CS 307 Data Communication-
Module II

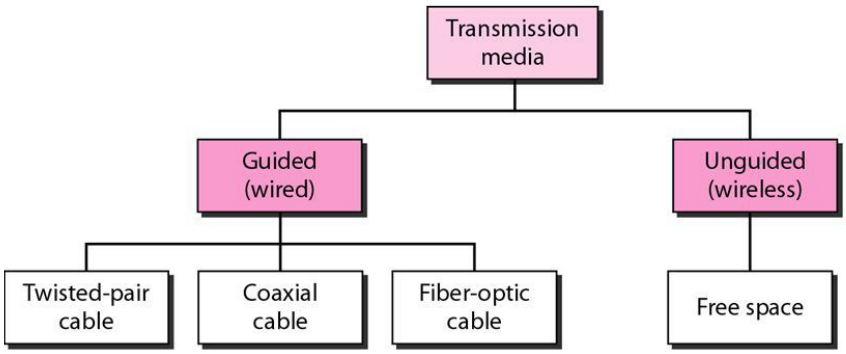
Syllabus

Transmission media - Guided Transmission Media:Twisted pair, Coaxial cable, optical fiber, Wireless Transmission, Terrestrial microwave, Satellite microwave. Wireless Propagation: Ground wave propagation, Sky Wave propagation, LoS Propagation.

Transmission media

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



Guided media provide a contact from one device to another,which mainly includes twisted-pair cable, coaxial cable, and fiber-optic cable. A signal travelling along any of these media is directed and contained by the physical limits of the medium. Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current. Optical fiber is a cable that accepts and transports signals in the form of light.

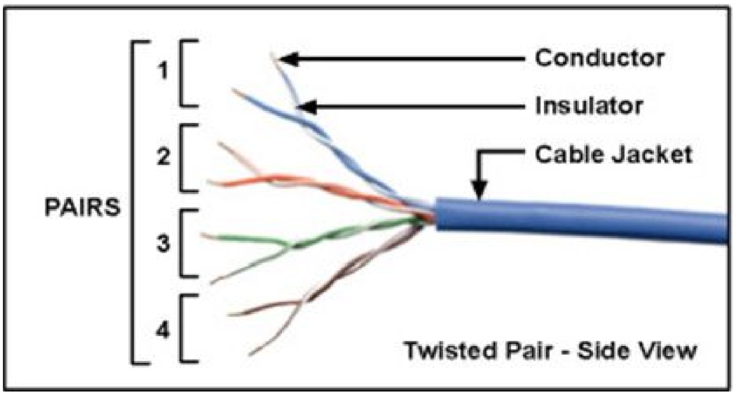
The characteristics and quality of a data transmission are determined both by the characteristics of the medium and the characteristics of the signal. In the case of guided media, the medium itself is more important in determining the limitations of transmission. For unguided media, the bandwidth of the signal produced by the transmitting antenna is more important than the medium in determining transmission characteristics.

Design Factors determining the data rate and distance :

- Bandwidth: higher bandwidth gives higher data rate
- transmission impairments :limits the distance of transmission. eg. attenuation
- Interference : Interference from competing signals in overlapping frequency bands can distort or wipe out a signal
- number of receivers in guided media : more receivers introduces more attenuation

Twisted-Pair Cable

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together.It is the most common guided transmission medium. It is used as medium in the telephone network , communications within buildings .It is much less expensive than the other commonly used guided transmission media (coaxial cable, optical fiber) .It is also easier to work with.



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 at different locations relative to the noise or crosstalk sources (e,g., one is closer and the other is farther). This results in a difference at the receiver. By twisting the pairs, a balance is maintained. Twisting makes it probable that both wires are equally affected by external influences

Unshielded Versus Shielded Twisted-Pair Cable:

The most common twisted-pair cable used in communications is referred to as unshielded twisted-pair (UTP). IBM has also produced a version of twisted-pair cable for its use called shielded twisted-pair (STP). STP cable has a metal foil or braided mesh covering that encases each pair of insulated conductors. Although metal casing improves the quality of cable by preventing the penetration of noise or crosstalk, it is bulkier and more expensive.

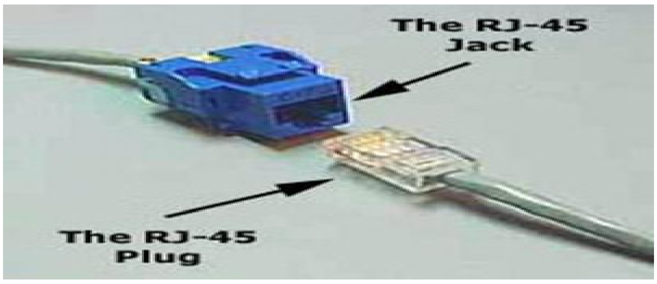
Twisted Pair – Transmission characteristics

- used to transmit both analog and digital transmission.
- analog transmission: needs amplifiers every 5km to 6km
- Digital transmission: needs a repeater every 2-3km
- Supports only limited distance ,limited bandwidth, limited data rate
- susceptible to interference and noise because of its easy coupling with electromagnetic fields

How can we reduce impairments in twisted pair cables?

- Shielding the wire with metallic braid or sheathing reduces interference.
- twisting of the wire reduces low-frequency interference,
- use of different twist lengths in adjacent pairs reduces crosstalk.

