the earth
- Low range of Coverage

- Through ionosphere
- Principle TIR
- High ν does not

- ν > 30 MHz
- Directly antenna to antenna
- d = $\sqrt{2hR}$

Identification of important topics/concepts for slow learners

Concepts	Degree of importance (From Examination point of view)	Commonly committed errors
Elements of communication system Block diagram and basic definitions of the different elements of the communication system	*	**Wrong identification of elements of communication system in different cases.**
Basic terminology used in electronic communication system.	*	**Problem in those terms which are not very frequently used.**
Bandwidth of signals	**	**Difference between frequency and**

(Speech, TV and digital data)		**bandwidth**
Bandwidth of transmission medium	*	**Less understanding of the concept**
Propagation of electromagnetic waves in the atmosphere(Sky and space wave propagation)	**	**Can not differentiate between sky wave and space wave**
Need of modulation	***	**Problem in understanding the antenna length and wavelength.**
Production of amplitude modulated wave	***	**Problem in understanding square law device**
Detection of amplitude modulated wave	**	**Circuit diagram**

Important derivation type and theoretical(knowledge based) type of questions which covering whole unit/concepts(3 marks &5 marks) with answers

1. What is a communication system? Describe briefly the major constituents of a communication system.

Ans:- Communication system: The set up used to transmit information from one point to another is called a communication system. The essential parts of communication system are transmitter, communication channel and receiver.

i) Transmitter: it's the set up that transmits the message to the receiving end through a communication channel. Its main function is to convert the message signal produced by the information source into a form suitable for transmission through the channel and to transmit it.

ii) Communication channel or transmission medium: it's the medium or physical path that connects a transmitter to a receiver. It carries modulated wave from the transmitter to the receiver. It can be a transmission line, an optical fibre or free space.

iii) Receiver: it's a set-up that receives the transmitted signals from the transmission medium and converts those signals back to their original form. This process of recovering the original signal is called demodulation or detection, which is reverse of the modulation process used at the transmitter.

2. What are analog and digital signals and analog communication? Give examples.

Ans: Analog signal: it's the signal in which current or voltage varies continuously with time.

Digital signal: it's the signal in which current or voltage can only take two discrete values. A digital signal can take only two values, 1 and 0. Digital signals are in the form of pulses of equal level.

Analog communication: it makes use of analog electronic circuit and analog signal in such a way that the output voltage varies continuously in accordance with the input voltage. For example, telegraphy, telex, TV network etc. it is less reliable due to its many valued output.

3. What is digital communication? Enumerate some of its advantages?

Ans-Digital communication: digital communication makes use of an electronic circuit that can handle only digital signals. Modern communication systems like FAX, e-mail, etc. are purely based on digital electronic circuits because of the following advantages:

1. As compared to many valued analog operation, the two-valued digital operation is more reliable because here all the signals are easily identified as low and high.
2. As the information to be transmitted is already in pulse form, so its transmission needs simple technique.
3. A large number of digital signals can be sent through a single channel only.

4. what is modulation? What is the need of modulation in communication system?

Ans- A high frequency carrier wave is used to carry the audio signal to large distances. Modulation is the process by which some characteristic, usually amplitude, frequency or phase angle of a high frequency carrier wave is varied in accordance with the instantaneous value of the low frequency of the low frequency audio signal, called the modulating signal.

Need of modulation in communication systems: audio signals have a bandwidth of 20 kHz. Such low frequency signals cannot be transmitted directly to long distances because of the following reasons:

1) Practical antenna length: to transmit a signal effectively, the height of the antenna should be comparable to the wavelength of the signal so that the antenna properly senses the time variations of the signal. So to transmit a signal of frequency 20 kHz, we need an antenna of height= $3 \times 10^8 / 20 \times 10^3$ m= 15 km. antenna of such a height cannot be constructed. On the other hand, if the carrier wave of 1MHz is used, required antenna height comes down to just 300 m.
2) Effective power radiated by an antenna: for the same antenna length, the power radiated by the short wavelength or high frequency signals would be large. If the audio signals are directly radiated into space, they die out after covering some distance due to their low power.
3) Mixing up signals from different transmitters: when audio signals are transmitted by many transmitters simultaneously, their signals get mixed up and it's not possible to separate them.

