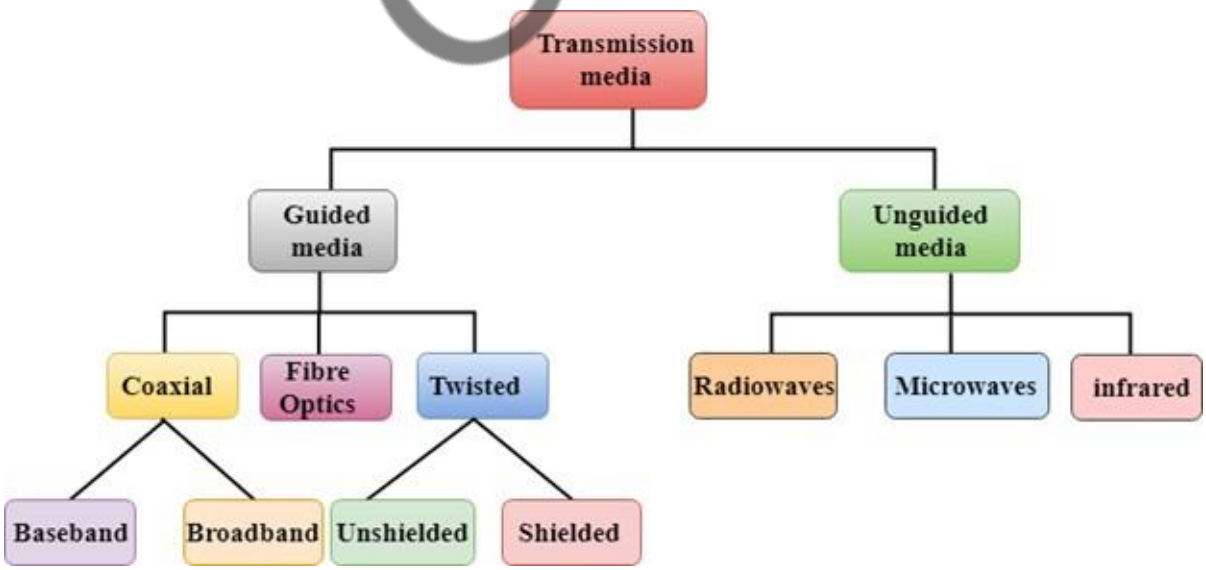
Computer Network

Unit-2 Physical Layer

A transmission medium can be broadly defined as anything that can carry information from a source to a destination. Transmission media are actually located below the physical layer and are directly controlled by the physical layer. The transmission medium is usually free space, metallic cable, or fiber-optic cable. The information is usually a signal that is the result of a conversion of data from another form. In telecommunications, transmission media can be divided into two broad categories: guided and unguided. Guided media include twisted-pair cable, coaxial cable, and fiber-optic cable. Unguided media employ an antenna for transmitting through air, vacuum, or water. Eg: terrestrial microwave, satellite microwave

Types Of Transmission Media

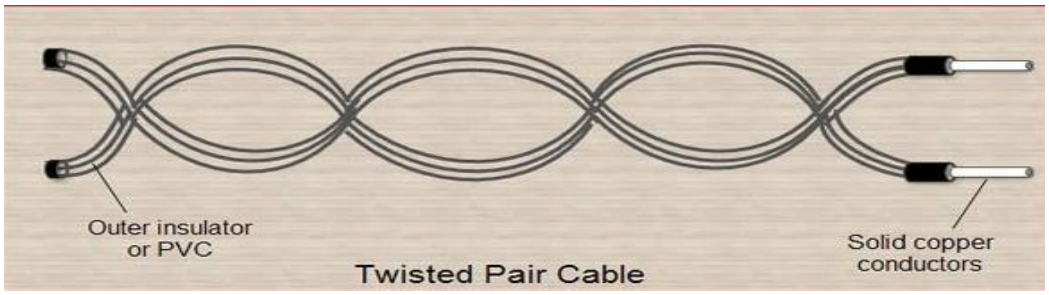


2.1 Guided Media:

All communication wires/cables are guided media, such as UTP, coaxial cables, and fiber Optics. In this media, the sender and receiver are directly connected and the information is send (guided) through it.

