UNIT II

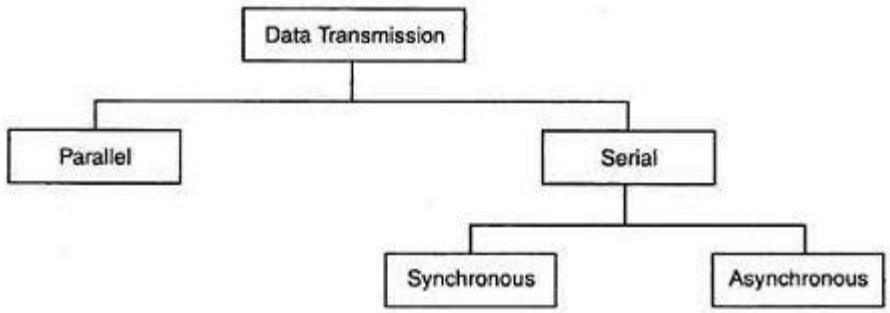
DATA TRANSMISSION : CONCEPT

Definition Data Transmission: When we enter data into the computer via keyboard, each keyed element is encoded by the electronics within the keyboard into an equivalent binary coded pattern, using one of the standard coding schemes that are used for the interchange of information. To represent all characters of the keyboard, a unique pattern of 7 or 8 bits in size is used. The use of 7 bits means that 128 different elements can be represented, while 8 bits can represent 256 elements. A similar procedure is followed at the receiver that decodes every received binary pattern into the corresponding character.

The most widely used codes that have been adopted for this function are the Extended Binary Coded Decimal (EBCDIC) and the American Standard Code for Information Interchange codes (ASCII). Both coding schemes cater to all the normal alphabetic, numeric, and punctuation characters, collectively referred to as *printable characters* and a range of additional control characters, known as *non-printable characters.*

Data transmission refers to the movement of data in form of bits between two or more digital devices. This transfer of data takes place via some form of transmission media (for example, coaxial cable, fiber optics etc.)

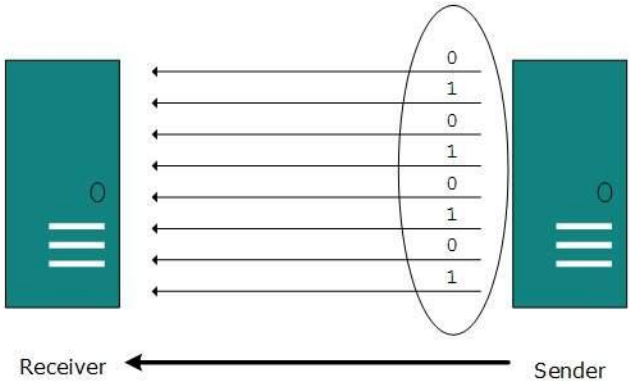
Types of Data Transmission



Transmission Modes

The transmission mode decides how data is transmitted between two computers.The binary data in the form of 1s and 0s can be sent in two different modes: Parallel and Serial.

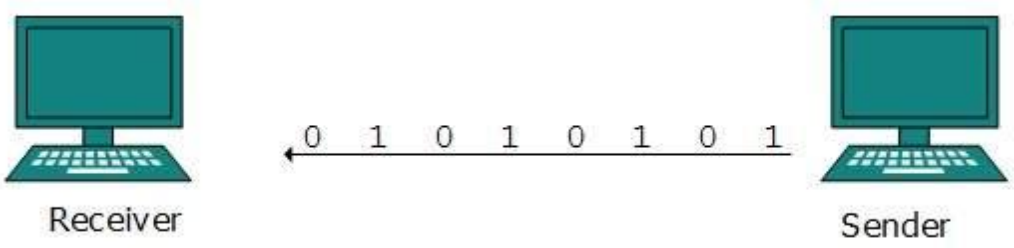
Parallel Transmission



The binary bits are organized in-to groups of fixed length. Both sender and receiver are connected in parallel with the equal number of data lines. Both computers distinguish between high order and low order data lines. The sender sends all the bits at once on all lines.Because the data lines are equal to the number of bits in a group or data frame, a complete group of bits (data frame) is sent in one go. Advantage of Parallel transmission is high speed and disadvantage is the cost of wires, as it is equal to the number of bits sent in parallel.

Serial Transmission

In serial transmission, bits are sent one after another in a queue manner. Serial transmission requires only one communication channel.