RJ-45 Connectors in Twisted pair

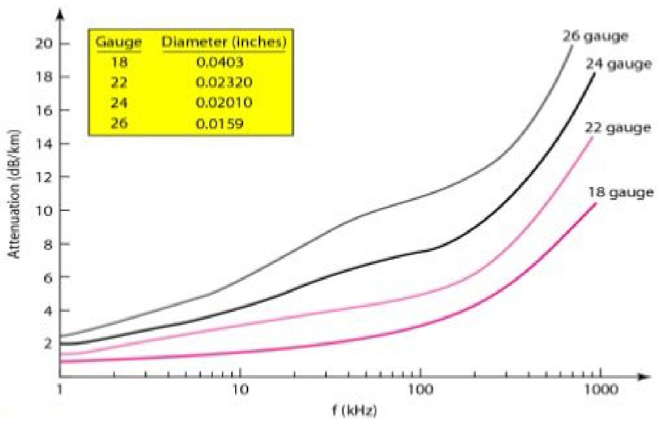


*RJ-Registered Jack

Categories of Twistedpair cables

Category	Description	Data Rate (in Mbps)
CAT 1	Unshielded twisted pair used for telephones	< 0.1
CAT 2	Unshielded twisted pair used for T1 data	2
CAT 3	Improved CAT2 used for computer networks	10
CAT 4	Improved CAT3 used for Token Ring networks	20
CAT 5	Unshielded twisted pair used for networks	100
CAT 5E	Extended CAT5 for more noise immunity	125
CAT 6	Unshielded twisted pair tested for 200 Mbps	200
CAT 7	Shielded twisted pair with a foil shield around the entire cable plus a shield around each twisted pair	600

Performance of Twisted Pair



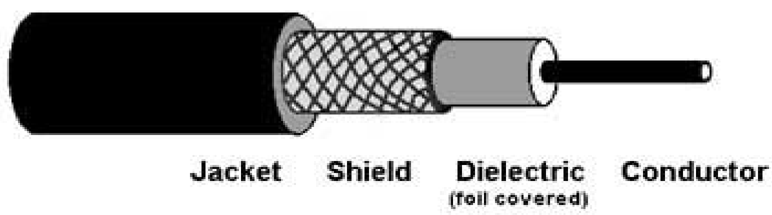
Applications

- Twisted-pair cables are used in telephone lines to provide voice and data channels.
- The DSL lines that are used by the telephone companies to provide high-data-rate connections also use the high-bandwidth capability of unshielded twisted-pair cables.

- Local-area networks, such as 10Base-T and 100Base-T also use twisted-pair cables.

Coaxial Cable

Coaxial cable (or coax) carries signals of higher frequency ranges than those in twistedpair cable, in part because the two media are constructed quite differently. Instead of having two wires, coax has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two. The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit. This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover



Advantages of coaxial cables

- can be used over longer distances
- support more stations on a shared line than twisted pair.
- operate over a wider range of frequencies
- much less susceptible to interference and crosstalk than twisted pair.

Coaxial Cable - Transmission Characteristics

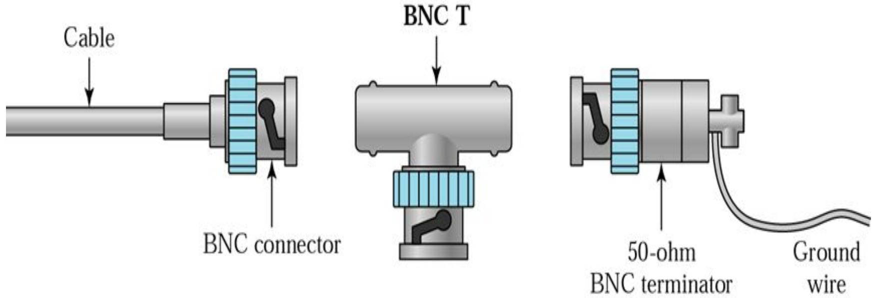
- superior frequency characteristics compared to Twisted Pair
- performance is limited by attenuation & noise
- For analog signals, amplifiers to be placed at every few km
- For digital signals, repeaters to be placed at every 1km

Coaxial Cable standards

- Categorized by Radio Government (RG)
- Based on wire gauge of inner conductor, thickness & type of insulation

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

BNC Connectors in Coaxial cables

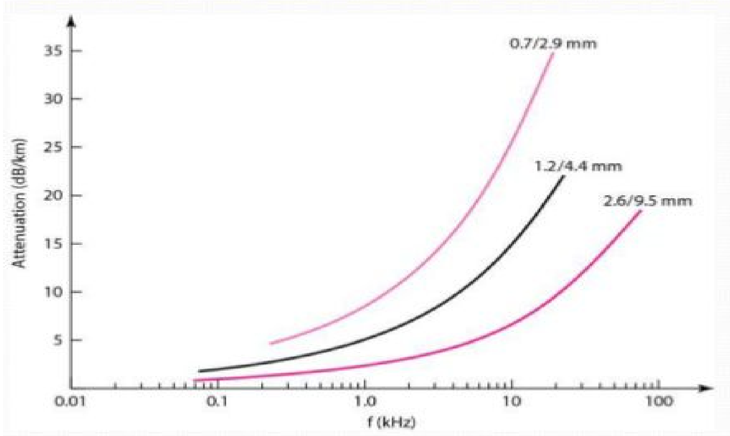


*BNC-Bayonet Neill–Concelman

Applications

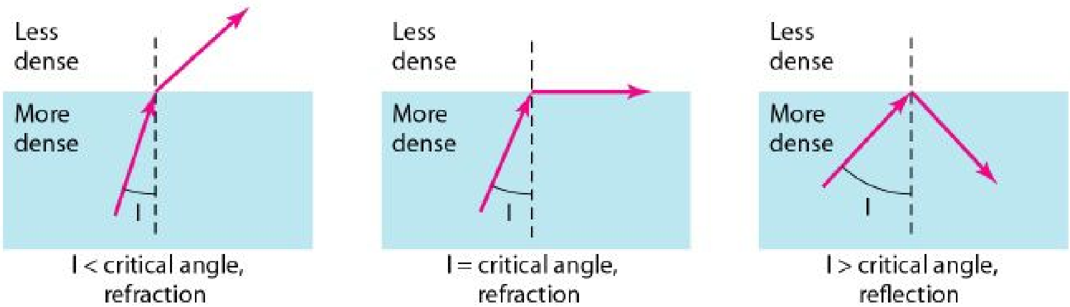
- Television distribution - aerial to TV & CATV systems
- Long-distance telephone transmission –
- traditional Ethernet LANs Local area networks

Performance of coaxial cable



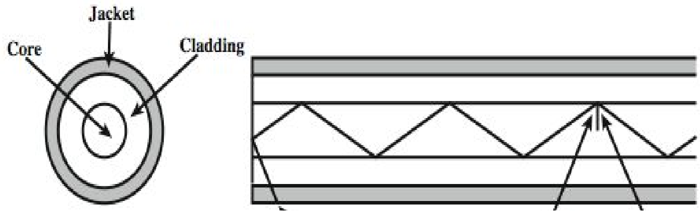
Fiber-Optic Cable

A fiber-optic cable is made of glass or plastic and transmits signals in the form of light. Light travels in a straight line as long as it is moving through a single uniform substance.If a ray of light traveling through one substance suddenly enters another substance (of a different density), the ray changes direction.