2.1.1 Twisted Pair

A twisted pair cable is made of two plastic insulated copper wires twisted together to form a single media. Out of these two wires, only one carries actual signal and another is used for ground reference. The twists between wires are helpful in reducing noise (electro-magnetic interference) and crosstalk. Pair



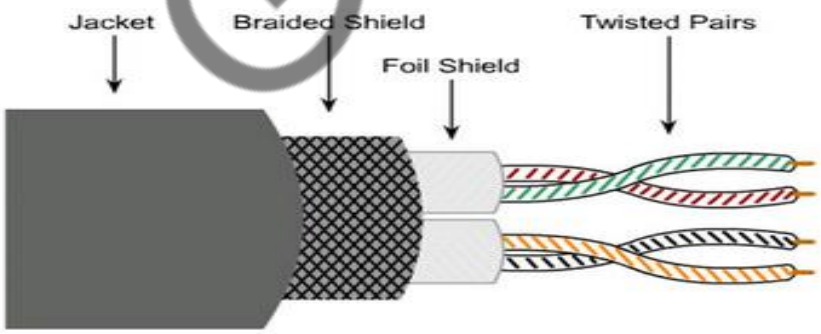
There are two types of twisted pair cables:

- Shielded Twisted Pair (STP) Cable
- Unshielded Twisted Pair (UTP) Cable

Shielded Twisted Pair Cable:

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

STP cables comes with twisted wire pair covered in metal foil. This makes it more indifferent to noise and crosstalk.



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.

Unshielded Twisted Pair Cable:

An unshielded twisted pair is widely used in telecommunication. Following are the categories of the unshielded twisted pair cable each suitable for specific use.

- **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:

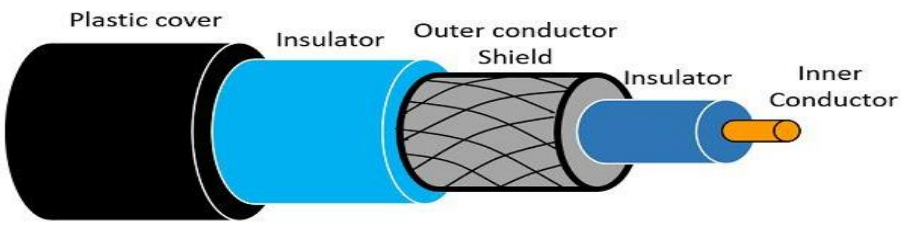
- It is cheap.
- Installation of the unshielded twisted pair is easy.
- It can be used for high-speed LAN.

Disadvantage:

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

2.1.2 Coaxial Cable

Coaxial cable (or coax) has two wires of copper. The core wire lies in the center and it is made of solid conductor. The core is enclosed in an insulating sheath. The second wire is wrapped around over the sheath and that too in turn encased by insulator sheath. This all is covered by plastic cover.



Because of its structure, the coax cable is capable of carrying high frequency signals than that of twisted pair cable. The wrapped structure provides it a good shield against noise and cross talk. Coaxial cables provide high bandwidth rates.

- 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:

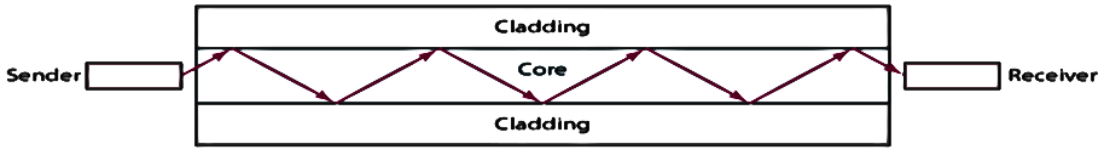
- The data can be transmitted at high speed.
- It has better shielding as compared to twisted pair cable.
- It provides higher bandwidth.

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.

2.1.3 Fiber Optics

Fiber Optic works on the properties of light. This property has been used in fiber optic. The core of fiber optic cable is made of high quality glass or plastic. From one end of it light is emitted, it travels through it and at the other end light detector detects light stream and converts it to electric data.

