Unit-2 Transmission Media

Unit II :

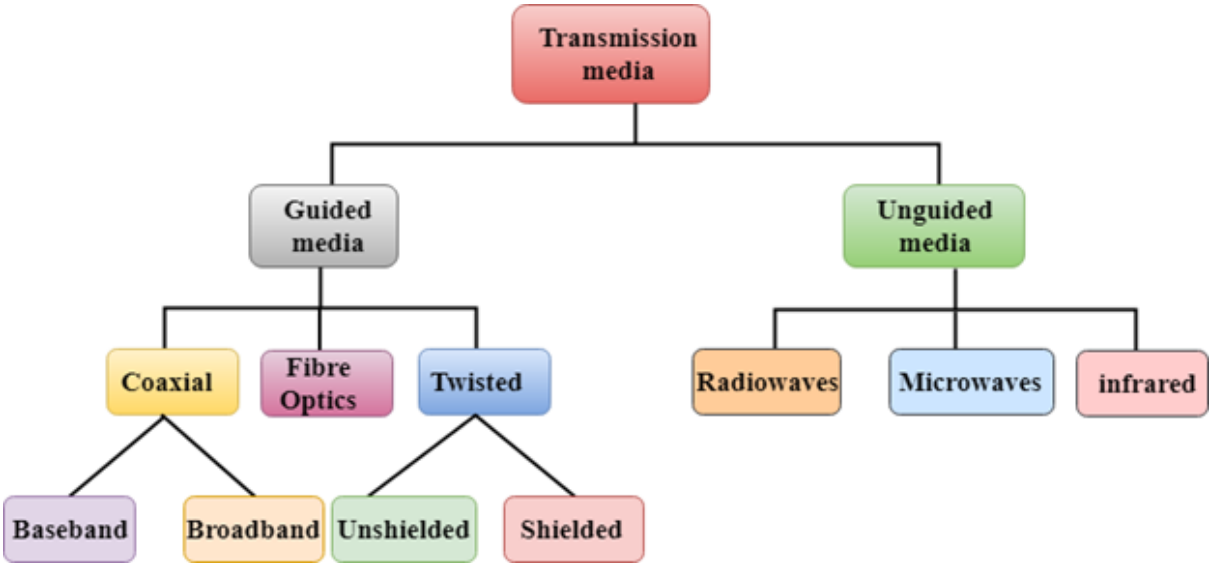
Transmission Media Guided media, Twisted-pair cable – UTP, STP, Connectors Coaxial Cable, Connectors Fiber-Optic Cable Propagation Modes, Unguided Media - Wireless Transmission – Terrestrial Microwave, Satellite Microwave, Radio Waves. Infrared.

Transmission media is a communication channel that carries the information from the sender to the receiver. Data is transmitted through the electromagnetic signals.It is a physical path between transmitter and receiver in data communication.

In a copper-based network, the bits are in the form of electrical signals.In a fibre based network, the bits are in the form of light pulses.The electrical signals can be sent through the copper wire, fibre optics, atmosphere, water, and vacuum.The characteristics and quality of data transmission are determined by the characteristics of medium and signal.

Transmission media of two types are wired(guided) media and wireless(unguided) media. In wired media, medium characteristics are more important whereas, in wireless media, signal characteristics are more important.

Classification of transmission media



GUIDED MEDIA

It is defined as the physical medium through which the signals are transmitted. It is also known as Bounded media.

