1. Details of Module and its structure

Module Detail	
Subject Name	Physics
Course Name	Physics 04 (Physics Part-2, Class XII)
Module Name/Title	Unit-10, Module-05: Short Range Communication Chapter 15 Communication Systems
Module Id	leph_201505_eContent
Pre-requisites	Frequency, wavelength, electromagnetic wave, antenna, transducer, band width, frequency range, signal, need for communication, common communication devices, electromagnetic wave transmission, channels of communication, need for modulation, types of modulation Amplitude modulation, modulation index
Objectives	After going through this module the learners will be able to • Understand the meaning of short range radio communications • Know that an antenna can increase the receiving area • Appreciate the application of short range communication in factories, villages, stadiums, townships and societies • Know about basic internet and world wide web
Keywords	Amplitude modulation, modulation index, graphical representation of amplitude modulated wave, application of amplitude modulated wave

2. Development Team

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Unit 10 Communication Systems

Chapter 15 Communication System

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2. MODULE WISE DISTRIBUTION OF UNIT SYLLABUS 6 MODULES

Module 1	• **History of communication** • **Special vocabulary** • **Signals and band width**
Module 2	• **Propagation of electromagnetic wave** • **Ground wave** • **Sky wave** • **Space wave** • **Satellite communication**
Module 3	• **Modulation** • **Need for modulation** • **Types of modulation**

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MODULE 5

3. WORDS YOU SHOULD KNOW

Communication: The process of putting across ideas through words and pictures

Audio communication: Communication by means of speech/sound or messages that can be received by our ears

Video communication- Communication by means of pictures, still or moving or messages that can be received by our eyes

Audio video communication- Communication by means of speech/sound or messages that can be received by our ears

Device- an apparatus designed for special functions

Mode of transfer of information- method of transfer of information

Antenna- a device designed to send out and receive electromagnetic waves.

Electromagnetic waves-

The range of electromagnetic signals encompassing all frequencies is referred to as the electromagnetic spectrum

Frequency: It is defined as number of cycles per second or number of waves per second.

Wavelength is the distance occupied by one cycle of a wave and is usually expressed in meters. Wavelength is also the distance traveled by an electromagnetic wave during the time of one cycle. The wavelength of a signal is represented by the Greek letter lambda (λ).

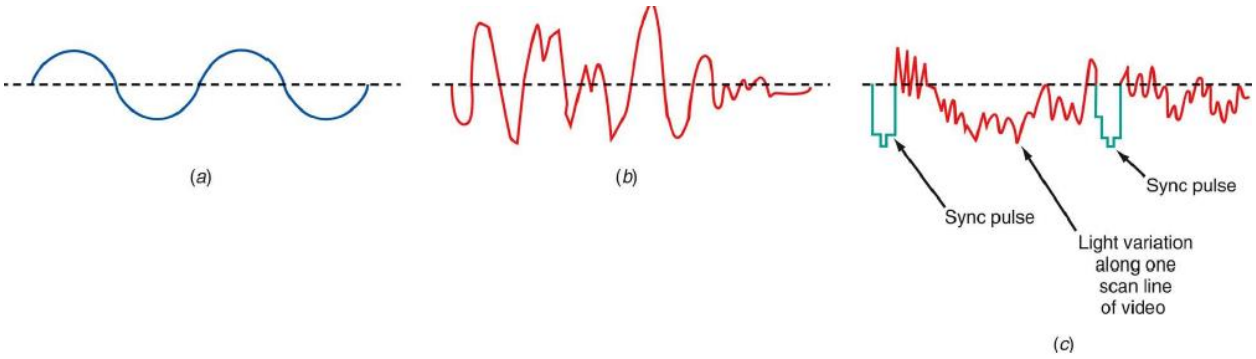
Transducer: An electrical transducer may be defined as a device that converts some physical variable (pressure, displacement, force, temperature, etc.) into corresponding variations in the electrical signal at its output. For example, a microphone converts sound energy into electrical energy.

Signal: Information converted in electrical form and suitable for transmission is called a signal. Signals can be either **analog or digital**.

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.



Analog signals (a) Sine wave "tone." (b) Voice. (c) Video (TV) 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.