   Thus, there is need for translating the original low frequency message signal into a high frequency wave before transmission such that the transmitted signal continues to possess the information contained in the original signal.

5. What are carrier waves? Mention the two types of carrier waves generally used.

   Ans: Carrier waves: An alternating current of a frequency, at least twice that of the highest frequency component in the information signal, is used to provide a carrier wave. Since this frequency signal is the signal which is actually transmitted and carries the information, so it is known as a carrier wave.
   Following are its two commonly used types:
   !) Continuous sinusoidal waves, and
   2) pulse shaped signals.

6. Mention the different types of modulation techniques when the carrier waves are sinusoidal waves.

   Ans: Three types of modulation of continuous carrier waves: it can be represented as:
   c(t) = Ac cos (omega c t + phi naught)

Where, c(t) is the signal strength, Ac is the amplitude. The above equation shows that a carrier wave can be modulated by controlling any of the three parameters by the message or the information signal. This results in the following three types of modulation:

1) Amplitude modulation: it's the process in which the amplitude of the high frequency carrier wave changes in accordance with the instantaneous value of the modulating signal.
2) Frequency modulation: it's the process of changing the frequency of the carrier voltage in accordance with the instantaneous value of the modulating voltage. The original frequency of the carrier signal is called resting frequency. The amount y which the frequency of the carrier wave changes or shifts above or below the resting frequency is called the frequency deviation.
3) Phase modulation: it is the process of varying the phase angle of the carrier voltage in accordance with the instantaneous value of the modulating voltage.

7. Define modulation factor. Express it in the terms of maximum and minimum voltages of AM wave. Give the importance of modulation factor.

Ans: Modulation factor: it represents the extent to which the amplitude of the carrier wave is changed by the modulating signal. It's defined as the ratio of the change in the amplitude of the carrier wave to the amplitude of the original carrier wave. It is also known as the degree of the modulation or modulation index. If Am and Ac are the amplitudes of modulating and carrier signals respectively, then modulation factor is given by,

Change in amplitude of carrier wave/
amplitude of the original carrier wave = Am/Ac

Modulation factor in terms of Amax and Amin:

$Am = Amax - Amin / 2$

And, $Ac = Amax - Am = Amax - (Amax-Amin)/2$

$= Amax + Amin/2$

Hence, the modulation factor is,

$Am/Ac = Amax - Amin / Amax + Amin$

Importance of modulation factor: it determines the strength and quality of the transmitted signal. If m is small, the amount of variation in the carrier amplitude is small. As a result the transmitted audio signal will not be strong enough. The greater the degree of modulation, the stronger and clearer will be the audio signal. However, if the carrier is over modulated, distortion will occur during reception.

8. What is meant by sideband frequencies in a carrier wave? Justify that bandwidth of an AM wave is 2fm, where fm is the modulating frequency.

Ans: AM wave is the sum of three sinusoidal waves:

i) First, the original carrier wave of amplitude Ac and frequency fc

ii) The second wave of amplitude Ac/2 and of frequency (fc + fm) is called upper side band frequency, (USB).

iii) The third wave of amplitude Ac/2 and frequency, (fc-fm). The difference of carrier frequency and modulating frequency (fc – fm) is called lower side band frequency (LSB)

The difference between the highest and the lowest frequencies present in the AM wave is called its bandwidth.

Bandwidth = (fc + fm) – (fc – fm) = 2 fm

Hence, bandwidth of the AM wave is twice the frequency of the modulating signal.

9. Define amplitude modulation. Derive an expression for an amplitude modulated wave**.**

ANS:- AMPLITUDE MODULATION: it is the process in which the high frequency carrier wave changes in accordance with the instantaneous value of modulating signal.

Expression: let modulating signal, $m(t)= A_m \sin\omega_m t$

And carrier signal, $c(t)=A_c \sin\omega_c t$.