If the angle of incidence I (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 is greater than the critical angle, the ray reflects (makes a turn) and travels again in the denser substance.

Optical fibers use 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 the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it.



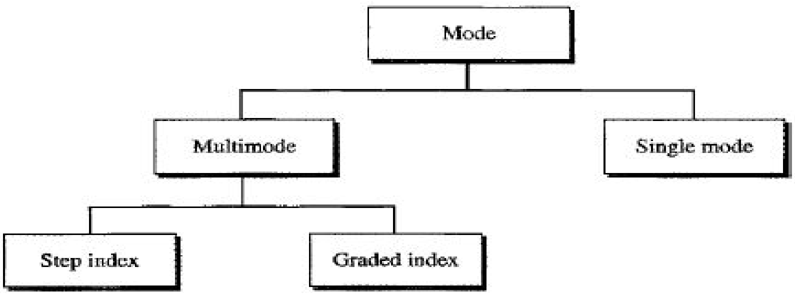
Construction:

Optical fiber cable has a cylindrical shape and consists of three concentric sections: the core, the cladding, and the jacket .The core is the innermost section and consists of one or more very thin strands, or fibers, made of glass or plastic; core has a diameter in the range of 8 to 50 µm. Optical cables are thin (2 to 125 µm), flexible medium capable of guiding an optical ray. Each fiber is surrounded by its own **cladding**, a glass or plastic coating that has optical properties different from those of the core and a diameter of 125 µm. The interface between the core and cladding acts as a reflector to confine light that would otherwise escape the core. The outermost layer, surrounding one or a bundle of cladded fibers, is the **jacket**. The jacket is composed of plastic and other material layered to protect against moisture, abrasion, crushing, and other environmental dangers.

Optical Fiber - Transmission Characteristics

- uses total internal reflection to transmit light
- can use several different light sources
  - Light Emitting Diode (LED)
    - cheaper, wider operating temp range, lasts longer
  - Injection Laser Diode (ILD)
    - more efficient, has greater data rate

Optical Fiber Transmission Modes



Multimode Transmission

Multimode is so named because multiple beams from a light source move through the core in different paths. How these beams move within the cable depends on the structure of the core.There are two types under multimode transmission: multimode step index and multimode graded index.

Multimode Step-Index Fiber

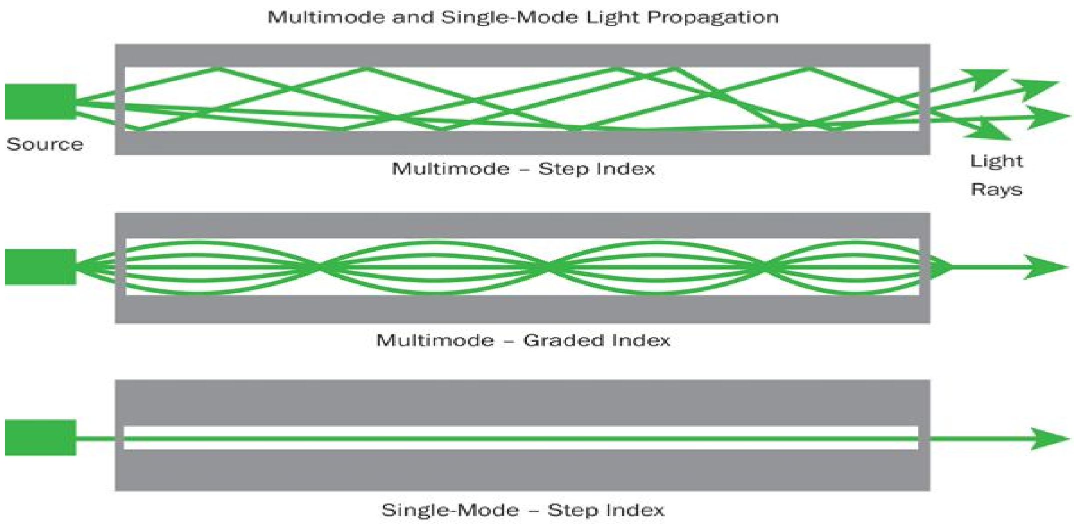
In multimode step-index fiber, the density of the core remains constant from the center to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding. At the interface, there is an abrupt change due to a lower density; this alters the angle of the beam's motion. The term 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

A second type of fiber, called multimode graded-index fiber, decreases this distortion of the signal through the cable. The word index here refers to the index of refraction.The index of refraction is related to density. A graded-index fiber, therefore, is one with varying densities. Density is highest at the center 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 singlemode fiber itself is manufactured with a much smaller diameter than that of multimode fiber, and with substantial 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. In this case, propagation of different beams is almost identical, and delays are negligible. All the beams arrive at the destination "together" and can be recombined with little distortion to the signal

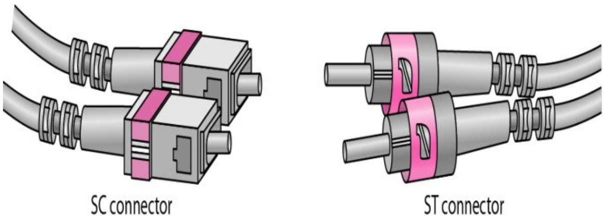


Fiber types

Type	Core (µm)	Cladding (µm)	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

Fiber-Optic Cable Connectors

There are three types of connectors for fiber-optic cables. The **subscriber 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. It uses a bayonet locking system and is more reliable than SC.**MT-RJ** is a connector that is the same size as RJ45



Advantages: Fiber-optic cable has several advantages over metallic cable (twistedpair or coaxial).