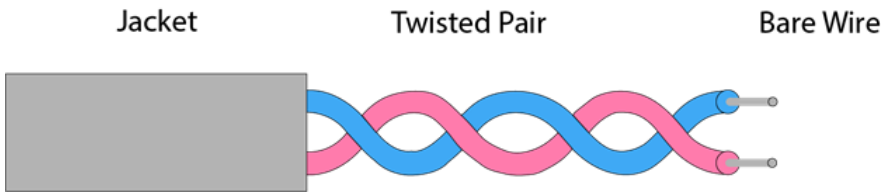
Types Of Guided media:

Twisted Pair Cable

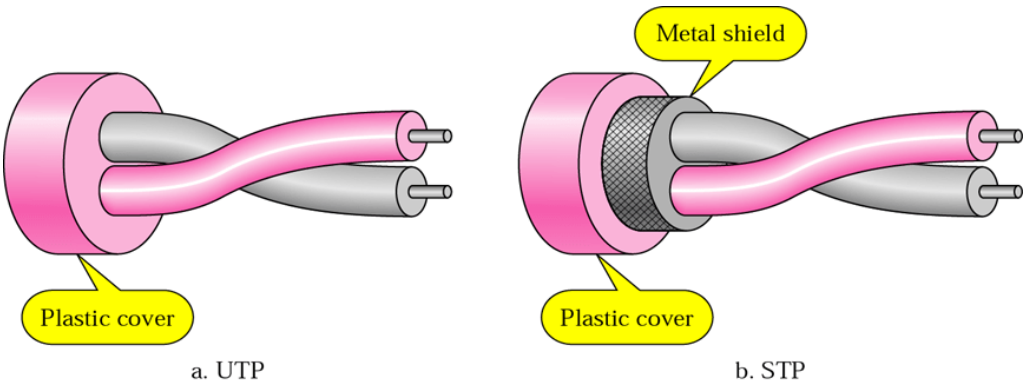
Twisted pair is a physical media made up of a pair of cables twisted with each other. A twisted pair cable is cheap as compared to other transmission media. The frequency range for twisted pair cable is from 0 to 3.5KHz.

A twisted pair consists of two insulated copper wires arranged in a regular spiral pattern,each with its own plastic insulation. One of the wires is used to carry signals to the receiver,and the other is used only as a ground reference. The receiver uses the difference between the two. In addition to the signal sent by the sender on one of the wires, interference(noise) and crosstalk may affect both wires and create unwanted signals.

If the two wires are parallel, the effect of these unwanted signals is not the same in both wires because they are different locations relative to the noise or crosstalk sources. This results in a difference at the receiver. By twisting the pairs, a balance is maintained.



Types of twisted pair: **Unshielded twisted-pair(UTP) and Shielded twisted pair(STP)**



Unshielded twisted-pair(UTP):An unshielded twisted pair is widely used in telecommunication. Following are the categories of the unshielded twisted pair cable:

- Category 1: Category 1 is used for telephone lines that have low-speed data.
- Category 2: It can support upto 4Mbps.
- Category 3: It can support upto 16Mbps.
- Category 4: It can support upto 20Mbps. Therefore, it can be used for long-distance communication.
- Category 5: It can support up to 200Mbps.

Advantages Of Unshielded Twisted Pair:

- It is cheap.
- Installation of the unshielded twisted pair is easy.
- It can be used for high-speed LAN.

Disadvantage:

- This cable can only be used for shorter distances because of attenuation.

Shielded twisted-pair(STP): A shielded twisted pair is a cable that contains the mesh surrounding the wire that allows the higher transmission rate. The metal casting improves the quality of cable by preventing the penetration of noise or cross talk

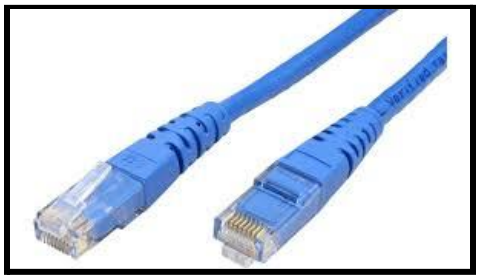
Advantages:

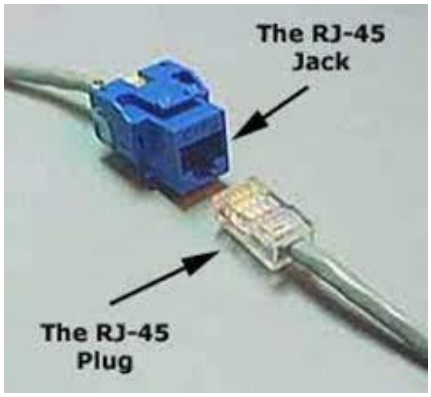
- The cost of the shielded twisted pair cable is not very high and not very low.
- Installation of STP is easy.
- It has higher capacity as compared to unshielded twisted pair cable.
- It has a higher attenuation.
- It is shielded and provides a higher data transmission rate.