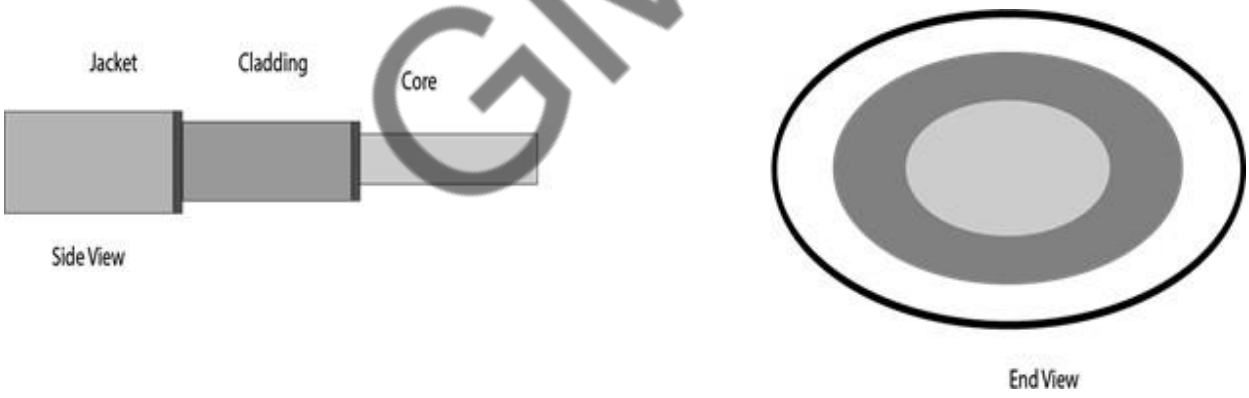


- A transmitter (Light Source) at senders end sends a Light across the fiber.
- A receiver at the other end makes use of Light Sensitive transistor to detect the absence or presence of light to indicate 0 or 1.
- The transmission medium is an ultra-thin fiber of glass.
- Light enters the cylindrical glass or plastic core at small angles are reflected and propagates along the fiber.
- The detector generates an electrical pulse when light falls on it.

Fiber Optic provides the highest mode of speed. It comes in two modes, one is single mode fiber and second is multimode fiber. Single mode fiber can carry a single ray of light whereas multimode is capable of carrying multiple beams of light. Fiber Optic also comes in unidirectional and bidirectional capabilities. To connect and access fiber optic special type of connectors are used.

- 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.

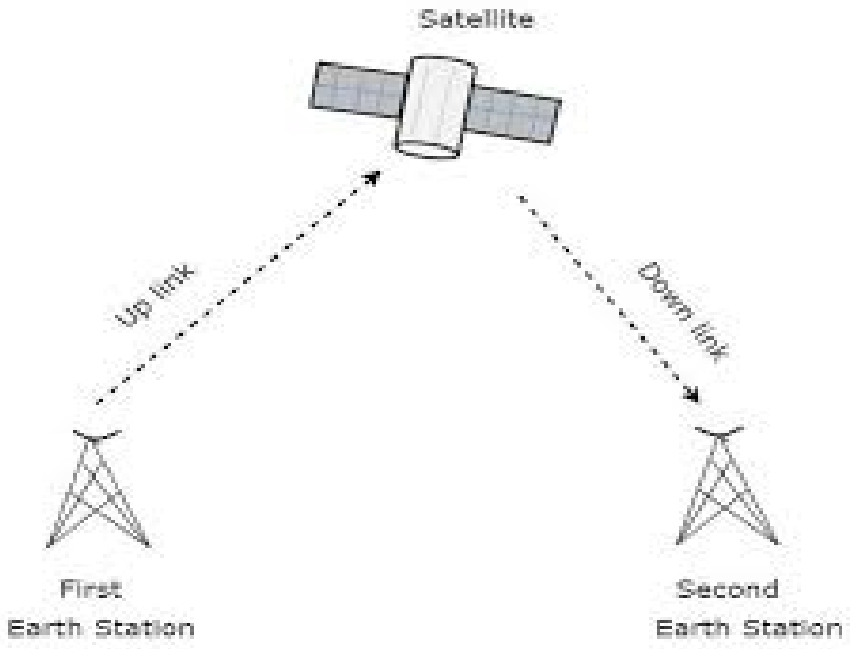
- **Jacket:** The protective coating consisting of plastic is known as a jacket. The main purpose of a jacket is to preserve the fibre strength, absorb shock and extra fibre protection.

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.

2.1.4 Satellite Communication

Satellite communications is the use of satellite technology in the field of communications. The services provided by satellite communications are voice and video calling, internet, fax, television and radio channels.