- Higher bandwidth: Fiber-optic cable can support dramatically higher bandwidths (and hence data rates) than either twisted-pair or coaxial cable.
- Less signal attenuation: Fiber-optic transmission distance is significantly greater than that of other guided media. A signal can run for 50 km without requiring regeneration. We need repeaters every 5 km for coaxial or twisted-pair cable.
- Immunity to electromagnetic interference: Electromagnetic noise cannot affect fiber-optic cables.
- Resistance to corrosive materials: Glass is more resistant to corrosive materials than copper.
- Light weight: Fiber-optic cables are much lighter than copper cables.
- Greater immunity to tapping: Fiber-optic cables are more immune to tapping than copper cables. Copper cables create antenna effects that can easily be tapped.

Disadvantages: There are some disadvantages in the use of optical fiber.

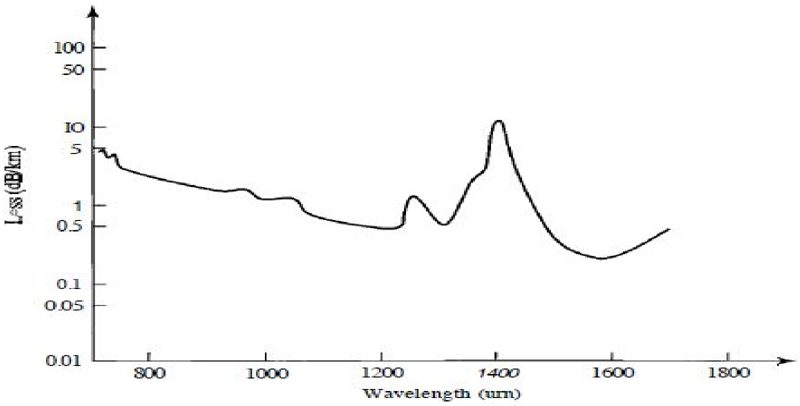
- Installation and maintenance: Fiber-optic cable is a relatively new technology. Its installation and maintenance require expertise that is not yet available everywhere.
- Unidirectional light propagation: Propagation of light is unidirectional. If we need bidirectional communication, two fibers are needed.
- Cost: The cable and the interfaces are relatively more expensive than those of other guided media. If the demand for bandwidth is not high, often the use of optical fiber cannot be justified.

Applications

- long-distance telecommunications
- military applications.
- The continuing improvements in performance and decline in prices, have made it increasingly attractive for local area networking.
- Five basic categories of telephone application : Long-haul trunks, Metropolitan trunks, Rural exchange trunks, Subscriber loops & Local area networks.

Performance

Attenuation is flatter than in the case of twisted-pair cable and coaxial cable. The performance is such that we need fewer (actually 10 times less) repeaters when we use fiber-optic cable.



Comparison of twisted pair,coaxial cable and twisted pair cables

Twisted pair cable	Co-axial cable	Optical fiber
1. Transmission of signals takes place in the electrical form over the metallic conducting wires.	1. Transmission of signals takes place in the electrical form over the inner conductor of the cable.	1. Signal transmission takes place in an optical forms over a glass fiber.
2. In this medium the noise immunity is low.	2. Coaxial having higher noise immunity than twisted pair cable.	2. Optical fiber has highest noise immunity as the light rays are unaffected by the electrical noise.
3. Twisted pair cable can be affected due to external magnetic field.	3. Coaxial cable is less affected due to external magnetic field.	3. Not affected by the external magnetic field.
4. Cheapest medium.	4. Moderate Expensive.	4. Expensive
5. Low Bandwidth.	5. Moderately high bandwidth.	5. Very high bandwidth
6. Attenuation is very high.	6. Attenuation is low.	6. Attenuation is very low.
7. Installation is easy.	7. Installation is fairly easy.	7. Installation is difficult.

Unguided Transmission Media

Unguided transmission techniques commonly include broadcast radio, terrestrial microwave, and satellite.Infrared transmission is used in some LAN applications.

General Ranges Of Frequencies In Wireless Transmission:

- **2GHz to 40GHz- Microwave frequencies**
  - highly directional beams are possible.
  - Suitable for point to point transmission.
  - Terrestrial and satellite microwaves

- **30MHz to 1GHz: Radio frequencies**
  - Suitable for omnidirectional applications.
- **3 x 10^{11} to 2 x 10^{14} Infrared frequencies.**
  - Local point-to-point and multipoint applications within confined areas, such as a single room.

Antennas

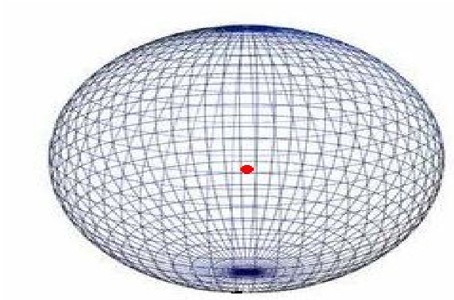
Antenna is defined as electrical conductor used to radiate or collect electromagnetic energy.There are mainly two types of antenna: Transmission antenna & Reception antenna.

- transmission antenna
  - radio frequency energy from transmitter is converted to electromagnetic energy by antenna and radiated into surrounding environment
- reception antenna
  - electromagnetic energy impinging on antenna is converted to radio frequency electrical energy and fed in to receiver
- In two-way communication, same antenna is often used for both transmission and reception .

Radiation Pattern

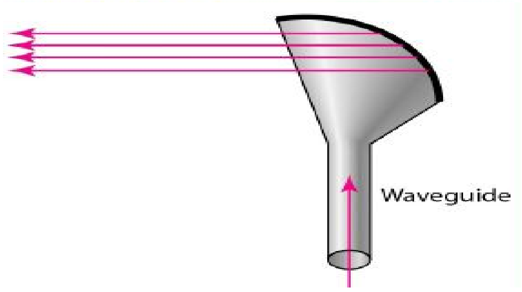
Antenna will radiate power in all directions but, typically, does not perform equally well in all directions. Radiation pattern is a graphical representation of the radiation properties of an antenna as a function of space coordinates.