Disadvantages

- It is more expensive as compared to UTP and coaxial cable.
- It has a higher attenuation rate.

*Connectors:*The most important UTP connector is RJ45 (R stands for registered jack). The RJ45 is a keyed connector.





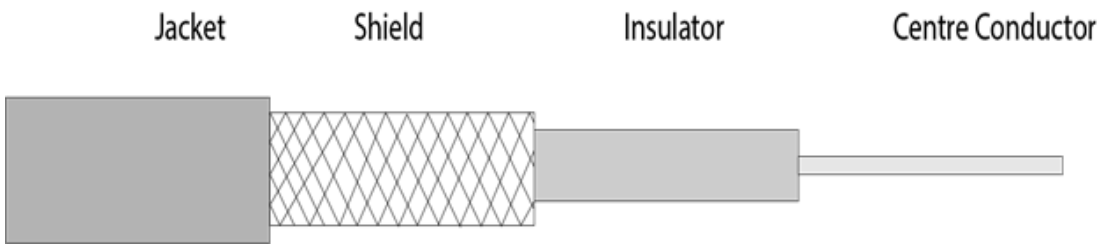
Twisted pair cables are used in telephone lines to provide voice and data channels.

Coaxial Cable

Coaxial cable is a very commonly used transmission media, for example, TV wire is usually a coaxial cable.The name of the cable is coaxial as it contains two conductors parallel to each other.It has a higher frequency as compared to Twisted pair cable.

The inner conductor of the coaxial cable is made up of copper, and the outer conductor is made up of copper mesh. The middle core is made up of non-conductive cover that separates the inner conductor from the outer conductor.

The middle core is responsible for the data transferring whereas the copper mesh prevents EMI(Electromagnetic interference). The whole cable is protected by a plastic cover.

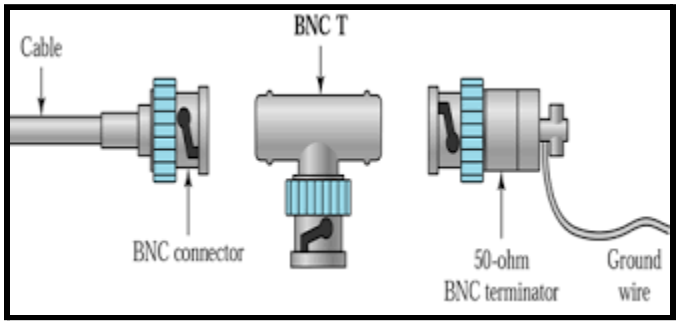


Coaxial cable is of two types:
Baseband transmission: It is defined as the process of transmitting a single signal at high speed.
Broadband transmission: It is defined as the process of transmitting multiple signals simultaneously.

Coaxial cable standards: Coaxial cable are categorised by their Radio Government (RG) ratings. Each RG number denotes a unique set of physical specifications, including the wire guage of the inner conductor, thickness and type of inner insulator,the construction of the shield and size and type of outer casting.

Category	Impedance	Use
RG-59	75	Cable TV
RG-58	50	Thin Ethernet
RG-11	50	Thick Ethernet

*Coaxial Cable Connectors:*To connect coaxial to device, we need coaxial connectors. The most common type of connector used today is the Bayonet Nell-Concelman (BNC) connector.



The BNC connector is used to connect the end of the cable to a device,such as a TV set. The BNC T connector is used in Ethernet networks to branch out to a connection to a computer or other devices.

Advantages Of Coaxial cable:

- The data can be transmitted at high speed.
- It has been shielding as compared to twisted pair cable.
- It provides higher bandwidth.