Serial transmission can be either asynchronous or synchronous.

Asynchronous Serial Transmission

It is named so because there'is no importance of timing. Data-bits have specific pattern and they help receiver recognize the start and end data bits.For example, a 0 is prefixed on every data byte and one or more 1s are added at the end.

Two continuous data-frames (bytes) may have a gap between them.

Synchronous Serial Transmission

Timing in synchronous transmission has importance as there is no mechanism followed to recognize start and end data bits.There is no pattern or prefix/suffix method. Data bits are sent in burst mode without maintaining gap between bytes (8-bits). Single burst of data bits may contain a number of bytes. Therefore, timing becomes very important.

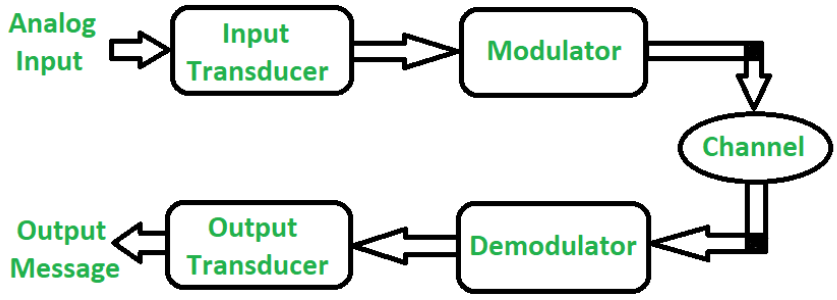
It is up to the receiver to recognize and separate bits into bytes.The advantage of synchronous transmission is high speed, and it has no overhead of extra header and footer bits as in asynchronous transmission.

ANALOG AND DIGITAL TRANSMISSION

1.Analog Communication: In analog communication the data is transferred with the help of analog signal in between transmitter and receiver. Any type of data is transferred in analog signal. Any data is converted into electric form first and after that it is passed through communication channel. Analog communication uses a continuous signal which varies in amplitude, phase, or some other property with time in proportion to that of a variable.

The below figure illustrates the

Analog Communication System:

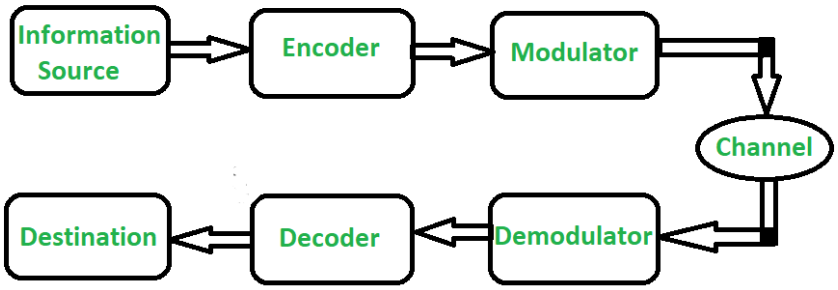


Analog Communication System

2. Digital Communication:

In digital communication digital signal is used rather than analog signal for communication in between the source and destination. The digital signal consists of discrete values rather than continuous values. In digital communication physical transfer of data occurs in the form of digital bit stream i.e 0 or 1 over a point-to-point or point-to-multipoint transmission medium. In digital communication the digital transmission data can be broken into packets as discrete messages which is not allowed in analog communication.

The below figure illustrates the **Digital Communication System**:



Digital Communication System

Difference between Analog Communication and Digital Communication:

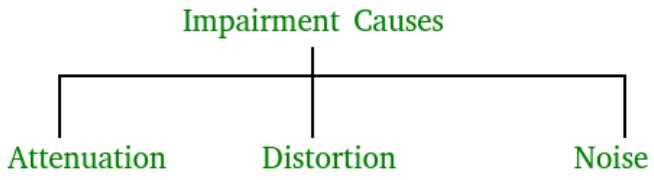
S .No.	ANALOG COMMUNICATION	DIGITAL COMMUNICATION
01.	In analog communication analog signal is used for information transmission.	In digital communication digital signal is used for information transmission.
02.	Analog communication uses analog signal whose amplitude varies continuously with	Digital communication uses digital signal whose amplitude is of two levels either Low