In isotropic antenna, power is radiated in all directions equally.so the radiation pattern follows a spherical radiation pattern



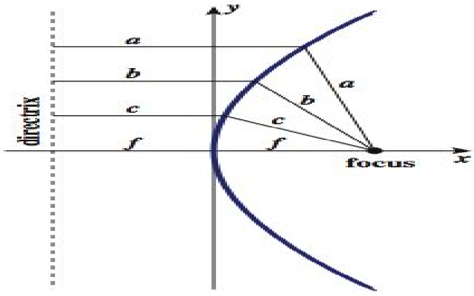
Horn Antenna

It is a Uni directional antenna which looks like gigantic scoop. Outgoing transmissions are broadcast up a stem & deflected outward in a series of narrow parallel beams by curved head. Received transmissions are collected by scooped shape of horn & are deflected down in to the stem.

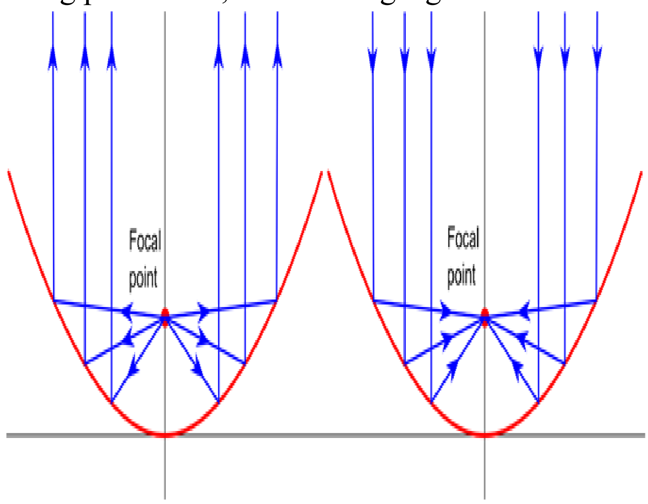


Parabolic Reflective Antenna

Parabolic Reflective Antenna **is** used in terrestrial microwave and satellite applications.A parabola is the locus of all points equidistant from a fixed line (the *directrix*) and a fixed point (the focus) not on the line. If a parabola is revolved about its axis, the surface generated is called a *paraboloid*.



If a source of electromagnetic energy (or sound) is placed at the focus of the paraboloid, and if the paraboloid is a reflecting surface, then the wave will bounce back in lines parallel to the axis of the paraboloid .On reception, if incoming waves are parallel to the axis of the reflecting paraboloid, the resulting signal will be concentrated at the focus.



Antenna Gain

It is the measure of directionality of antenna. It is defined as the power output in a particular direction compared to that produced in any direction by a perfect omnidirectional antenna (isotropic antenna). It is measured in decibels (dB). Antenna Gain is mainly based on effective area of antenna which inturn relates to size and shape.

$$G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi f^2 A_e}{c^2}$$

where

G = antenna gain
A_e = effective area
f = carrier frequency
c = speed of light ($\approx 3 \times 10^8$ m/s)
λ = carrier wavelength

- The effective area of an ideal isotropic antenna is $\lambda^2/4$ □ with a power gain of 1.

- The effective area of a parabolic antenna with a face area of *A is* 0.56*A, with a power gain of 7A/* λ^2.

Example: For a parabolic reflective antenna with a diameter of 2 m, operating at 12 GHz, what is the effective area and the antenna gain?

Ans: given diameter=2m, then radius= 1m

$f = 12GHz = 12*10^9 Hz$

$c = 3*10^8 m/s^2$

effective area of a parabolic antenna with a face area of *A is* 0.56*A*

$A = \pi r^2$

i.e $A = 1 m^2$

$A_e = 0.56A$

i.e $A_e = 0.56 m^2$

$G = 4\pi f^2 A_e / C^2$

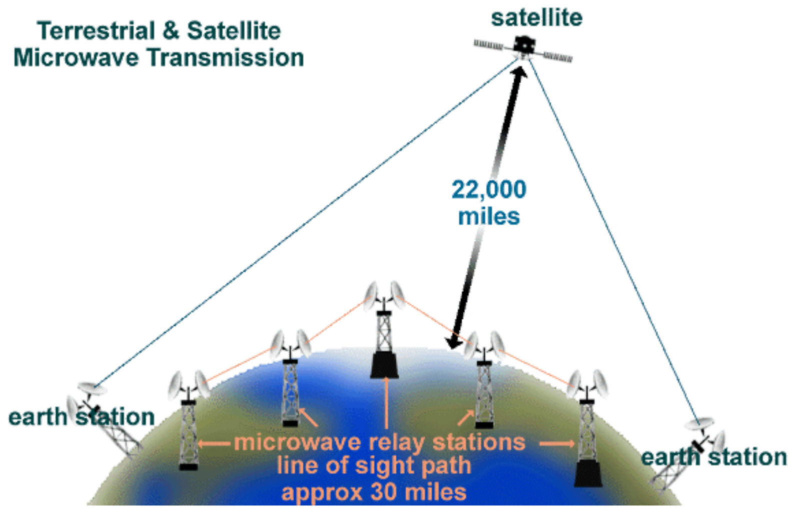
i.e G= 35,186

G in dB= 10 log 35186

G in dB= 45.46 dB

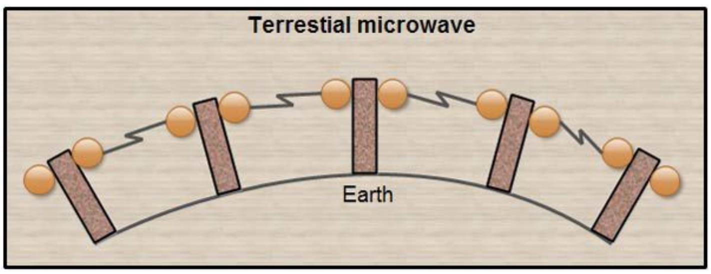
Microwave Transmissions

They are highly directional beams suitable for point to point transmission. Possible range of frequency between 2GHz to 40GHz. There are basically two types of microwaves: Terrestrial and satellite microwaves**.**



- **Terrestrial microwave** transmissions are sent between two microwave stations on the earth (earth station). It is the most common form of long-distance communication.
- **Satellite microwave** transmissions involve sending microwave transmissions between two or more earth-based microwave stations and a satellite.