Disadvantages Of Coaxial cable:

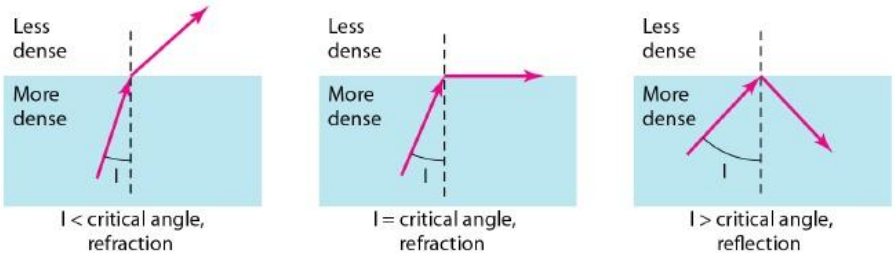
- It is more expensive as compared to twisted pair cable.
- If any fault occurs in the cable causes the failure in the entire network.

Fibre-Optics Cable

A fibre optic cable is made of glass or plastic and transmits signals in the form of light.Fibre optic is a cable that holds the optical fibres coated in plastic that are used to send the data by pulses of light.The plastic coating protects the optical fibres from heat, cold, electromagnetic interference from other types of wiring.Fibre optics provide faster data transmission than copper wires.

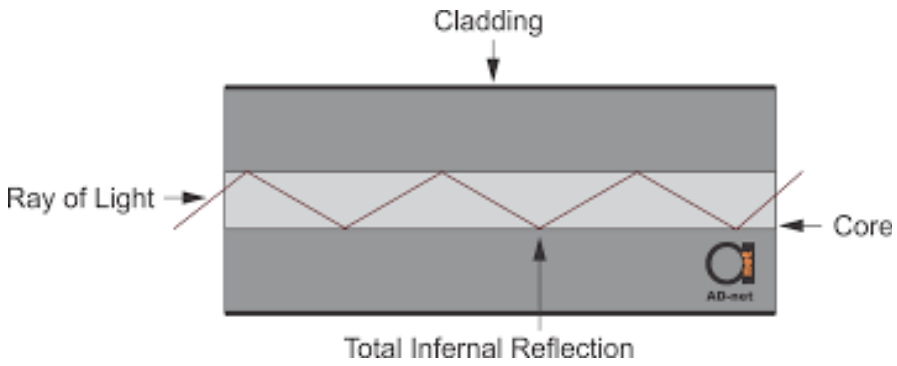
Light travels in a straight line as long as it is moving through a single uniform substance. If a ray of light travelling through one substance suddenly enters another substance (of a different density),the ray changes direction.

Figure 7.10 ***Bending of light ray***



7.14

If the angle of incidence (the angle the ray makes with the line perpendicular to the interface between the two substances) is less than the critical angle, the ray refracts and moves closer to the surface. If the angle of incidence is equal to the critical angle,the light bends along the interface. If the angle of incidence is greater than the critical angle, the ray reflects and travels again in the denser substance.

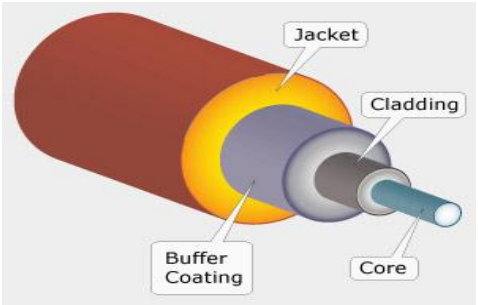


Optical fiber uses reflection to guide light through a channel. A glass or plastic core is surrounded by a cladding of less dense glass or plastic. The difference in density of two materials must be such that a beam of light moving through the core is reflected off cladding instead of being refracted into it.