Digital signals (a) Telegraph (Morse code). (b) Continuous-wave (CW) code. (c) Serial binary code

Technically speaking, a signal is a wave, amplitude or frequency of which varies with time and the signal can be analog or digital.

NOISE: These are unwanted signals having same or similar frequency as that of required signal. They distort the transmission and receiving process. A virus in a computer is example of noise. A virus is an unwanted program in the same language in which your required program is, it disrupts your program.

Communication channel: The **communication channel** is the medium by which the electronic signal is sent from one place to another. Types of media include electrical conductors, Optical media, Free space, and System-specific media (e.g., water is the medium for sonar).

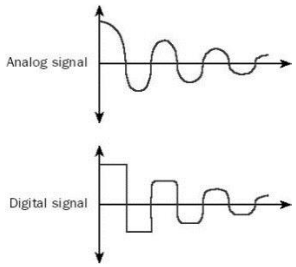
Transmitter: It is the device that converts the information (message) into a form suitable for transmission. In above example the online shopping company is the transmitter.

Receiver: It is the device that retrieves the information from received signal. In shopping example, you are the receiver. A **receiver** is a collection of electronic components and circuits that accepts the transmitted message from the channel and converts it back into a form understandable by humans. Receivers contain **amplifiers, oscillators, mixers, tuned circuits** and **filters**, and a detector that recovers the original intelligence signal from the modulated carrier

Transceivers: A **transceiver** is an electronic unit that incorporates circuits that both send and receive signals. Examples are: Telephones, Fax machines, radios, Cell, mobile phones, computers.

Amplification: It is the process of increasing the strength of signal. Amplification compensates for attenuation. Amplification is done by electronic circuit.

Attenuation: It refers to loss in strength of signal while propagating from transmitter to receiver Signal **attenuation,** or degradation, exists in all media of wireless transmission. It is usually proportional to the square of the distance between the transmitter and receiver



Range: It is the maximum distance that a signal can travel with sufficient strength.

Band width: It is the frequency range over which a system works. It is calculated as highest frequency – lowest frequency. For example, the human audio frequency range is 20 Hz to 20,000 Hz, so audio bandwidth = 20,000 – 20 = 19,980 Hz **Bandwidth is** that portion of the electromagnetic spectrum occupied by a signal. **Channel bandwidth** refers to the range of frequencies required to transmit the desired information.

Band width of transmission medium **the transmission channels are of three types**

Wires, free space and optical fiber

Repeater: repeater station is equipped with Receiver, Amplifier and Transmitter.

The mobile phone towers in your area are repeater stations.

Communication satellites are repeater stations in space. They receive signal from one ground station amplify it and transmit it to another ground station.

Antenna: It is the device through which transmission and receiving process are done. The dish connected to your TV set is an antenna in itself.

Carrier wave: A **carrier** is a high frequency signal that is modulated by audio, video, or data. A **radio-frequency (RF) wave** is an electromagnetic signal that is able to travel long distances through space

Broadcasting is the distribution of audio or video content to a dispersed audience via any electronic mass communications medium, but typically one using the electromagnetic spectrum (radio waves), in a one-to-many model

Mode of em wave propagation: **em waves travel in three ways through the atmosphere, ground wave, sky wave and space wave.**

The modulated wave **is a combination of message signal and carrier wave.**

A sinusoidal carrier wave can be represented as

$$c(t) = A_c \sin(\omega_c t + \theta)$$

Where,

***c*(*t*) is the signal strength (voltage or current),**
***Ac* is the amplitude,**
ω*c* (= 2πfc) is the angular frequency
and
θ is the initial phase of the carrier wave.

During the process of modulation, **any of the three parameters**,
Viz **Ac, ωc and θ,** 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)
(iii) Phase modulation (PM),

Amplitude modulation The process of varying amplitude of a high frequency carrier wave in accordance with the signal (code, voice or music) to be transmitted , keeping the frequency and phase of the carrier wave unchanged is known as amplitude modulation

An amplitude modulated wave has frequencies ($\omega_c - \omega_m$), ω_c and ($\omega_c + \omega_m$) .