S .No.	ANALOG COMMUNICATION	DIGITAL COMMUNICATION
	time from 0 to 100.	i.e., 0 or either High i.e., 1.
03.	It gets affected by noise highly during transmission through communication channel.	It gets affected by noise less during transmission through communication channel.
04.	In analog communication only limited number of channels can be broadcasted simultaneously.	It can broadcast large number of channels simultaneously.
05.	In analog communication error Probability is high.	In digital communication error Probability is low.
06.	In analog communication noise immunity is poor.	In digital communication noise immunity is good.
07.	In analog communication coding is not possible.	In digital communication coding is possible. Different coding techniques can be used to detect and correct errors.
08.	Separating out noise and signal in analog communication is not possible.	Separating out noise and signal in digital communication is possible.
09.	Analog communication system is having complex hardware and less flexible.	Digital communication system is having less complex hardware and more flexible.
10.	In analog communication for multiplexing Frequency Division Multiplexing (FDM) is used.	In Digital communication for multiplexing Time Division Multiplexing (TDM) is used.
11.	Analog communication system is low cost.	Digital communication system is high cost.
12.	It requires low bandwidth.	It requires high bandwidth.
13.	Power consumption is high.	Power consumption is low.
14.	It is less portable.	Portability is high.
15.	No privacy or privacy is low, so it is not highly secured.	Privacy is high, so it is highly secured.
16.	Not assures an accurate data transmission.	It assures a more accurate data transmission.
17.	Synchronization problem is hard.	Synchronization problem is easier.

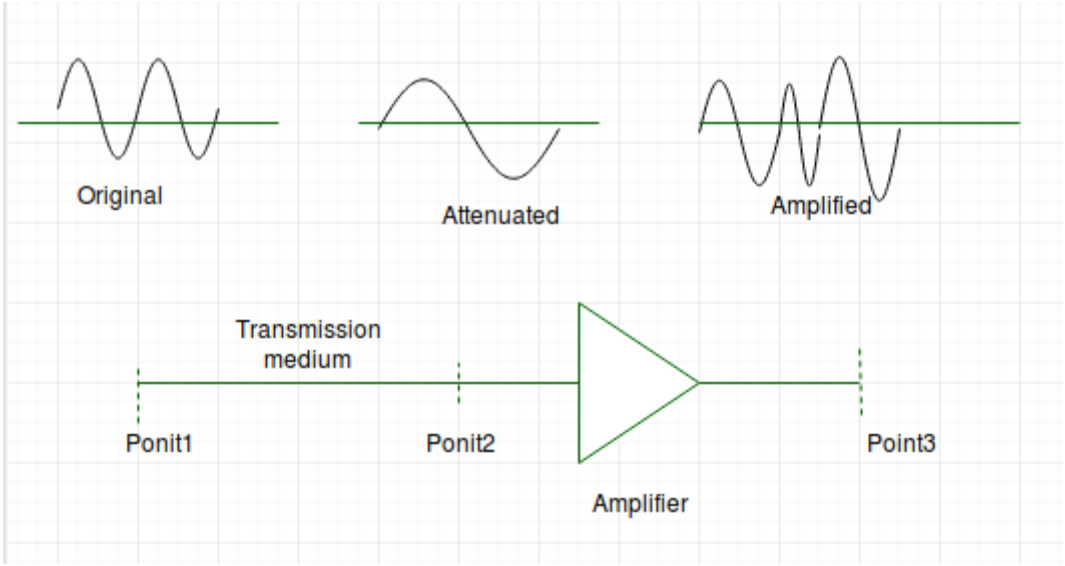
TRANSMISSION IMPAIRMENT

In communication system, analog signals travel through transmission media, which tends to deteriorate the quality of analog signal, which means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. The imperfection causes signal impairment. Below are the causes of the impairment.

Causes of impairment –



- **Attenuation –** It means loss of energy. The strength of signal decreases with increasing distance which causes loss of energy in overcoming resistance of medium. This is also known as attenuated signal. Amplifiers are used to amplify the attenuated signal which gives the original signal back and compensate for this loss.