Where, m(t)= instantaneous voltage of modulating wave

A_m = amplitude of modulating wave

$\omega_m = 2\pi f_m$ =angular frequency of modulating wave

$\omega_c t$= instantaneous voltage of carrier wave

A_c= amplitude of carrier wave

$\omega_c = 2\pi f_c$ =angular frequency of carrier wave

The amplitude of the carrier wave varies at the frequency of the modulating wave. So amplitude of modulating wave is given by,

$A = A_c + A_m \sin\omega_m t$

$= A_c + \mu A_c \sin\omega_m t = A_c(1+\mu \sin \omega_m t)$

Here $u = \frac{Am}{Ac}$ is the modulation index.

The instantaneous voltage of the A.M is given by

$c_m(t) = A \sin\omega_c t = A_c (1 + u\times \sin \omega_c t) \times \sin\omega_c t$

$= A_c \sin \omega_c t + u A_c/2 \times 2\sin\omega_c t.\sin\omega_m t$

$= A_c \sin\omega_c t + u A_c/2[\cos(\omega_C-\omega_m) t - \cos(\omega_c+\omega_m) t]$

$c_m(t) = A_c \sin\omega_c t - uA_c/2 \cos(\omega_c + \omega_m) t + uA_c/2 \cos(\omega_c-\omega_m) t$

10. What is need of modulation?

Ans:- simultaneous transmission: consider u transmit speech signal without modulation then this signal will interfere with the normal voice in the air (from people and radios and everything) that's why u get radio station at different frequencies

Multiplexing signals: the same concept as simultaneous transmission but from the sender perspective, say u need DSL on your landline then u need to modulate the DSL data on a higher carrier to prevent interfering with telephone signal.

11. what is communication channel? Describe the various communication channels employed in communication.

Ans: - communications channel: - the physical path between the transmitter and receiver is called communication channel or transmission medium of communication system.

Types of communications:

i) LINE COMMUNICATION: - it invokes point –to-point contact between transmitter and receiver. It occurs through guided media such as twisted pair and coaxial cable.

Coaxial cable is widely used wire medium, which offers a bandwidth of 750MHz.

ii) OPTICAL COMMUNICATION:- it makes use of a light beam in carrying an information from one point to another through a guided medium like optical fibre.

Optical communication using fibers is carried in the frequency range of 1THz to 1000 THz. An optical fiber can have a bandwidth above 100GHz.

iii) SPACE COMUNNICATION: - Here electromagnetic waves of different frequencies are used to carry the information through the physical space acting as the transmission medium. Radio, television and satellite communications are all space communications.

Q12. Discuss the advantages and disadvantages of amplitude modulation?

Ans. Advantages

i. It is an easier method for transmitting and receiving voice signals.

2. It requires simple and cheaper transmitters and receivers.

3. Its transmission requires low carrier frequencies of 0.5-20 Mhz.

4. Area in each AM transmission can be received in much larger than that in case of FM transmission.

Disadvantages

1. Amplitude modulation suffers from noise.

2. Quality of audio signals is poor.

3. Efficiency of FM transmission is low.

13.. What is phase modulation?

Ans. **Phase modulation** – It is the process by which the phase angle of the high frequency carrier wave changes in accordance with the instantaneous value of the modulating signals. Frequency of the phase modulated (PM) wave changes in accordance with the phase of the modulating signal. Frequency is the maximum when phase angle is zero, it decreases when the phase angle increases and becomes minimum when the phase angle becomes π.

Q14. Give the advantages and disadvantages of frequency modulation over amplitude modulation?

Ans-Advantages:-

1. F.M. transmission is highly efficient because all the transmitted power is useful but in A.M. transmission, most of the power goes waste in transmitting the carrier alone.

2. Since amplitude remains constant in F.M. so amplitude limiters can be used to reduce noise in F.M.

3. F.M. transmission gives high fidelity reception due to the presence of a large number of side bands. Disadvantages:-

1. The channel required in F.M. is about 10 times wider than that in A.M.

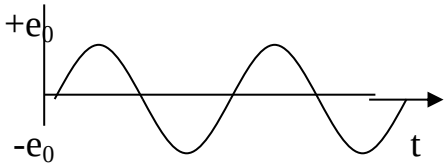
2. F.M. receivers and transmitters are very complex and costly.