($\omega_c - \omega_m$) = Lower side band frequency

($\omega_c + \omega_m$) = Upper side band frequency.

Bandwidth of AM wave = highest freq. - Lowest freq.

= USB - LSB

$= (\omega_c + \omega_m) - (\omega_c - \omega_m)$

$= 2\ \omega_m$

Modulation index

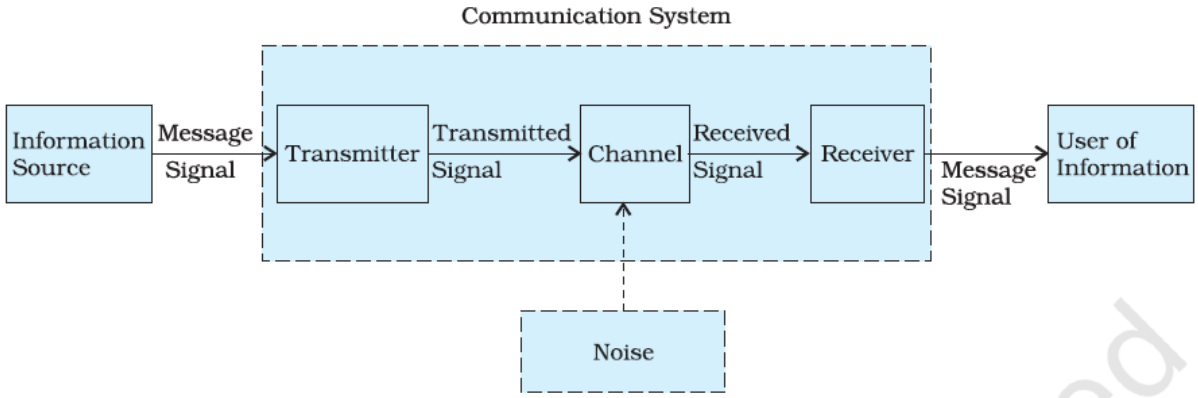
$\mu = A_m/A_c$ is called modulation index in practice $\mu \leq 1$ to avoid distortion of signal.

4. INTRODUCTION

Electronic communication refers to the faithful transfer of information or message (available in the form of electrical voltage and current) from one point to another point. Electronic communication involves a transmitter, transmission channel and receiver. These are the three basic units of a communication system.

Two important forms of communication system are: Analog and Digital. The information to be transmitted is generally in continuous waveform for the former while for the latter it has only discrete or quantised levels.

A simple picture of the communication arrangement would be as shown by the block diagram



Every **message signal** occupies a range of frequencies. The bandwidth of a message signal refers to the band of frequencies, which are necessary for satisfactory transmission of the information contained in the signal. Similarly, any practical communication system permits transmission of a range of frequencies only, which is referred to as the bandwidth of the system.

We have learnt in earlier modules that low frequencies cannot be transmitted over long distances. Therefore, they are superimposed on a high frequency carrier signal by a process known as **modulation.** In modulation, some characteristic of the carrier signal like

amplitude, frequency or phase varies in accordance with the modulating or message signal. Correspondingly, they are called **Amplitude Modulated (AM), Frequency Modulated (FM) or Phase Modulated (PM) waves.**

Amplitude modulated signal contains frequencies $(\omega_c - \omega_m), \omega_c, (\omega_c + \omega_m)$.Amplitude modulated waves can be produced by application of the message signal and the carrier wave to an appropriate device, followed by suitable circuits . AM detection, which is the process of recovering the modulating signal from an AM waveform, is carried out using a rectifier and an envelope detector.

For transmission over long distances, signals are radiated into space using devices called **antennas**. The radiated signals propagate as electromagnetic waves and the mode of propagation is influenced by the presence of the earth and its atmosphere.

Near the surface of the earth, electromagnetic waves propagate as surface waves. Surface wave propagation is useful up to a few MHz frequencies.

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 up to frequency of about 30 MHz Above this frequency, electromagnetic waves essentially propagate as space waves. Space waves are used for line-of-sight communication and satellite communication.