Terrestrial Microwave



It is used for long haul telecommunications; commonly used for both voice and television transmission .It support short point-to-point links between buildings, LAN . It only requires far fewer amplifiers or repeaters than coaxial cable over the same distance but requires line-of-sight transmission.

It uses a parabolic dish to focus a narrow beam onto a receiver antenna. Typical of size 3m in diameter. Microwave antennas are usually located at substantial heights above ground level to extend the range between antennas. The higher the frequency used, the higher the potential bandwidth and therefore the higher the potential data rate.

The main sources of loss are:

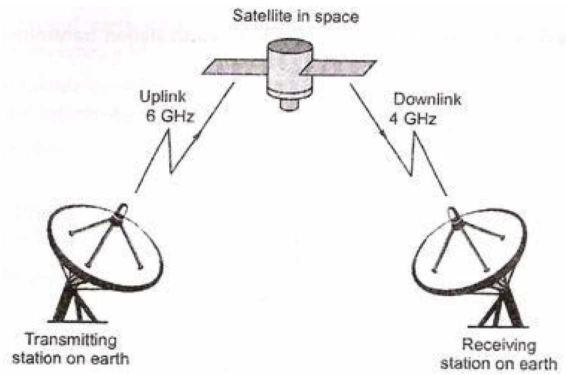
- attenuation, related to the square of distance.

$$L = 10 \log\left(\frac{4\pi d}{\lambda}\right)^2 \text{dB}$$

- effects of rainfall
- interference.

Satellite Microwave

It is used to link two or more ground-based microwave transmitter/receivers, known as earth stations, or ground stations. A communication satellite is, in effect, a microwave relay station.Satellite receives transmissions on one frequency band (uplink), amplifies or repeats the signal, and transmits it on another frequency (downlink). eg. uplink 5.925-6.425 GHz & downlink 3.7-4.2 GHz.



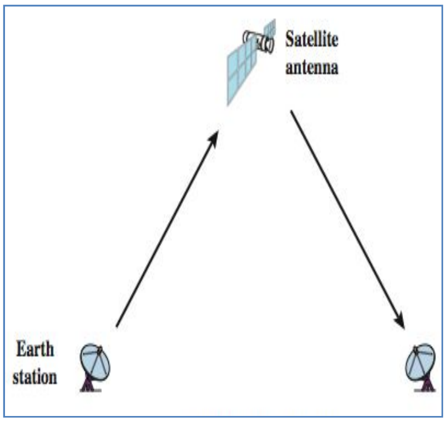
A single orbiting satellite will operate on a number of frequency bands, called **transponder channels**, or simply **transponders**. The optimum frequency range for satellite transmission is in the range **1 to 10 GHz.**

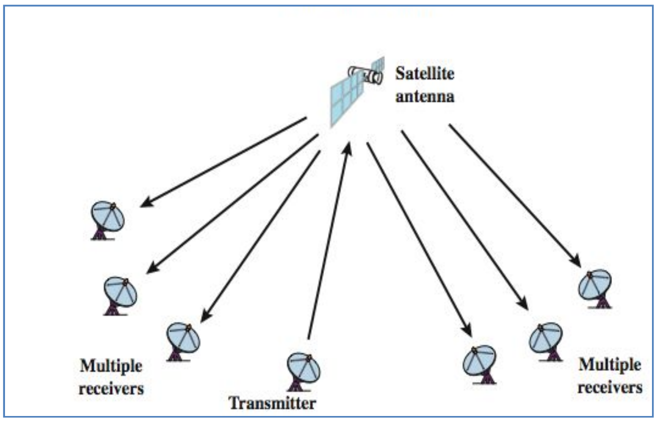
Applications:

- television
- long distance telephone
- private business networks
- global positioning

For a communication satellite to function effectively, it is generally required that it remain stationary with respect to its position over the earth to be within the line of sight of its earth stations at all times. To remain stationary, the satellite must have a period of rotation equal to the earth's period of rotation, which occurs at a height of 35,863 km at the equator. Two satellites using the same frequency band, if close enough together, will interfere with each other. To avoid this, current standards require a 4° spacing in the 4/6-GHz band and a 3° spacing at 12/14 GHz.

Satellite Point to Point Link: Satellite is being used to provide a point-to-point link between two distant ground-based antennas.





Satellite Broadcast Link: Satellite provides communications between one ground-based transmitter and a number of ground-based receivers.

GEO, LEO & MEO Satellites

- **Geosynchronous orbiting satellites (GEOS)** are placed into orbit **22,300 miles** above the earth's surface. The earth's gravity keeps the satellite in orbit at the same rate as the earth.
- **Low earth orbiting satellites (LEOS)** orbit the earth at a height of **325-1,000 miles** and they orbit around the poles.
- **Medium earth orbiting satellites (MEOS)** are similar to LEOS but are positioned at **6,000-10,000 miles** above the earth.

Satellite signal can only reach a part of the earth. This area is called a **footprint.**

Broadcast Radio Waves

Radio is a general term used to encompass frequencies in the range of 3 kHz to 300 GHz. It use broadcast radio, 30MHz - 1GHz, for FM radio & UHF and VHF television.

Radio waves, for the most part, are omnidirectional. When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and receiving antennas do not have to be aligned. A sending antenna sends waves that can be received by any receiving antenna. The omnidirectional property has a disadvantage, too. The radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signals using the same frequency or band. Radio waves, particularly those waves that propagate in the sky mode, can travel long distances. This makes radio waves a good candidate for long-distance broadcasting such as AM radio.