3. As F.M. reception is limited to line of sight, so its area of reception is much smaller than that for A.M.

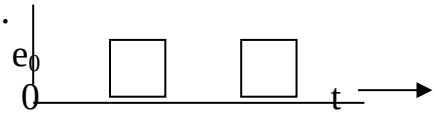
Previous 8 years AISSCE questions
1 MARK QUESTIONS

1. Distinguish between sinusoidal and pulse shaped signals. (All India 2009C)

Ans: A signal which current or voltage change continuously with time sinusoidally is known as sinusoidal signal.



A signal in which current or voltage can take only two discrete values for it is called pulse shaped signals.



2. What is the meaning of the term attenuation in communication system? (All India 2008C)

Ans: It refers to the loss of strength of a signal during their propagation through the communication channel.

3. Name the mode of propagation of radio waves which travel in a straight line from the transmitting antenna to the receiving antenna.
(All India 2008C)

Ans: Space wave propagation is that mode of wave propagation in which the radio waves emitted from the transmitter antenna reaches the receiving antenna through space.

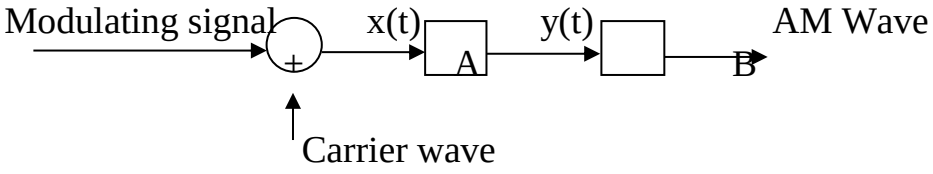
4. What should be the length of dipole antenna for a carrier wave of frequency 5×10^8 Hz? (All India 2007)

Ans: $\lambda = c/\nu = 0.6$ m

Length of dipole antenna = $\lambda /2 = 0.6 / 2 = 0.3$ m = 30 cm.

2 marks questions

5. In the block diagram of a simple modulator for obtaining an AM signal shown in the figure identify the boxes A and B. Write their function.
(All India 2013)



Ans: A is square law device and B is band pass filter.

Square law device is a non linear device it produces a non linear output of message and carrier signals.

Band pass filter it rejects low and high frequencies and allows a band of frequencies to pass through.

6. What is sky wave communication? Why is this mode of propagation restricted to the frequencies only upto few MHz?
(All India 2011)

Ans: Sky wave propagation when radio wave propagate from one place of earth to other after reflection by ionosphere the range of frequencies from few MHz to 30 MHz gets reflected back by ionosphere.

Reason behind restriction upto few MHz the radio wave of frequencies upto 30 MHz cannot penetrate the ionosphere and they get reflected back to earth whereas higher frequencies (> 40 MHz) bends slightly but not reflected back to earth.

7. What is space wave communication? Write the range of frequencies suitable for space wave communication. (All India 2011)

Ans: It is also known as Line Of Sight (LOS) propagation. The radio wave transmitted by antenna directly reaches the receiving antenna travelling along a straight line.

The range of frequencies suitable for space wave communication is 100 MHz to 220 MHz.

8. Write two factors justifying the need of modulating a signal. A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%?
(All India 2010)

Ans: Need for modulation (i) To reduce the length of antenna from 15 km to reasonable height.
(ii) Effective power radiated by antenna take place for high frequency.

% modulation index $\mu = \frac{A_m}{A_c} \times 100$ => $A_m = 9$ V

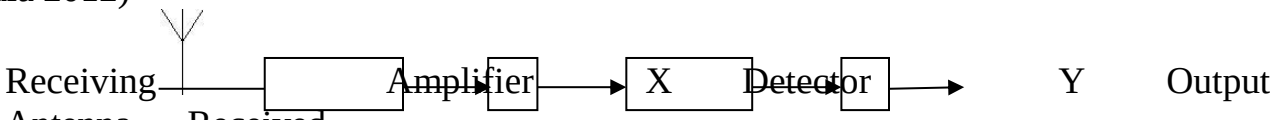
9. Name any two types of transmission media that are commonly used for transmission of signals. Write the range of frequencies of signals for which these transmission media are used. (All India 2010C)

Ans: Two types of transmission media are used (i) Sky wave or short wave propagation (ii) space wave or line of sight communication. Range of frequencies (i) Sky wave 30 MHz > ν > 1500 kHz (ii) Space wave 220 MHz > ν > 100 MHz.