Satellite communications can provide communication capabilities spanning long distances and can operate under circumstances or conditions which are inoperable for other forms of communication.

Communication satellite comprises of a transponder, antenna, communication payload, switching systems, command, and control system. Satellite communications also provide weather information. It can be helpful during times of disasters as the services rarely fail. High amount of data can be transmitted with the help of satellites.

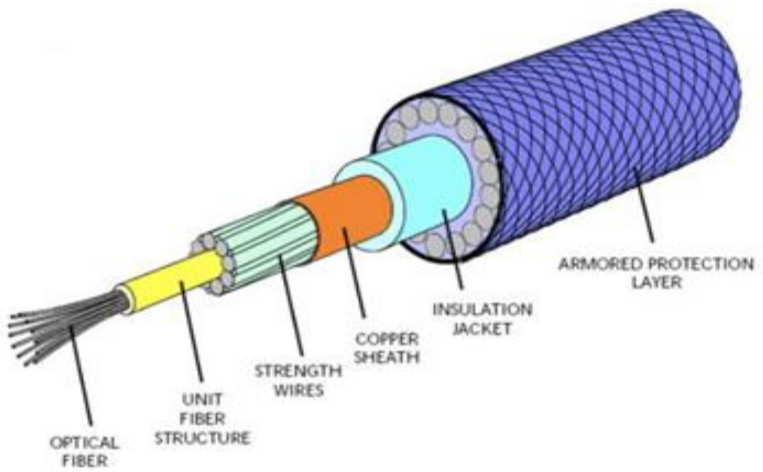
2.1.5 Submarine Cables.

Submarine cables, also called undersea cables, sea cables, or underwater cables, are long, durable cables laid across the seabed. These cables can transmit data and electricity between continents and countries. These cables are vulnerable and difficult to repair, making them relatively unknown to the general public.

Anatomy of a Submarine Cables

The construction of undersea fiber optic cables is designed to protect its core components while withstanding extreme pressures and hazards on the ocean floor. Here's a look at its primary layers:

- **Conductor:** The heart of the cable, typically made of copper or aluminum, carries the electrical current or data signals.
- **Optical Fibers:** In communication cables, this core houses a bundle of tiny glass fibers that transmit data using pulses of light.
- Insulation and Shielding: Surrounding the conductor or optical fibers, layers of insulating materials like polyethylene and petrolatum protect the core from water and other environmental factors.
- **Steel Wire Armor:** A robust layer of steel wires provides mechanical protection to the cable, shielding it from potential damage caused by external forces such as fishing nets or ship anchors.
- **Outer Sheath:** The outermost layer, often made of polyethylene, acts as a waterproof and abrasion-resistant barrier, safeguarding the cable from the harsh marine environment.



2.2 Unguided Media

Unguided media transmit electromagnetic waves without using a physical conductor. This is also called as wireless communication. Wireless or open-air space is said to be unguided media, because there is no connectivity between the sender and receiver. Information is spread over the air that means broadcast through free space, and available to anyone who has a device capable of receiving them including the actual recipient may collect the information.

2.2.1. Electromagnetic Spectrum

Electromagnetic spectrum includes radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. Each type of radiation has different frequencies and wavelengths. These waves carry energy and can travel through a vacuum at the speed of light.

The electromagnetic (EM) spectrum is the range of all types of electromagnetic radiation, which is energy that disperses and expands as it travels. This includes everything from the visible light emitted by a household lamp to the radio waves broadcast by radio stations, illustrating the diverse forms of electromagnetic radiation.

The tiny portion of light that we can see, known as visible light, which includes every color in the rainbow, is located exactly in the middle of this enormous spectrum. But there's so much more to it than that.

The electromagnetic spectrum is useful in real life for communication, medical imaging, technology, Solar Energy, Food Processing, Forensic Analysis, Night Vision Technology and so many.

2.2.2. Radio Transmission

Radio waves in Radio transmission are easy to generate and can penetrate through buildings.

The sending and receiving antennas need not be aligned.