In the process of transmission of message/ information signal, noise gets added to the signal anywhere between the information source and the receiving end. Can you think of some sources of noise? Also in the process of modulation, new frequencies called sidebands are generated on either side (higher and lower than the carrier frequency) of the carrier by an amount equal to the highest modulating frequency. Is it possible to retrieve the message by transmitting (a) only the side bands, (b) only one side band? In amplitude modulation, modulation index $\mu \leq 1$ is used. What will happen if $\mu > 1$?
In this module we will take a closer look at short range communication

5. SHORT RANGE RADIO COMMUNICATION

Short range communication is very often wired, meaning like we have in our schools whether it is at assembly, auditorium or public address system. We have a microphone into which the speaker or singer sends the sound waves to be converted into electrical signals. wires connect the microphones to loudspeakers.

Here we will talk about wireless systems. which do not need any wires and use electromagnetic radio waves for sending the signal from source to observers.

Short range radio communication like communication between security personnel/organizers in a fair, mela or hospital or in a large residential society or in a village etc. is done using **ground wave propagation of wave.** Before cellphones became popular during the 1980s and 1990s, walkie-talkies were the most effective way to share information over short to medium ranges—and they're still widely used by police officers, military personnel, and the organizers of public events

Do you read me, over? Yes, I read you, over.

You must have seen traffic policemen with walkie-talkie, saying something followed by 'over'

A typical walkie-talkie set

https://commons.wikimedia.org/wiki/File:Walkie-talkie.JPG

Walkie-talkies are battery-powered transceivers, meaning they can both send and receive radio messages. They have a half-duplex channel, which indicates that only one **walkie-talkie** on a channel can transmit a signal at one time, although many radios can receive that same signal.

They communicate wirelessly using electromagnetic waves on a single, shared frequency band

What are they and how do they work?

There are two identical units Each unit contains a transmitter/receiver. They each have a small antenna as shown in the picture (for sending and receiving radio waves), Each hand held device uses device to convert electrical signal to sound (loudspeaker) and a device to convert sound to electrical signal (microphone) when you talk into it, and a button that you "push-to-talk" The loudspeaker/microphone double up as they contain essentially the same components (a coil of wire, a horse she magnet, and a paper or plastic cone to pick up or generate audio signal),

Comparing walkie-talkie to mobile phone which also duplex or **'speaks and listens'**. Mobile phone technology has been advancing at a mind boggling rate. But mobile phones still need servers and internet connectivity -- they're completely helpless without a network of nearby cellular towers. Walkie-talkies, though? These old-school radios make short-range wireless communications possible in places where cell phones cannot be used.

Walkie-talkies are wireless, hand-held radios that are small enough to take just about anywhere.

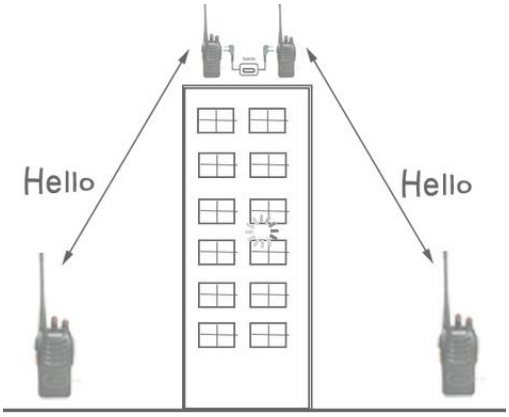
They look a lot like cordless phone handsets, with a body that includes a microphone and speaker, as well as an antenna. Unlike a phone, though, a walkie-talkie's speaker and mic are placed right next to each other, and the speaker is much louder, so that anyone within earshot can follow the conversation.

Walkie-talkies are robust, easy-to-use, and simple (with relatively few parts and features), so they are excellent for use outdoors and great for children They're particularly handy in places where cell phone or mobile phone network coverage is poor or unavailable (in disasters or emergencies, for example).. They're very handy in situations where lots of people need to listen and only one needs to talk at once (for example, if you're giving instructions to workers on a camp site). They're extremely convenient, weighing just 100–200g work over a decent range (typically 5–10 square km); and have long battery life. Walkie-talkies generally have multiple channels (from about 8 to 25 or more) so you can easily switch to another frequency if other people are also using walkie-talkies nearby.