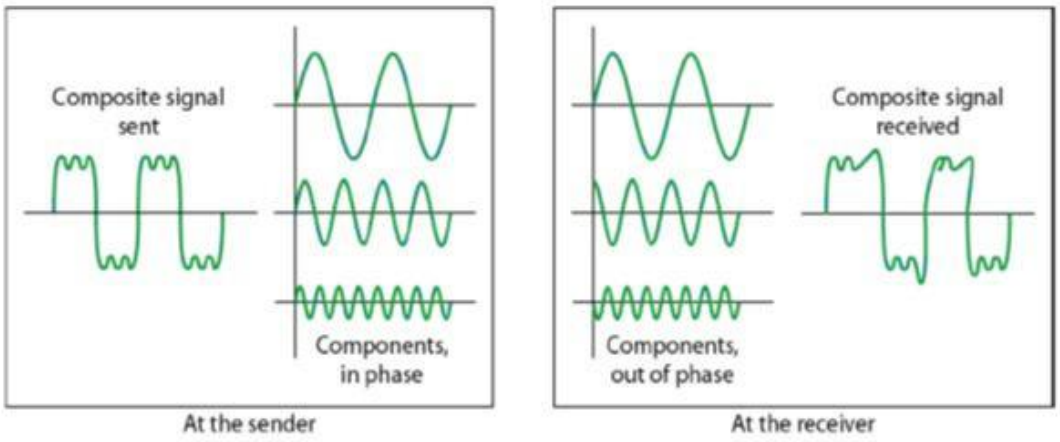


- Image Source – aviationchief
  Attenuation is measured in **decibels(dB)**. It measures the relative strengths of two signals or one signal at two different point.

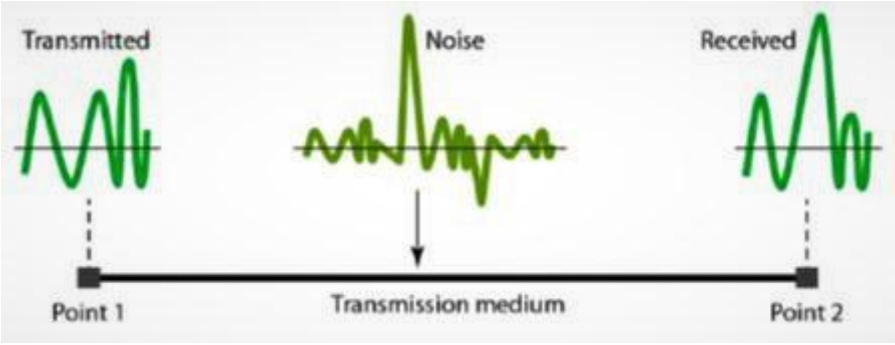
Attenuation(dB) = 10log10(P2/P1)
P1 is the power at sending end and P2 is the power at receiving end.
Some where the decibel is also define in terms of voltage instead of power.In this case because power is proportional to the square of the voltage the formula is

Attenuation(dB) = 20log10(V2/V1)
V1 is the voltage at sending end and V2 is the voltage at receiving end.

- **Distortion –** It means changes in the form or shape of the signal. This is generally seen in composite signals made up with different frequencies. Each frequency component has its own propagation speed travelling through a medium. And thats why it delay in arriving at the final destination Every component arrive at different time which leads to distortion. Therefore, they have different phases at receiver end from what they had at senders end.



- **Noise –** The random or unwanted signal that mixes up with the original signal is called noise. There are several types of noise such as induced noise, crosstalk noise, thermal noise and impulse noise which may corrupt the signal.
  Induced noise comes from sources such as motors and appliances. These devices act as sending antenna and transmission medium act as receiving antenna. **Thermal** noise is movement of electrons in wire which creates an extra signal. **Crosstalk** noise is when one wire affects the other wire. **Impulse** noise is a signal with high energy that comes from lightning or power lines



- To find the theoretical bit rate limit, we need to know the ration .The signal-to-noise ratio is defined as

SNR = AVG SIGNAL POWER / AVG NOISE POWER

SNR_{dB} = 10Log10SNR

EXAMPLE

The values of SNR and SNR_{dB} for a noiseless channel are

SNR = Signal Power/0 = ∞

SNR_{dB} = $10Log_{10}$ ∞ = ∞

We can never achieve this ratio in real life ; it is an ideal.

CHANNEL CAPACITY

By capacity of a channel, it means the capacity of the **transmission medium (wire or link)**. Capacity is the number of bits the transmission medium can hold. So basically there are 2 types of channels – Full duplex and half duplex.

1. **Half duplex –** the transmission can happen in one direction at a time.

2. **Full duplex –** the transmission can happen in both the direction simultaneously.

For example, the transmission medium is operating in its maximum capacity then at that time the number of bits it is holding is called capacity of the transmission medium.

But how can we find the capacity mathematically?