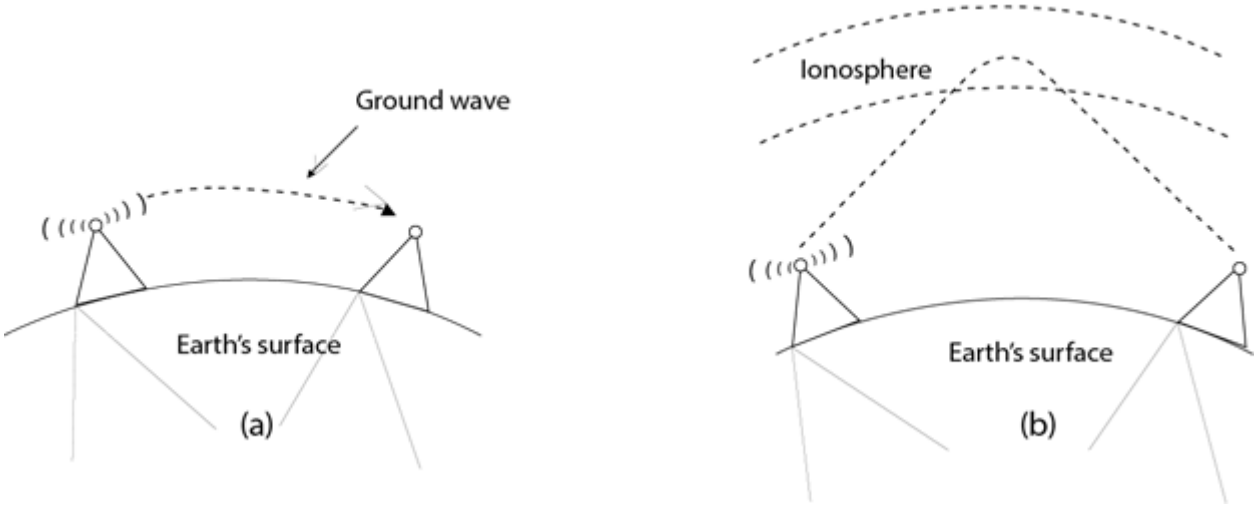
Radio waves are the electromagnetic waves that are transmitted in all the directions of free space.

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:

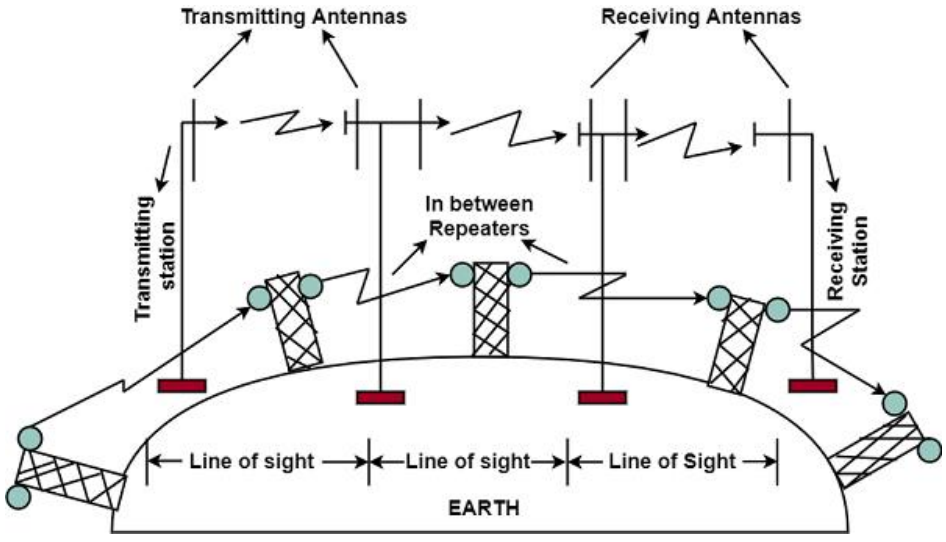
- A Radio wave is useful for multicasting when there is one sender and many receivers.
- An FM radio, television, cordless phones are examples of a radio wave.

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.

2.2.3. Microwave Transmission

The electromagnetic waves having frequencies between 1 and 300 GHz are known as a microwave. Microwave systems use very high-frequency radio or television signals to transmit data through space. Therefore, the transmitter and receiver of a microwaves system, which is mounted on very high towers, should be invisible to each other, i.e., they both should be in a line-of-sight. Moreover, the signals become weak after travelling a certain distance and require power amplification.



Microwave systems can carry large quantities of data at high rates of speed. The data transmission rate is about 16 gps (Gigabits per second). A microwave system can take 250,000 voice channels at the equivalent time. They are used for the transmission of Radio, TV, and telephone signals.