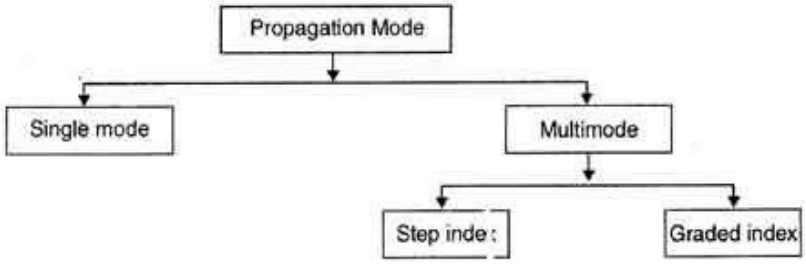
Core: The optical fibre consists of a narrow strand of glass or plastic known as a core. A core is a light transmission area of the fibre. The more the area of the core, the more light will be transmitted into the fibre.

Cladding: The concentric layer of glass is known as cladding. The main functionality of the cladding is to provide the lower refractive index at the core interface as to cause the reflection within the core so that the light waves are transmitted through the fibre.

Jacket: The protective coating consisting of plastic is known as a jacket. The main purpose of a jacket is to preserve the fibre strength, absorb shock and extra fibre protection.



Propagation modes: Current technology supports two modes (multimode and single mode) for propagation of light along optical channels, each requiring fiber with different physics characteristics.

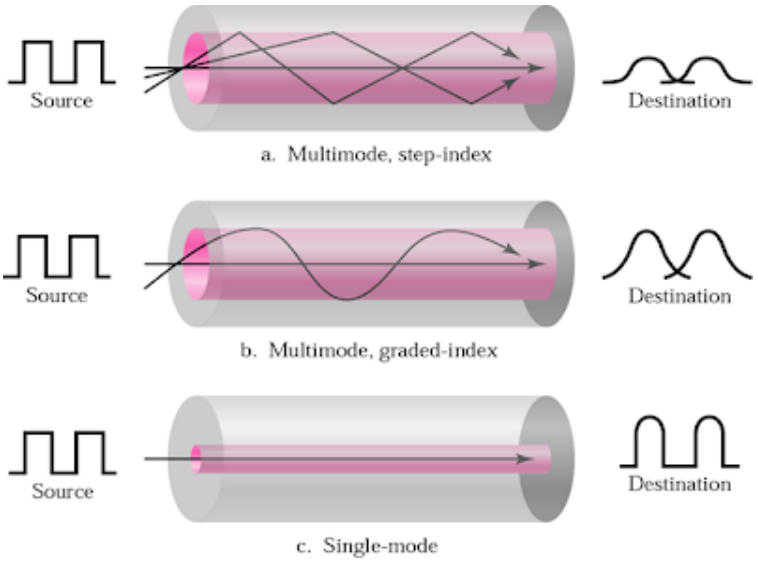


Multimode: Multimode is named so because multiple beams from a light source move through the core in different paths.

In multimode step index fiber,the density of the core remains constant from the centre to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding. At the interface, there is an abrupt change due to the lower density; this alters the angle of the beam's motion. The step index refers to the suddenness of this change,which contributes to the distortion of the signal as it passes through the fiber.

Multimode graded- index fiber decreases this distortion of the signal through cable. Index here refers to the index of refraction. A graded index fiber is one with varying densities. Density is the highest at the centre of the core and decreases gradually to its lowest at the edge.

Single-Mode: Single-mode uses step index fiber and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal. The single-mode fibre itself is manufactured with a much smaller diameter than that of multimode fiber,and with substantially lower density (index of refraction).The decrease in density results in a critical angle that is close enough to 90° to make the propagation of beams almost horizontal.



Fiber sizes: Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding,both expressed in micrometers.

Type	Core	Cladding	Mode
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	Multimode,graded index
100/125	100.0	125	Multimode,graded index
7/125	7.0	125	Single mode

Cable Composition: The composition of a typical fiber-optic cable. The outer jacket is made of either PVC or Teflon. Inside the jacket are Kevlar strands to strengthen the cable. Kevlar is a strong material used on the fabrication of bulletproof vests. Below the Kevlar is another plastic coating to cushion the fiber. The fiber is at the centre of the cable, and it consists of cladding and core.