10. A communication satellite is essentially a repeater station in space. Justify this statement by analyzing the function of a repeater.
(All India 2009C)

Ans: A communication satellite (i) pick up the signal transmitted by transmitter (ii) amplifies it (iii) retransmit it towards information users. These all are also a function of repeater.

11. In the given block diagram of a receiver identify the boxes labelled as X and Y also write their functions. (All India 2012)



Ans: X is Intermediate frequency (IF) stage, Y is power amplifier
IF stage changes the high frequency of carrier wave curve into lower frequency and amplifier enhaces the strength for the signals.

12. Write the function of (i) Transducer and (ii) Repeater in the context of communication system. (All India 2009)

Ans: Transducer used as a sensor or detector in communication system. It converts the physical signal into another signal.
Repeater it picks up the signals from the transmitter, amplifies it and transmit it the receiver Thus comprises up of receiver, transmitter and amplifier. Its function is to extend the range of communication.

13. Write two factors justifying the need of modulation for transmission of a signal. (All India 2009)

Ans: (i) The transmission of low frequency signal needs antenna of height 4-5 km which is impossible to construct. So there is need to modulate the wave in order to reduce the height of antenna to a reasonable height.
(ii)Effective power radiated by antenna for low wavelength or high frequency wave as $p\alpha(1/\lambda^2)$.

14. A message signal of frequency 10 kHz and peak voltage of 10 V is used to modulated frequency of 1 MHz and peak voltage of 20 V. Determine (i) modulation index (ii) the side bands produced.
(All India 2009C)

Ans: (i) A_m = 10 V and A_c = 20 V

$\mu = \frac{A_m}{A_c}$ = ½

(ii) Upper side band frequency = $f_c + f_m$ = 1 MHz + 10 kHZ = 1.01 MHz

Lower side band frequency = $f_c - f_m$ = 1 MHz - 10 kHZ = 0.99 MHz

15. Distinguish between frequency modulation and amplitude modulation. Why is an FM signal less susceptible to noise than AM signal? (All India 2006)

Ans:

S. No.	Characteristic	Frequency modulation	Amplitude modulation
01	Efficient transmission	Highly efficient	Most power goes waste
02	Modulation index(μ)	No limit	1> μ >0
03	Bandwidth of channel	It require nearly 10 times to that of AM	Relative smaller bandwidth
04	Fidelity	High fidelity due to presence of large number of side band	Relative low fidelity in reception
05	Area of receptor	Being LOS area of reception is much smaller	Relatively larger area of receptions

FM signal are less susceptibility to noise than an AM signal as amplitude remains constant in FM so amplitude limiters may be used to reduce noise and it can be reduced also by increasing deviation δ and availability of large number of side bands.

HOTS questions with answers (2 marks &3 marks)--05 questions

1.Ground wave propagation cannot be used above a particular frequency. Why?

Ans. When a transmitting station emits waves parallel to ground, the waves are absorbed by the earth because earth is good conductor. The absorption of the waves increases with increase in frequency, so the frequency above 1.5 MHz (1500 kHz) is not used for ground wave propagation.

2. why do we prefer transmission of a signal through optical fiber rather than wires?

Sol. If we use conducting wires for sending a signal there are many losses like heat loss, power loss etc. and signals become weak. But in optical fibers, there is negligible loss i.e. there is almost no absorption of light and hence signal does not become weak, even after covering a distance of a few kilometers.

3. Define the term "Modulation index" for an AM wave. What would be the modulation index for an AM wave for which the maximum amplitude is "a" and minimum amplitude is 'b'?