Most inexpensive walkie-talkies are **analog** units, so they're subject to interference and relatively easy to eavesdrop (more expensive digital units get around interference, but generally only military walkie-talkies use encrypted language for security.

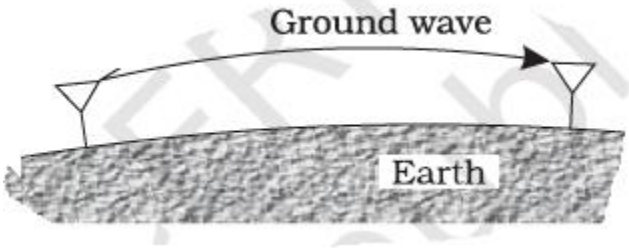
6. GROUND WAVES AND SHORT RANGE RADIO COMMUNICATION

Ground wave or surface wave propagation is a mode of propagation in which the wave moves close to earth's surface.



https://nl.aliexpress.com/item/Repeater-Box-for-Baofeng-Pofung-Walkie-Talkie-Radio-UV-5R-V2-RT-5R-VEV-3288-s/32366387128.html

It is suitable for low frequencies few KHz to 3MHz.
The ground waves glide along the surface of the earth
This can be imagined as shown in the figure.



As wave glides over the surface of earth, a large amount of energy of wave is absorbed by the ground. This loss in strength of wave is called attenuation

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Also, due to surface nature of propagation, the wave bends around the edges of an obstacle falling in their way. This phenomenon of bending around the edges of an object is called Diffraction.

- Due to attenuation and diffraction, this mode of propagation is suitable for local broadcast like **AM broadcast** of **medium wave band** of frequency range 530KHz to 1710Khz.
- This attenuation increases rapidly with increase in frequency of wave and with increase in distance. So, high frequencies and long distance transmission are not suitable for this mode of propagation.
- The maximum range of coverage depends upon power of transmitter and frequency used. For a given frequency of wave the range can be increased by increasing power of transmitter

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This mode of communication is used at airports, marine, trade fairs, shopping malls or local mela.

7. INCREASING THE AREA OF INFLUENCE BY ANTENNA

A transmitting antenna sends signals in all directions and thus covers a circular area.
The radius of this circle is called radio horizon of transmitting antenna (d), which is given by;

$$d = \sqrt{2Rh}$$

where

d = radio horizon of transmitting antenna (it is the radius up to which the transmitting antenna can send the signal)

R = radius of earth $R = 6.4 \times 10^6$ m

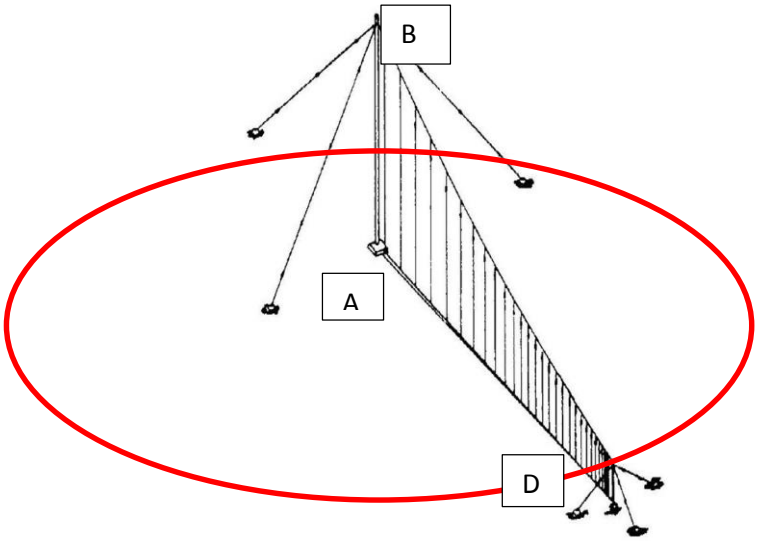
h = height of transmitting antenna **above earth surface**