Fiber-optic cable connector:There are three types of connectors. The subscribe channel (SC) connector is used for cable TV. It uses a push /pull locking system. The straight-tip(ST) connector is used for connecting cable to networking devices. MT-RJ is a connector that is the same size as RJ45.

Advantages

- **Greater Bandwidth:** The fibre optic cable provides more bandwidth as compared to copper. Therefore, the fibre optic carries more data as compared to copper cable.

- **Faster speed:** Fibre optic cable carries the data in the form of light. This allows the fibre optic cable to carry the signals at a higher speed.
- **Longer distances:** The fibre optic cable carries the data at a longer distance as compared to copper cable.
- **Better reliability:** The fibre optic cable is more reliable than the copper cable as it is immune to any temperature changes while it can cause obstruction in the connectivity of copper cable.
- **Thinner and Sturdier:** Fibre optic cable is thinner and lighter in weight so it can withstand more pull pressure than copper cable.

Disadvantages

- **Installation and maintenance**:Fibre optic cable is a relatively new technology. It's installation and maintenance require expertise that is not yet available everywhere.
- **Unidirectional light propagation**: Propagation of light is unidirectional.If we need bidirectional communication, two fibers are needed.
- **Cost**:The cable and interfaces are relatively more expensive than those of other guided media.

UNGUIDED MEDIA (WIRELESS)

Unguided medium transport electromagnetic waves without using a physical conductor. This type of communication is wireless communication. Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.

Electromagnetic spectrum for wireless communication ranges from 3kHz to 900 THz.

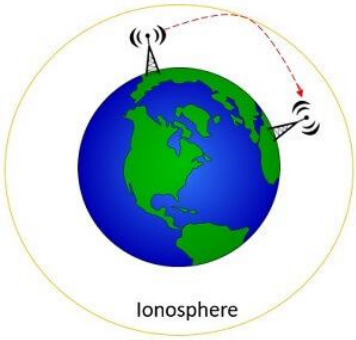
Unguided signals can travel from the source to the destination in several ways: **ground propagation, sky propagation and line-of-sight propagation.**

In the ground propagation, the electromagnetic wave is propagated close to the atmosphere i.e. between ionosphere and earth surface. These electromagnetic waves are the low-frequency wave that is transmitted in all directions and the wave follows the curvature of the earth as you can see in the image below.

Ground Propagation

The distance traveled by the electromagnetic wave in the ground propagation depends on the power of the propagated signal. More power is in a signal longer the distance it travels.

In sky propagation, the electromagnetic wave with a higher frequency is radiated up in the ionosphere from the source transmitter antenna which gets reflected back to the earth surface. In skywave propagation, the electromagnetic wave travels a longer distance and it can be received thousands of kilometres away from the transmitter.



Sky Propagation

In line of sight propagation, the electromagnetic wave with very high frequency is transmitted in the ‘straight-line’ direction from the transmitter antenna to the receiver antenna.

Line-of-Sight Propagation

In this way, the electromagnetic wave does not get affected by the curvature of the earth because the transmitter and receiver antenna are either tall or close enough to maintain the line of sight.

The section of the electromagnetic spectrum defined as radio waves and microwaves is divided into eight ranges, called bands, each regulated by government authorities.

Band	**Range**	**Propagation**	**Application**
Very low frequency (VLF)	3-30kHz	Ground	Long-range radio navigation
low frequency (LF)	30-300kHz	Ground	Radio beacons and navigational locators
middle frequency (MF)	300kHz-3MHz	Sky	AM radio
high frequency (HF)	3-30MHz	Sky	Citizens band (CB), ship/aircraft
very high frequency (VHF)	30-300MHz	Sky and line-of-sight	VHF TV, FM radio
ultrahigh frequency (UHF)	300MHz-3GHz	Line-of-sight	UHF TV, cellular phones,paging, satellite
super high frequency (SF)	3-30GHz	Line-of-sight	Satellite
extremely high frequency (EHF)	30-300GHz	Line-of-sight	Radar, satellite

We can divide wireless transmission into three broad categories: radio waves, microwave and infrared waves.