Ans-: Modulation index -: It is the Ratio of amplitude of modulating signal (E_m) to amplitude of the carrier wave (E_c)

i.e. modulation index, (μ)=E_m/E_c

Here, for AM wave, maximum amplitude 'a'=E_m+E_c

and minimum amplitude, 'b'=E_c-E_m.

So E_c = a+b/2 and E_m = a-b/2

So $\mu=E_m/E_c$= [(a-b) /2]/ [(a+b)/2]= (a-b)/ (a+b)

μ=(a-b)/(a+b)

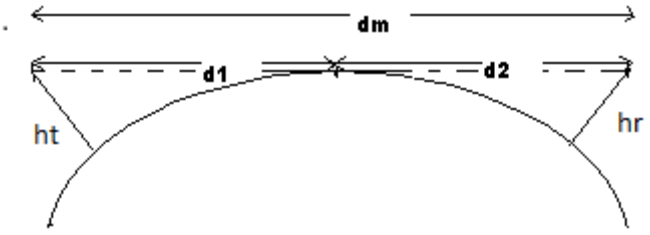
4. What is space wave propagation? Which two communication methods make use of this made of propagation? If the sum, of the heights of transmitting and receiving antenna in LOS communication is fixed at 'h' show that the range in maximum when the two antenna have a height h/2 each.

Ans. Space wave propagation: - When the frequency (> 40MHz) is transmitted from transmitting antenna to receiving antenna through the space is known as space wave propagation.

=> Satellite communication and line of sight (LOS) communication makes use of space waves.

Here $d_1= \sqrt{2}Rh_1$ and $d_2=\sqrt{2}Rh_2$

For minimum range,



$d_m=\sqrt{2}Rh_1+\sqrt{2}Rh_2$

Where $dm=d_1+d_2=d$

Given $h_1 + h_2 = h$.

Let $h_1 = x$ then $h_2 = h-x$

so $dm = \sqrt{2}rx + \sqrt{2}r(h-x)$

Or $d(dm)/dx = \sqrt{r}/2x - \sqrt{r}/2(h-x) = 0$

I.e. $1/2x = ½(h-x)$

$\therefore x = h/2$

hence $h_1 = h_2 = h/2$

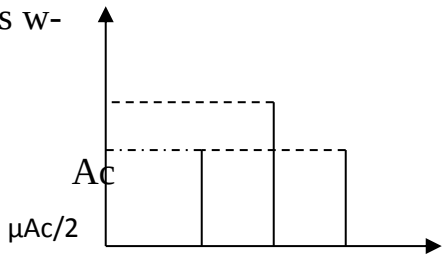
5.- Draw a plot of the variation of amplitude v/s w for am amplitude modulated wave. Define modulation index. State its importance for effective modulation.

Ans. Plot of variation of Amplitude v/s w-

Ac=Amplitude of carrier wave

ω_c =frequency of carrier wave

Wm=frequency of modulating



$(\omega_c - \omega_m)$=L.S.B. (lower side band)

$(\omega_c - \omega_m)$=U.C.B. (upper side band)

$(\omega_c - \omega_m)$ ω_c $(\omega_c + \omega_m)$ ω in Radians

Modulation index:-

It is the ratio of amplitude modulating signal to the amplitude of carrier wave. It is represented by μ.

i.e.….μ=Am/Ac

Importance of "μ"for effective modulation :-

The modulation index determine4s the quality of the modulated wave.

(1) if μ=0, there is no modulation.

(2) if μ=1/2 or 50%, then Amax is three times the Amin.

(3) if μ=1 or 100%, then Amin becomes zero.

(4) if μ>1,then the modulation is known as over modulation. In this case the audio signal is distorted.

Note;-To avoid distortion, μ is kept <=1.

6. Due to economic reasons, only the size of upper side of band of an AM wave is transmitted, but at receiving station, there is a facility for generating the carrier show that if a device is available which can multiply two signals, then it is possible to recover the modulating signal at receiver station.