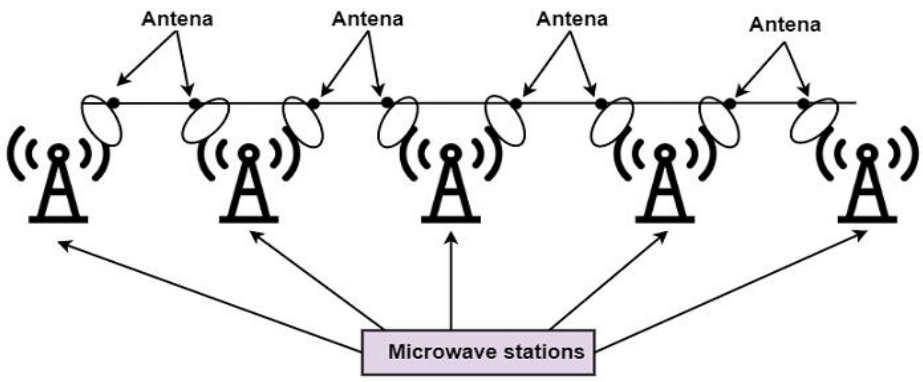
Microwaves are of two types:

1. Terrestrial microwave
2. Satellite microwave communication.

1. 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 focused.
- ✓ 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.

These systems use directional parabolic antennas to transmit and receive signals in the lower gigahertz range, as shown in the figure. These signals are highly focussed and travel insight. Relay towers can extend signals. Smaller terrestrial microwaves systems can be used inside a building. Some microwave LANS works at low power using small transmitters that communicate with Omni-directional Hub.



Microwave Communication

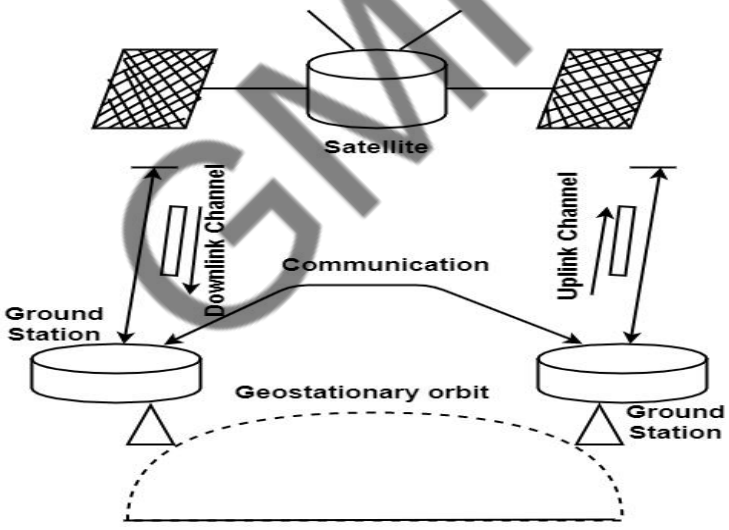
Characteristics of Terrestrial Microwave Systems

There are the following characteristics of Terrestrial Microwave Systems, which are as follows.

- The frequency range used in from 4-6 GHz and 21 to 23 GHz.
- It provides bandwidth from 1 to 10 Mbps.
- The signals are affected by the EMI effect, jamming and eavesdropping,
- Line of sight requirements makes installation difficult.
- Short-distance systems can be inexpensive, but long-distance systems are relatively expensive.

2. Satellite Microwave Communication

Satellite transmission is much like line-of-sight microwave transmission in which one of the stations is a satellite orbiting the earth. The principle is similar to terrestrial microwave, with a satellite acting as a super tall antenna and repeater. Although satellite transmission signals must still travel in straight lines, the limitations imposed on distance by the earth's curvature are reduced. In this way, satellite relays allow microwave signals to span continents and oceans with a single bounce.



Satellite Communication

Advantages of Satellite Microwave Communication

- Satellite is a single microwave relay station visible from any point of a vast area.
- The transmission and reception costs are independent of the distance between two points.
- A transmission station can retrieve its transmission & check whether the satellite has transmitted the information correctly.