Radio Waves

The radio waves are the **low-frequency** electromagnetic waves ranging from '**3kHz to 1GHz'.**

Radio waves are the electromagnetic waves that are transmitted in all the directions of free space.The radio waves are propagated in **sky mode** and are **omnidirectional**

which means that the source transmitter transmits the radio wave in the sky and they are reflected from the sky and received by the receiving antenna.

In omnidirectional the signals are propagated in all the directions.This means that the sending and receiving antenna are not aligned, i.e,The wave sent by the sending antenna can be received by any receiving antenna.In sky mode propagation, radio waves can travel long distances.This make radio waves a good candidate for long distance broadcasting such as AM radio.

Radio waves use **omnidirectional antennas** that send out signals in all directions,Based on the wavelength ,strength,and the purpose of transmission.

*Applications Of Radio waves:*A Radio wave is useful for multicasting when there is one sender and many receivers. AM and FM radio, television, cordless phones are examples of a radio wave.

Advantages Of Radio transmission:

- Radio transmission is mainly used for wide area networks and mobile cellular phones.
- Radio waves cover a large area, and they can penetrate the walls.
- Radio transmission provides a higher transmission rate.

Microwaves

The microwave is the electromagnetic waves with frequency ranging from **‘1 to 300 GHz’**. The microwaves are **unidirectional** in nature and due to which it propagates in **line-of-sight** mode. In line-of-sight propagation, the source transmitting antenna and the receiving antenna need to be aligned to each other in such a way that they must be facing each other which enables point-to-point transmission.

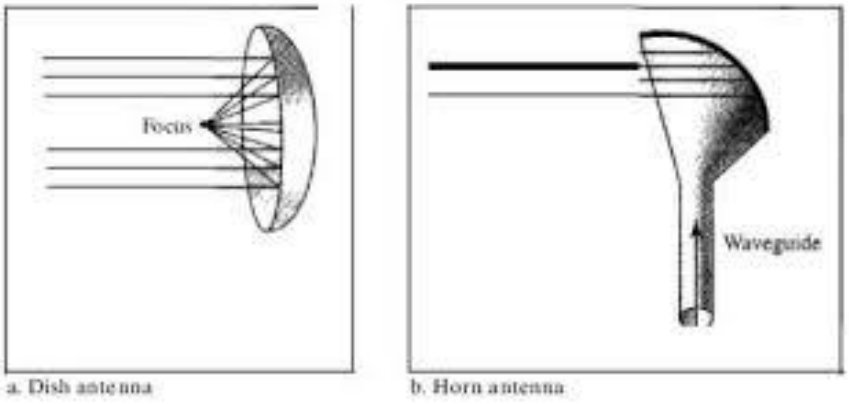
Characteristics of Microwave:

- Microwave propagation is line of sight. Since towers with the mounted antennas need to be in direct sight of each other,towers that are far apart need to be very tall. The curvature of the earth as well as other blocking obstacles do not allow two short towers to communicate by using microwaves. Repeaters are often needed for long distance communication.
- Very high-frequency microwaves cannot penetrate walls.
- Bandwidth: It supports the bandwidth from 1 to 10 Mbps.
- Short distance: It is inexpensive for short distance.
- Long distance: It is expensive as it requires a higher tower for a longer distance.
- Attenuation: Attenuation means loss of signal. It is affected by environmental conditions and antenna size.

The microwave transmission can be classified into two types:

1. **Terrestrial Microwave Transmission**
   In terrestrial microwave transmission, the transmitting and receiving antenna both are fixed on the ground and the signal wave is transmitted using the line-of -sight propagation mode. It is mostly used for telecommunication.
2. **Satellite Microwave Transmission**
   In satellite microwave transmission the electromagnetic wave is transmitted by the source transmitting antenna (earth station) which is received by satellite which amplifies the signal and rebroadcasts it to the receiver antenna (earth station). Satellite microwave transmission is mostly used for television, long-distance telecommunication, and global positioning systems.