Ans. For simplicity, let the received signals be:

$A_0\cos(\omega_{c+}\omega_m)\ t.$

The carrier $A_c\cos\omega_c\ ct$ is available at the receiving station. By multiplying the two signals,we get

$\Rightarrow A_0\cos(\omega_{c\ +}\ \omega_m\ )t.\ A\cos\ \omega_c t$

$\Rightarrow\ A_0 A\cos\ (\omega_{c\ +}\omega_m)t.\ \cos\ \omega_{ct}$

$\Rightarrow A_0 Ac/2[(\cos\ \omega_{m)t+}\ \cos(2\ \omega_{c+}\ \omega_{m)t}]$

If this signal is passed through a low pass filter, we can record the modulating signal $A_0 Ac/2$ $\cos\ \omega_{m\ t.}$

$A_{0\ \rightarrow}$ amplitude of modulated wave.

$(\omega_{c\ +}\omega_m)\rightarrow$angular frequency of modulated wave.

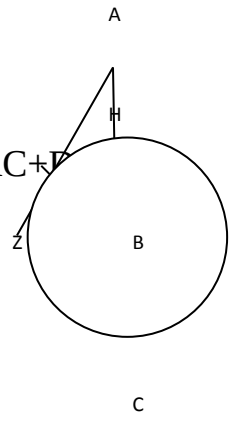
$Ac\ _{\rightarrow}$amplitude of carrier wave.

$\omega_c\ \rightarrow$frequency of carrier wave.

7. Find expression for the area covered by the transmitting T.V. antenna of height H".

Ans. Let Earth is a sphere of radius "R". Let the maximum distance up to which the signal of a tower can be received be "d". Then the area covered will be πd^2.

Let AB be the transmitting antenna and AN is the tangent to the sphere of earth.



$\angle ANC = 90^0$B

In following figure AB=H,BC=R,AN=AC+R

By Pythagoras theorem,

In ∇ANC,

$AC^2=AN^2+NC^2$

$(R+H)^2= d^2 +R^2$

$R^2+H^2+2RH= d^2+ R^2$

Or $H^2+2RH = d^2$

Here H^2 is very small as compared to d^2 2RH, so we neglect $H^{2,}$

Then,

$2RH = d^2$

Multiplying both sides by π, we get

$\pi d^2 = 2\pi RH$ = area covered

This is required formula of area covered.

<u>Value based questions with answers -(5questions)</u>

1. A TV tower has a height of 70m with an average population density around the tower as 1000 per km-2. In about 5 years the CITY LIMIT the place doubled and the residents were not able to get the broadcast clearly. Niharika, a student, identified the problem and notified the Government saying that the height of the tower should be increased to double its coverage.

Contextual :

By how much should the height of the tower be increased?

Value Based :

What values would you appreciate in Niharika?

Ans: Awareness
Concern for public
Helping the society / being helpful to the society, initiative

2. Two students of class 12 were interested in doing a project on 'transmitting signals of different frequencies'. They completed their project without any help but found that (i) the transmission is attenuated and (ii) the various information signals transmitted at low frequencies got mixed up.

Contextual :

Identify the solution for the problem

Value Based :

What values can we learn from those students?

Ans : Eagerness / Curiosity to learn more.
Scientific attitude.

3. During a class discussion regarding the bandwidth of transmission medium, group A was of the opinion that message signals could be transmitted at any bandwidth. They were not aware of the transmission media to be used. Group B gave information about the commonly used transmission media while group C informed about the government procedures to be followed.

Contextual :

What was the information given by group B and group C?

Value Based :

What values do you observe in this class discussion?