- If the length of the transmission medium is longer than its capacity will be higher.
- It also depends on the area of cross section of the medium.
- If the bandwidth is 1 bps, then every second it can take 1 bit. After every second it will move forward so that next bit could occupy the space. Therefore the final time in which it will occupy all the bits will be its propagation delay.

The capacity of the channel depends on two things:

1. Bandwidth
2. Propagation delay

Capacity = bandwidth * propagation delay
(in case of half duplex)

Capacity =2* bandwidth * propagation delay
(in case of full duplex)

TRANSMISSION MEDIA

Guided transmission Media

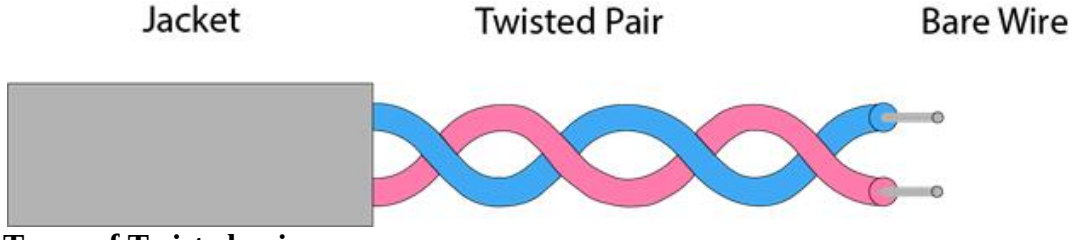
It is defined as the physical medium through which the signals are transmitted. It is also known as Bounded media.

Types Of Guided media:

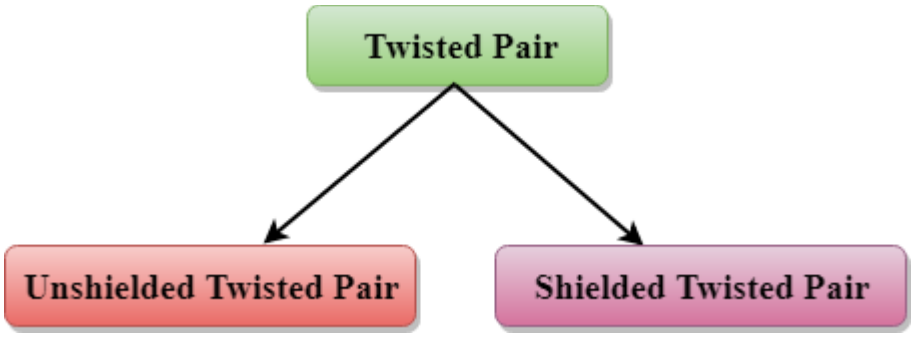
Twisted pair:

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. Installation of the twisted pair cable is easy, and it is a lightweight cable. 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.
The degree of reduction in noise interference is determined by the number of turns per foot. Increasing the number of turns per foot decreases noise interference.



Types of Twisted pair:



Unshielded Twisted Pair:

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 upto 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

A shielded twisted pair is a cable that contains the mesh surrounding the wire that allows the higher transmission rate.

Characteristics Of Shielded Twisted Pair:

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

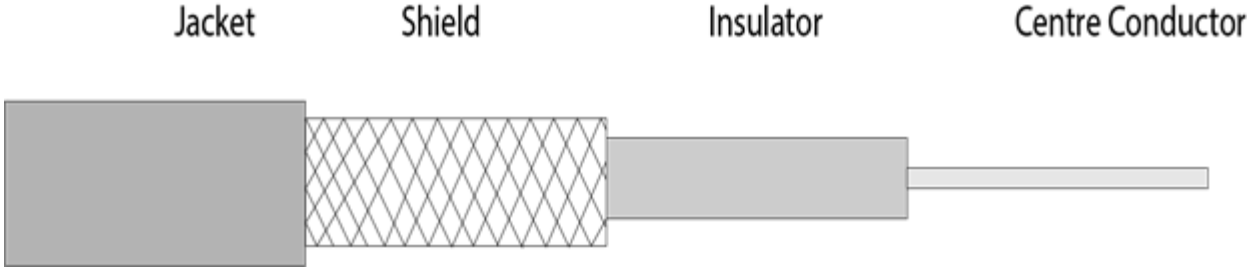
Disadvantages

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

Coaxial Cable

- Coaxial cable is 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 from the **EMI**(Electromagnetic interference).