Radio waves, particularly those of low and medium frequencies, can penetrate walls. This characteristic can be both an advantage and a disadvantage. It is an advantage because, for example, an AM radio can receive signals inside a building. It is a disadvantage because we cannot isolate a communication to just inside or outside a building. The radio wave band is relatively narrow, just under 1 GHz, compared to the microwave band. When this band is divided into subbands, the subbands are also narrow, leading to a low data rate for digital communications. Almost the entire band is regulated by authorities (e.g., the FCC in the United States). Using any part of the band requires permission from the authorities.

Comparison of Radiowaves & Microwaves

Factor	**Radio waves**	**Micro waves**
Frequency range	30MHz to 1GHz	2GHz to 40GHz
Beam	Omni directional	Uni directional
Antenna	Isotropic antenna	Parabolic antenna, Horn antenna
Characteristics	penetrate walls	Cannot penetrate walls
Applications	Multicast communication –radio & television	Unicast communication –cellular telephone, satellite networks,Wireless LANs

Infrared Waves

Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication. Infrared waves, having high frequencies, cannot penetrate walls. This advantageous characteristic prevents interference between one system and another; a short-range communication system in one room cannot be affected by another system in the next room. When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors. However, this same characteristic makes infrared signals useless for long-range communication. In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

It is achieved using transceivers that can modulate infrared light. Transceivers must be within the line of sight of each other either directly or via reflection from a light-colored surface such as the ceiling of a room. There is no frequency allocation issue with infrared, so no licensing is required.
Typical uses: TV remote control, IRDA port

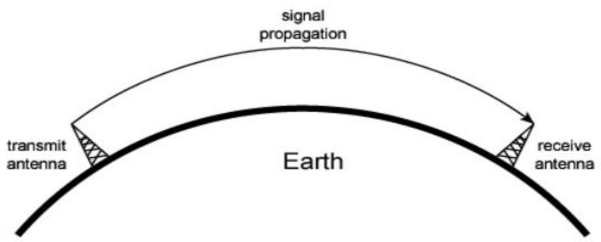
Wireless Propagation

A signal is radiated from an antenna travels along one of three routes

- ground wave (below 2 MHz)
- sky wave (2-30 MHz)
- line of sight (above 30 MHz)

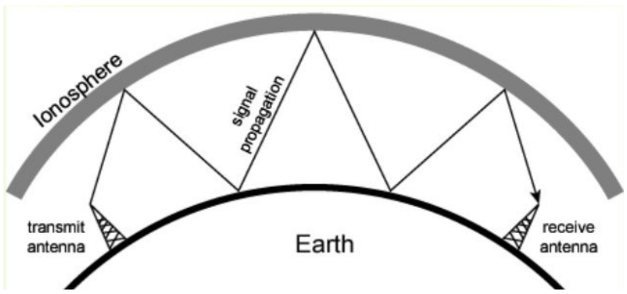
Wireless Propagation: Ground Wave

- Radio waves travel through the lowest portion of the atmosphere ,hugging the earth
- Low frequency signals radiates in all directions from transmitting antenna and follow the curvature of earth.
- Distance depends on amount of power in the signal. Greater the power, greater the distance.
- Used in AM Radio



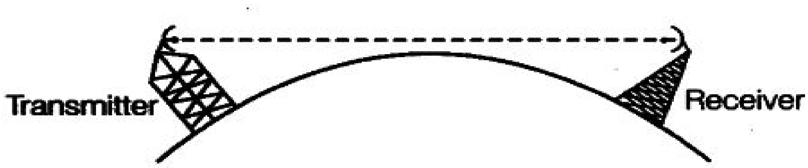
Wireless Propagation: Sky Wave

- a signal from an earth-based antenna is reflected from the ionized layer of the upper atmosphere (ionosphere) back down to earth.
- allows greater distance with lower output power.
- used for amateur radio, CB radio, and international broadcasts such as BBC



Wireless Propagation: Line of Sight

- Very high frequency signals are transmitted in straight lines directly from antenna to antenna
- Antennas must be directional, facing each other, and tall enough such that it should not be affected by the curvature of earth.



Refraction:

Refraction occurs because the velocity of an electromagnetic wave is a function of the density of the medium through which it travels. In a vacuum, an electromagnetic wave (such as light or a radio wave) travels at approximately This is the constant, c, commonly referred to as the speed of light, but actually referring to the speed of light in a vacuum.

When an electromagnetic wave moves from a medium of one density to a medium of another density, its speed changes.The effect is to cause a one-time bending of the direction of the wave at the boundary between the two media. Moving from a less dense to a more dense medium, the wave will bend toward the more dense medium. Although an abrupt, one-time change in direction occurs as a signal moves from one medium to another, a continuous, gradual bending of a signal will occur if it is moving through a medium in which the index of refraction gradually changes.

Optical and Radio Line of Sight:

With no intervening obstacles, the optical line of sight can be expressed as

$$d = 3.57\sqrt{h}$$

where *d* is the distance between an antenna and the horizon in kilometers and *h* is the antenna height in meters.

The effective, or radio, line of sight to the horizon is expressed as

$$d = 3.57\sqrt{(Kh)}$$

where K is an adjustment factor to account for the refraction. Normally k taken as 4/3.

Thus, the maximum distance between two antennas for LOS propagation is

$$d = 3.57\left(\sqrt{(Kh_1)} + \sqrt{(Kh_2)}\right)$$

where h_1 and h_2 are the heights of the two antennas.

EXAMPLE **:**Find the maximum distance between two antennas for LOS transmission if one antenna is 100 m high and the other is at ground level.

$$d = 3.57\left(\sqrt{(Kh_1)} + \sqrt{(Kh_2)}\right)$$

h_1=100m

h_2=0

d=41 Km (distance always in Km)

Now suppose that the receiving antenna is 10 m high. To achieve the same distance,how high must the transmitting antenna be?

$$d = 3.57\left(\sqrt{(Kh_1)} + \sqrt{(Kh_2)}\right)$$

h_2=10

$$41 = 3.57\left(\sqrt{(Kh_1)} + \sqrt{(K*10)}\right)$$

h_1 =46.2 m

Impairments specific to wireless line-of-sight transmission.