Ans: Team Work
Togetherness
Awareness

4. The teacher asked the students " Why are calling the world today as the global village". One student Rahat Replied due to modern generalized communication among the

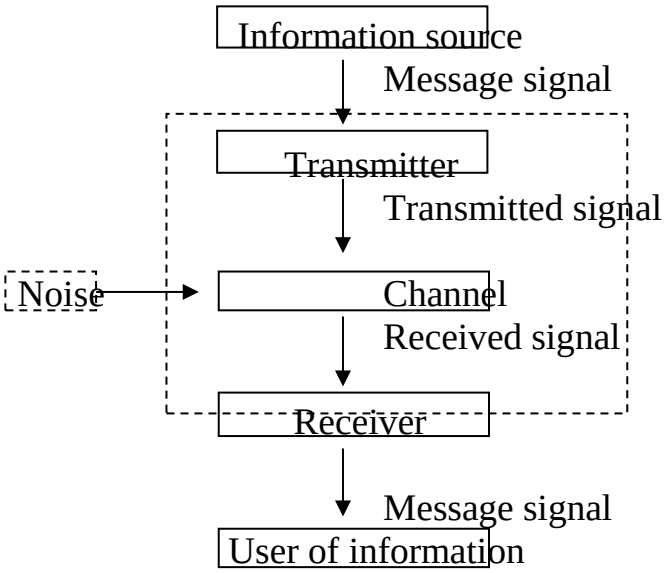
countries across the world is leading various types of commercial and traditional relationships between them.

(i) Do you agree with Rahat's reply? If yes, then why? Justify.

(ii) What do you mean by communication? Draw a blok diagram of a generalized communication system.

Ans: (i) Yes any type of relation can be developed between two bodies because of communication. If no communication exists between two bodies i.e. no thought transaction or no sharing then none can come closer and hence forth it will not be possible to make a highly integrated society.

(ii) The shortest appropriate definition of communication can be " In act of transmission of information". Block diagram of a generalized communication system.



5. We brought a new DISH TV our neighbours gathered around that Saturday to help us in putting up the satellite dish antenna. Since we had only the simplest of tools we weren't making much progess then a man who was new to the neighbourhood appeared with a very impressive tool box. It had everything we needed to put up the dish in no time at all as we stood around congratulating ourselves on this piece of good luck, we asked our new neighbour what he made with his fancy tools. Looking at us all, he smiled and said: "Friends."

(i) How does long distance communication take place? Discuss in context of sky wave and space wave communication?

(ii) If the height of antenna is h_T then give the range d_T antenna radiates electromagnetic waves?

(iii) What values are shown by the new neighbour?

Ans: (i) Long distance communication between two points on the earth is achieved through reflection of electromagnetic waves by ionosphere. Such waves are called sky waves. Sky wave propagation takes place upto frequency of about 30 MHz. Above this frequency

electromagnetic waves essentially propagate as space waves. Space waves are used for line of sight mode of communication and satellite communication.

(ii)If an antenna radiates electromagnetic waves from a height h_T then the range d_T is given by

$$d_T = \sqrt{2h_T R}$$, where R is the radius of earth.

(iii) Value are shown by the new neighbour are friendship warmth towards neighbour and empathy.

6. Group discussion was arranged in class-XII on the topic atmosphere. Three groups made. Teacher asked the question. "Why can moon be not used as a communication satellite?" Answer were given by all the three groups. Each group could give only one reason. Teacher told that the reason given by each group is correct. The group collected all the reasons and thus came to a correct conclusion.
   (i) What values were showed by all three groups?
   (ii)Give the correct reason for the above questions.

Ans: (i) Team spirit and critical thinking.
(ii)Moon is not a geostationary satellite.

7. Deepa's uncle wants to talk to his son in USA. He does not have money to spend on telephone calls. He has a computer at his home. Deepa told her uncle that he could talk his son with the help of computer and also told him about internet. Her uncle now talks to his son every day. He thanked Deepa for giving useful advice.
   (i) What according to you the values displayed by Deepa?
   (ii)How does internet work?

Ans: (i) Caring and creating awareness.
(ii)Internet is a global network of computers linked by high speed data lines and wireless systems. It allows communication and sharing of information between any two or more computers connected through the network.

8. Nidhi has to take admission in some professional college. It was last date of admission and Nidhi left her birth certificate at her home. College was very far from the home. She called her brother and he faxed the birth certificate. She got the admission and thanked her brother.
   (i) What value was displayed by Nidhi?
   (ii)What value was displayed by her brother?
   (iii) What is the function of Fax?

Ans: (i) Awareness.
(ii)Understanding.
(iii)It is used to produce an exact copy of a document or picture at distance place.