Coaxial cable is of two types:

1. **Baseband transmission:** It is defined as the process of transmitting a single signal at high speed.
2. **Broadband transmission:** It is defined as the process of transmitting multiple signals simultaneously.

Advantages Of Coaxial cable:

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

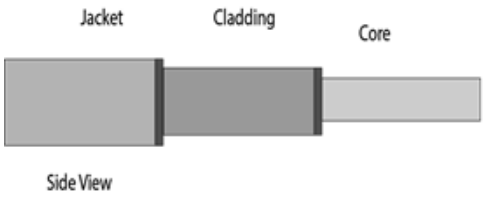
Disadvantages Of Coaxial cable:

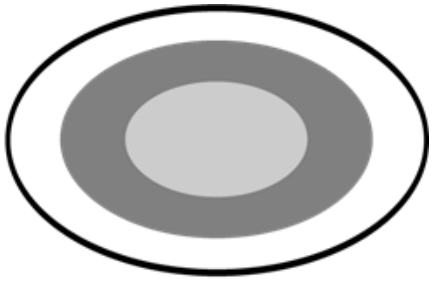
- It is more expensive as compared to twisted pair cable.
- If any fault occurs in the cable causes the failure in the entire network.

Fibre Optic

- Fibre optic cable is a cable that uses electrical signals for communication.
- 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.

Diagrammatic representation of fibre optic cable:





Basic elements of Fibre optic cable:

- **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.

Following are the advantages of fibre optic cable over copper:

- **Greater Bandwidth:** The fibre optic cable provides more bandwidth as compared 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 obstruct 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.

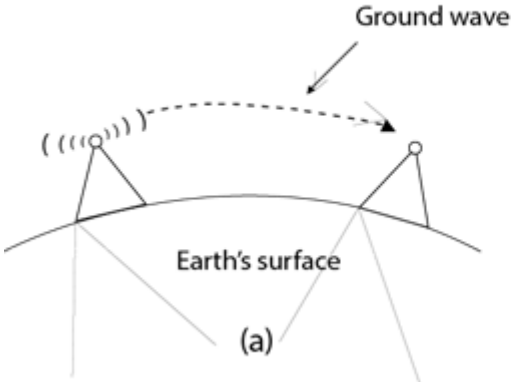
UnGuided Transmission

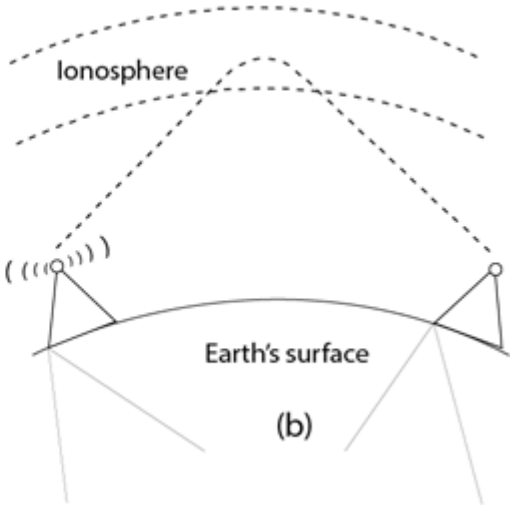
- An unguided transmission transmits the electromagnetic waves without using any physical medium. Therefore it is also known as **wireless transmission**.
- In unguided media, air is the media through which the electromagnetic energy can flow easily.

Unguided transmission is broadly classified into three categories:

Radio waves

- Radio waves are the electromagnetic waves that are transmitted in all the directions of free space.
- Radio waves are omnidirectional, i.e., the signals are propagated in all the directions.
- The range in frequencies of radio waves is from 3Khz to 1 khz.
- In the case of radio waves, the sending and receiving antenna are not aligned, i.e., the wave sent by the sending antenna can be received by any receiving antenna.
- An example of the radio wave is **FM radio**.