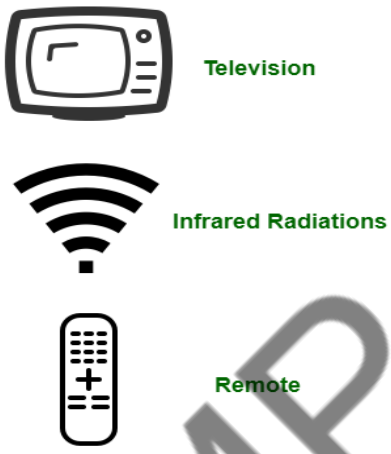
Disadvantages of Satellite Microwave Communication

- It is a very high cost of placing the satellite into its orbit.
- Since the waves are transmitted by satellites all around the world. Therefore, the security of the message is fragile.
- Satellite use microwaves which are vulnerable to electromagnetic interferences.

2.2.4. Infrared & Millimeter Waves

Infrared Waves :

Infrared Waves are electromagnetic waves that have frequency range between 300 GHz to 400 THz. These cannot travel along long distances. These waves are used for short range communication and they also use line-of-sight of propagation. These waves cannot pass through solid objects like walls etc. These also not penetrate through walls. The most common application of the IR waves is remote controls that are used for TV, DVD players, and stereo system.



Applications of Infrared :

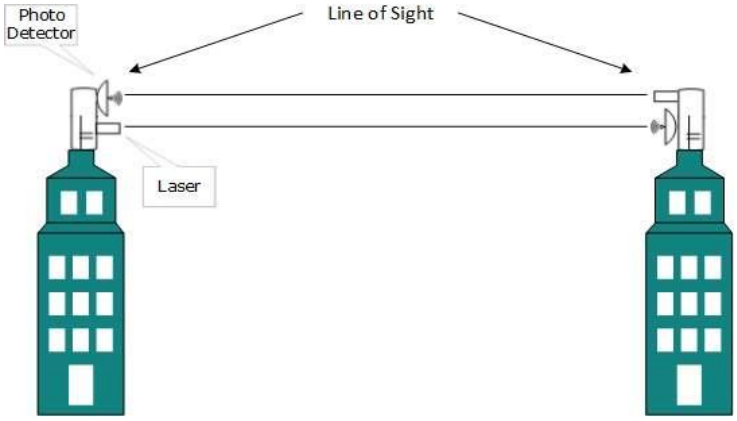
- With these devices, we can talk via short range wireless signals.
- With infrared transmission, computers can transfer files and other digital data bidirectional.
- Very high data rates can be supported, due to very high bandwidth (approximately 400THz).
- For communication between keyboard, mouse PCs and printers.
- It is used in medical, scientific and industrial applications.

2.2.5. Light wave Transmission

Light Transmission

Highest most electromagnetic spectrum which can be used for data transmission is light or optical signaling. This is achieved by means of LASER.

Because of frequency light uses, it tends to travel strictly in straight line. Hence the sender and receiver must be in the line-of-sight. Because laser transmission is unidirectional, at both ends of communication the laser and the photo-detector needs to be installed. Laser beam is generally 1mm wide hence it is a work of precision to align two far receptors each pointing to lasers source.



Laser works as Tx (transmitter) and photo-detectors works as Rx (receiver).
Lasers cannot penetrate obstacles such as walls, rain, and thick fog. Additionally, laser beam is distorted by wind, atmosphere temperature, or variation in temperature in the path.
Laser is safe for data transmission as it is very difficult to tap 1mm wide laser without interrupting the communication channel.

Difference between the Guided Media and Unguided Media

Guided Media	**Unguided Media**
The guided media is also called wired communication or bounded transmission media.	The unguided media is also called wireless communication or unbounded transmission media.
The signal energy propagates through wires in guided media.	The signal energy propagates through the air in unguided media.
Used to perform point-to-point communication.	Unguided media is generally suited for radio broadcasting in all directions.
It is affordable.	It is costly.
Discrete network topologies are formed by the guided media.	Continuous network topologies are formed by the unguided media.
Signals are in the form of voltage, current, or photons in the guided media.	Signals are in the form of electromagnetic waves in unguided media.
By adding more wires, the transmission capacity can be increased in guided media.	It is not possible to obtain additional capacity in unguided media.
It sends out a signal that indicates which way to go.	It does not indicate which way to travel.
For a shorter distance, this is the best option.	For longer distances, this method is used.
It is unable to pass through walls.	It can pass through walls.