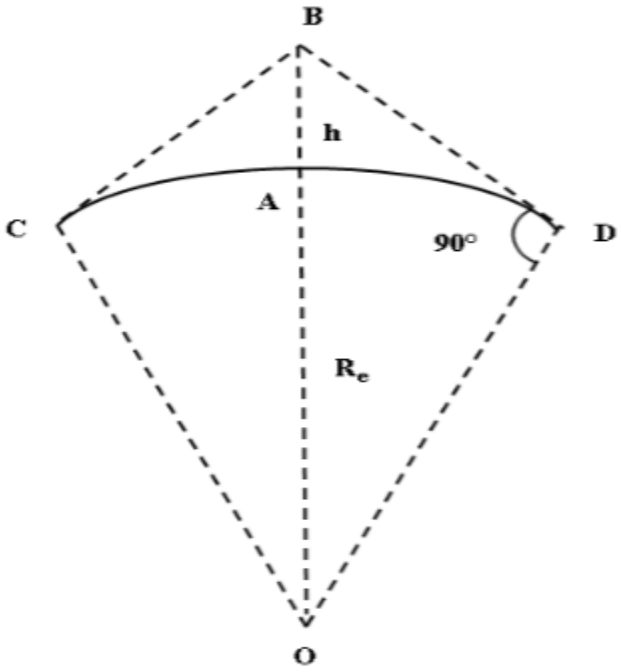
from relation

$$d = \sqrt{2Rh}$$

we see that area of influence can be increased by increasing the height of antenna above earth surface.

Consider the antenna and the region of influence





Consider AB be a tower of height h and R, radius of earth.
If broadcast is made from the top B of tower (AB), no reception of direct signals is possible beyond points C and D as shown in the figure.
The distance up to which signals can be received AC=AD is limited due to the curvature of the earth and is called the range of the antenna.
Let this be the range = d
The signals may be received in the region CAD
Let us relate d to h and R
In right angled triangle BOD

$$\angle BDO = 90^0$$

$$BO^2 = (OD)^2 + (BD)^2$$

$$(R+h)^2 = (R)^2 + (BD)^2$$

As height h of the antenna tower is very small as compared to radius R of the earth , hence point S will be close to A or we can say

$$BD \sim AD = d$$
$$(R+h)^2 = (R)^2 + (d)^2$$
$$d^2 = (R+h)^2 - (R)^2 = 2Rh + h^2$$

Now since h <<R hence $h^2 \ll 2Rh$

$$d^2 \backsimeq 2Rh$$

Area covered $= \pi d^2$

Population covered = area covered x population density

EXAMPLE:

A transmitting antenna at the top of a tower has a height of 32m. Find the no. of people receiving the transmission if population density is 10,000 people per sq. Km. Given radius of earth R = 6.4 × 10^6 m and $\sqrt{10} = \pi$

SOLUTION:

Range of transmitting antenna (radio horizon of transmitting antenna) $d = \sqrt{2Rh}$

$$= (2 \times 6.4 \times 10^6 \times 32)^{1/2}$$

$$= 64 \times 10^2 \sqrt{10}$$

$= 64 \times 10^2 \times \pi$ meter

$= 6.4 \times \pi$ km

Population covered = population density x area covered

$= 10{,}000 \times \pi\, d^2$

$= 10{,}000 \times \pi^3 \times 6.4 \times 6.4$

$= 100 \times 10 \times 3.14 \times 64 \times 64$

= 12,861,440 people

8. POLICE COMMUNICATION NETWORK

Police uses a large range of frequencies for their communication. Since police has to cover the whole local area as well as the whole state even it has to communicate with other state police as well, police use all modes of propagation of wave viz. Ground wave propagation, sky wave propagation and space wave propagation of wave.

We have discussed that increasing the height of antenna, increases the area of coverage. Therefore, the main wireless station of police is established at the highest point of area/state to avoid any interference from high rise buildings. (specially in LOS mode of communication of space wave propagation). So, if you happen to see some dish or antenna at a hilltop in your area, it could be a communication station of police or army.

For local coverage ground wave propagation may be used. But due to large attenuation (loss of energy) in ground wave , nowadays sky wave propagation or space wave propagation is being used even for local coverage, but equipment for this is more expensive.

The two modulation types used are AM and FM

Characteristics of AM:

(i) Amplitude of carrier wave is varied according to message signal.
(ii) Devices used for transmitting and receiving AM wave are simple in design and hence cheaper.
(iii) Large introduction of noise.