Microwaves need **unidirectional antennas** that send out signals in one direction. Two types of antennas are used for microwave communications: the **parabolic dish and the horn.**



a. Dish antenna b. Horn antenna

A parabolic dish antenna is based on the geometry of a parabola. Every line parallel to the line of symmetry reflects off the curve at angles such that all lines intersect in a common point called focus. The parabolic dish works as a funnel, catching a wide range of waves and directing them to a common point. In this way ,more of the signal is recovered than would be possible with a single point receiver.

Outgoing transmissions are broadcast through a horn aimed at the dish. The microwaves hit the dish and are reflected outward in a reversal of the receipt path.

A **horn antenna** looks like a gigantic scoop. Outgoing transmissions are broadcast up a stem and deflected outward in a series of narrow parallel beams by the curved head. Received transmissions are collected by the scooped shape of horn, in a manner similar to the parabolic dish, and deflected down into the stem.

Advantages Of Microwave:

- Microwave transmission is cheaper than using cables.
- It is free from land acquisition as it does not require any land for the installation of cables.
- Microwave transmission provides easy communication in terrains as the installation of cable in terrain is quite a difficult task.
- Communication over oceans can be achieved by using microwave transmission.

Disadvantages of Microwave transmission:

- Eavesdropping: An eavesdropping creates insecure communication. Any malicious user can catch the signal in the air by using its own antenna.
- Out of phase signal: A signal can be moved out of phase by using microwave transmission.
- Susceptible to weather conditions: A microwave transmission is susceptible to weather conditions. This means that any environmental change such as rain, wind can distort the signal.

- Bandwidth limited: Allocation of bandwidth is limited in the case of microwave transmission.

Satellite Microwave Communication: A satellite is a physical object that revolves around the earth at a known height.Satellite communication is more reliable nowadays as it offers more flexibility than cable and fibre optic systems.We can communicate with any point on the globe by using satellite communication.

How Does Satellite work? :- The satellite accepts the signal that is transmitted from the earth station, and it amplifies the signal. The amplified signal is retransmitted to another earth stationThe coverage area of a satellite microwave is more than the terrestrial microwave.The transmission cost of the satellite is independent of the distance from the centre of the coverage area.Satellite communication is used in mobile and wireless communication applications.

Advantages:

- It is easy to install.
- It is used in a wide variety of applications such as weather forecasting, radio/TV signal broadcasting, mobile communication, etc.

Disadvantages:

- Satellite designing and development requires more time and higher cost.
- The Satellite needs to be monitored and controlled on regular periods so that it remains in orbit.
- The life of the satellite is about 12-15 years. Due to this reason, another launch of the satellite has to be planned before it becomes non-functional.

Infrared

An infrared transmission is a wireless technology used for communication over short ranges.The frequency of the infrared in the range from 300 GHz to 400 THz. The infrared transmission uses **line-of-sight** propagation and thereby is used for short-distance communication.

As the infrared transmission is the **high-frequency** waves, they cannot penetrate the wall so we can easily differentiate the communication going on inside the building and the communication outside a building. In this way, there are no chances of interference.we cannot use infrared waves outside a building because the sun's rays contain infrared waves that interfere with the communication.

The most popular example of infrared transmission that we daily come across is your remote that you use to operate AC, television, music system, etc. The remote emits infrared waves which are received by the television and perform the action.

It is used for short-range communication such as data transfer between two cell phones, TV remote operation, data transfer between a computer and cell phone that resides in the same closed area.

Characteristics Of Infrared:

- It supports high bandwidth, and hence the data rate will be very high.
- Infrared waves cannot penetrate the walls. Therefore, the infrared communication in one room cannot be interrupted by the nearby rooms.
- An infrared communication provides better security with minimum interference.
- Infrared communication is unreliable outside the building because the sun rays will interfere with the infrared waves.