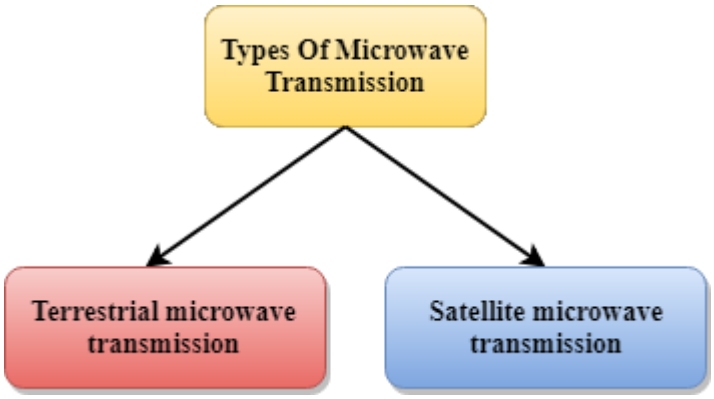
Applications Of Radio waves:

- A Radio wave is useful for multicasting when there is one sender and many receivers.
- An 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



Microwaves are of two types:
Current TimeÂ 0:00
/
DurationÂ 18:10
Â

- Terrestrial microwave
- Satellite microwave communication.

Terrestrial Microwave Transmission

- Terrestrial Microwave transmission is a technology that transmits the focused beam of a radio signal from one ground-based microwave transmission antenna to another.
- Microwaves are the electromagnetic waves having the frequency in the range from 1GHz to 1000 GHz.

- Microwaves are unidirectional as the sending and receiving antenna is to be aligned, i.e., the waves sent by the sending antenna are narrowly focussed.
- In this case, antennas are mounted on the towers to send a beam to another antenna which is km away.
- It works on the line of sight transmission, i.e., the antennas mounted on the towers are the direct sight of each other.

Characteristics of Microwave:

- **Frequency range:** The frequency range of terrestrial microwave is from 4-6 GHz to 21-23 GHz.
- **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.

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 an 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 condition:** A microwave transmission is susceptible to weather condition. 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 station.

Advantages Of Satellite Microwave Communication:

- The 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.
- 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 Of Satellite Microwave Communication:

- 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.
- 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 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.

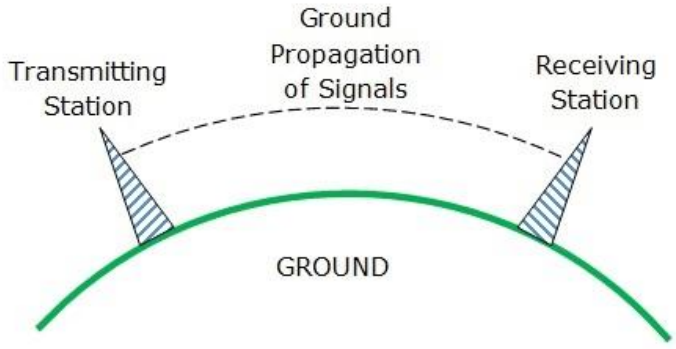
Wireless propagation

In wireless transmission media, data is transmitted in the form of electromagnetic waves that do not require any physical conductors for transmission. The waves are broadcast through free space and any device who has permission to connect can receive them.

The three ways in which unguided signals travel are −

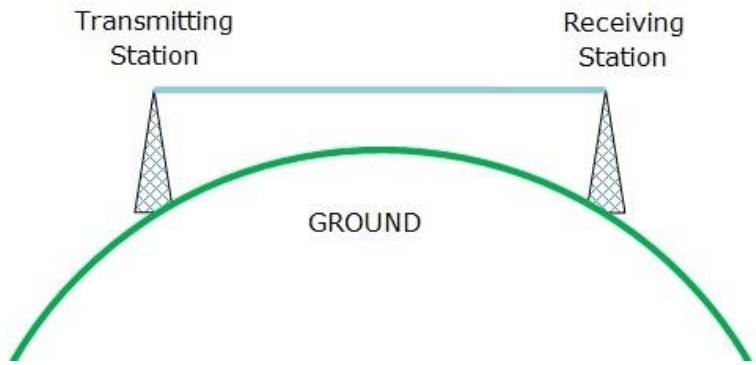
Ground Propagation:

It is a method of propagation, in which radio waves travel through the lowest layers of the atmosphere along the earth's surface, following the earth's curvature. The frequency of these signals is low (≤ 2MHz), and the distance they travel is directly proportional to the power in signal.



Sky Propagation:

In sky propagation, high frequency radio waves (2–30 MHz) are reflected back from the ionosphere towards the earth's surface. They can be used to transmit signals over a large geographical area since their distance is not bounded by the earth's curvature.



Line – of – Sight Propagation

In line – of – sight propagation, very high frequency waves (> 30 MHz) travel at straight lines from the source antenna (transmitter) to the destination antenna (receiver). These waves are easily disrupted by present of objects in their path. So the antennas are placed tall enough above obstructions. They are unidirectional facing each other.