Characteristics of FM:

(i) Frequency of carrier wave is varied according to message signal.

(ii) Devices used for transmitting and receiving FM wave are complex in design and hence costlier.

(iii) Very less introduction of noise.

Because there is large noise in AM than FM, AM has very limited use and FM is widely used.

9. INTERNET

It is a system with billions of users worldwide. It allows communication and sharing of all types of information (text, data, audio or video) between any two or more computers through a large and complex network. It was started in 1960's and opened for public use in 1990's. With passage of time it grew tremendously and is still expanding. Its applications include

(i) **E mail:** It permits exchange of text/graphic material using email software. We can write letter and send it to recipient through ISP's (Internet Service Providers) who works like the dispatching and receiving post offices.

(ii) **File transfer:** A FTP (File Transfer Programs) allows transfer of files/software from one computer to another computer connected to the internet.

(iii) **World Wide web:** Computers that store specific information for sharing with others provide *websites* either directly or through web service providers. Government departments, companies, NGO's (Non-Government Organizations) and individuals can post information about their activities for restricted or free use on their websites. This information becomes accessible to the users through search engine. Several search engines like Google, Yahoo etc. help us in finding information by listing the related websites. *Hypertext* is a powerful feature of the web that automatically links relevant information from one page on web to another using HTML (Hypertext Markup language).

(iv) **e - commerce: Use o**f the internet to promote business using electronic means such as using credit cards is called e - commerce. Customers view images and receive all the information about various products or services of companies through their websites. They can do on-line shopping from home/office. Goods are dispatched or services are provided by the company through mail/courier.

(v) **Chat:** Real time conversation among people with common interests through typed messages is called chat. Everyone belonging to the chat group gets the message instantaneously and can respond rapidly.

WORKING OF INTERNET:

In internet, the computers are connected with each other through a device called **Server.** The simplest working is as under:

Case 1: In this case, the information being sent has no specific address but is meant for bulk of people. Suppose a company wish to promote his business, then it will upload (send) all the details of his product/services, on the server, through their computer. People looking for same product/services, can download (receive) the information of product/service, from server on their computers.

Case 2: In this case, the information being sent is meant only for a specific person.

Suppose a person A wish to write an electronic letter (E mail) to person B. Then A will type the letter on his computer, will put address of B on it and will send it to the server. From the server it will be delivered to person B.

INTERNET SERVERS

The servers are basically computers designed for storing purpose. You can think of a server as an electronic filing cabinet or a post office. Different servers store different information , some are used for storing files these are called file servers , some are used for storing mails these are called mail servers while some others are used for storing the WWW (world wide web) addresses or Web pages, these are called Web servers.

In your school library, different cabinets store books on different subjects. So, each cabinet has different information (books). These cabinets may be considered as servers.

There are millions of servers on internet. Each possessed by a company called internet service provider (ISP). A computer cannot be connected to a server directly; it is connected to the server through a device called **router**. The Wi Fi device at your home is the router. A single router can support a number of computers.

10. SUMMARY

- Short range radio communication is used for disbursing signals to local area or small area coverage
- These use ground waves and simple walki-talki transmitters and receivers
- The coverage area can be increased by using antennas of suitable heights.
- Short range communication is used for police , hospital , airports, mela or localized communication
- Internet allows communication and sharing of all types of information (text, data, audio or video) between any two or more computers through a large and complex network
- **E mail:** It permits exchange of text/graphic material using email software. We can write letter and send it to recipient through ISP's (Internet Service Providers) who works like the dispatching and receiving post offices.

- **File transfer:** A FTP (File Transfer Programs) allows transfer of files/software from one computer to another computer connected to the internet.
- **World Wide Web:** Computers that store specific information for sharing with others provide *websites* either directly or through web service providers.
- **e- Commerce: Use o**f the internet to promote business using electronic means such as using credit cards is called E- commerce.
- **Chat:** Real time conversation among people with common interests through typed messages is called chat.
- **In** internet: the computers are connected with each other through a device called Server.
- The internet servers are basically computers designed for storing purpose. You can think of a server as an electronic filing cabinet or a post office.