Free space loss:

The transmitted signal attenuates over distance because the signal is being spread over a larger and larger area. This form of attenuation is known as free space loss, which can be expressed in terms of the ratio of the radiated power p_t to the power received p_r by the antenna or, in decibels, by taking 10 times the log of that ratio. For the ideal isotropic antenna, free space loss is

$$p_t/p_r = (4\pi d)^2/\lambda^2$$

$$p_t/p_r = (4\pi fd)^2/C^2$$

where p_t= signal power at the transmitting antenna

p_r= signal power at the receiving antenna

λ = carrier wavelength

d = propagation distance between antennas

In decibels; $L_{dB}=10\log(p_t/p_r)$

Atmospheric Absorption

An additional loss between the transmitting and receiving antennas is atmospheric absorption. Water vapor and oxygen contribute most to attenuation. A peak attenuation occurs in the vicinity of 22 GHz due to water vapor. At frequencies below 15 GHz, the attenuation is less. Rain and fog cause scattering of radio waves that results in attenuation. This can be a major cause of signal loss.

Multipath

For wireless facilities where there is a relatively free choice of where antennas are to be located, they can be placed so that if there are no nearby interfering obstacles, there is a direct line-of-sight path from transmitter to receiver. In cases, such as mobile telephony, there are obstacles in abundance. The signal can be reflected by such obstacles so that multiple copies of the signal with varying delays can be received.

Refraction

Radio waves are refracted (or bent) when they propagate through the atmosphere.The refraction is caused by changes in the speed of the signal with altitude or by other spatial changes in the atmospheric conditions. Normally, the speed of the signal increases with altitude, causing radio waves to bend downward. However,on occasion, weather conditions may lead to variations in speed with height that differ significantly from the typical variations. This may result in a situation in which only a fraction or no part of the line-of-sight wave reaches the receiving antenna.

Important Questions:

1. What are the advantages of optical fibre communication?
2. Define guided transmission and unguided transmission. Describe three different types of guided transmission media.
3. Why are the wires twisted in twisted pair copper cable?
4. Compare the construction and features of twisted pair and coaxial cables
5. Determine the isotropic free space loss at 4 GHz for the shortest path to a geosynchronous satellite from earth (35,863 km).
   - λ= 0.075 m
   - L=3.61*10^{19}
   - L_{dB}=195.6 dB
6. Find the maximum distance between two antennas for LOS transmission if one antenna is 100m high and the other is at ground level. Also find height of transmitting antenna , to achieve the same distance if receiving antenna is 10m high.
   - d = 41 km
   - h1 = 46.2 m
7. what is the length of an antenna one-half wavelength long for sending radio at 300 Hz
   - λ= 1000 Km
   - h=500km
8. A microwave transmitter has an output of 0.1W at 2GHz. Assume that this transmitter is used in a microwave communications system where the transmitting and receiving antennas are parabolas, each 1.2m in diameter.
   a. What is the gain of each antenna in decibels?
   b. Taking into account antenna gain, what is the effective radiated power of the transmitted signal?
   - G = 351.85
   - G_{dB} = 25.46 dB
   - P=0.1 W x 351.85 = 35.185 W
9. Determine the height of an antenna for a TV station that must be able to reach customers 80km away.
   h=379 m
10. Explain shortly wireless Transmission in wireless transmission

11. What are the two functions performed by an antenna?
12. Explain Antenna gain and radiation pattern with respect to an isotropic antenna
13. What is the advantage of parabolic reflective dish antenna? Define antenna gain
14. Explain Satellite communication.
15. Explain microwave communication
16. Explain wireless propogation
17. Describe in detail the various wireless transmission media.
18. Explain three routes of propagation in wireless transmission.
19. For a parabolic reflective antenna with a diameter of 2 m, operating at 12 GHz, what is the effective area and the antenna gain?
    - G= 35,186
    - G in dB= 45.46 dB
20. Explain three frequency ranges in wireless transmission.
21. Explain the impairments that can cause in wireless transmission.
22. Compare the features of microwave and radio waves.

Previous Year KTU University questions

1. Mention the purpose of cladding in Optical Fibres?
2. Indicate some significant differences between broadcast radio and microwave.
3. For a parabolic reflective antenna operating at 12 GHz with a diameter of 2 m, Calculate the effective area and the antenna gain.
4. Briefly discuss Line of Sight Propagation
5. Explain the followingterms:
   i)Direct broadcast satellite (DBS) ii) Isotropic antenna

Direct broadcast satellite (DBS) refers to satellite television (TV) systems in which the subscribers, or end users, receive signals directly from geostationary satellites. Signals are broadcast in digital format at microwave frequencies. DBS is the descendant of direct-to-home (DTH) satellite services.

A DBS subscriber installation consists of a dish antenna, a conventional TV set, a signal converter placed next to the TV set, and a length of coaxial cable between the dish and the converter. The dish intercepts microwave signals directly from the satellite. The converter produces output that can be viewed on the TV receiver.

6. Write physical and transmission characteristics of Optical Fibre Cable guided transmission media

7. What are the advantages of microwave transmission over radio wave transmission?For a parabolic reflective antenna with a diameter of 2m, operating at 12 GHz. Calculate the antenna gain? Given effective area= 56π.

8. How does cross talk occurs in twisted pair cables? Give the purpose of CAT5e, CAT6, CAT7 twisted pair cables.

9. Show that doubling the transmission frequency or doubling the distance between transmitting antenna and receiving antenna attenuates the power received by 6 dB.

ratio of transmitted power to received power is

$$Pt/P\,r = (4\pi d/\lambda)^2$$

If we double the frequency or if we double the distance, so the new ratio for either of these events is:

$$P_t/P_{r2} = (8\pi d/\lambda)^2$$

Therefore:

$$10 \log (P_r / P_{r2}) = 10 \log (2^2) = 6 \text{ dB}$$

10. Explain following wireless propagation modes

(i) Ground wave propagation(ii) Sky wave propagation