CHAPTER 6

Unit II

Transmission Media

Syllabus :
Transmission media, Guided media, Twisted pair cable, Coaxial cable, Fiber optic cable.

factors – Transmission Rate
– Cost & installation
– Resistance & environment
– Distance

6.1 Transmission Media :

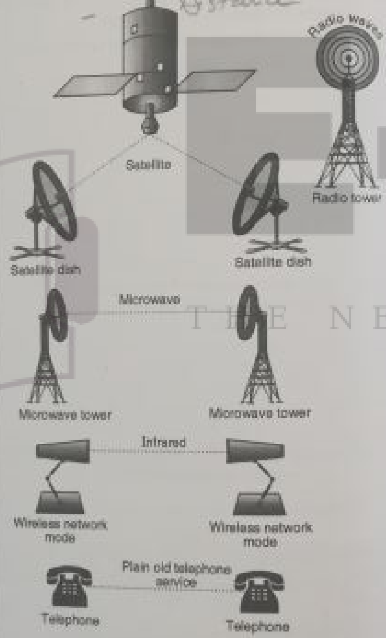
- Media are what the message is transmitted over. In other words a communication channel is also called as a medium.
- Different media have different properties and used in different environments for different purposes.
- The purpose of the physical layer is to transport a raw bit stream from one computer to another.

6.1.1 Classification of Transmission Media :

- We can classify the transmission media as shown in Fig. 6.1.1 into two categories.

(L-571) **Fig. 6.1.1 : Classification of transmission media**

- Media are roughly grouped into two classes :
  1. Guided media 2. Unguided media
  1. **Guided media** : Guided media is a communication medium which allows the data to get guided along it. For this the media need to have a point to point physical connection.
  2. **Unguided media** : The wireless media is also called as an unguided media.
- The examples of guided media are copper wires and fiber-optics, whereas radio and lasers through the air are examples of unguided media as shown in Fig. 6.1.2.



(L-573) **Fig. 6.1.2 : Transmission medias**

6.1.2 Comparison of Wired and Wireless Media :

Comparison of wired and wireless media is given in Table 6.1.1.

Table 6.1.1 : Comparison of wired and wireless media

Sr. No.	Wired media	Wireless media
1.	The signal energy is contained and guided within a solid medium.	The signal energy propagates in the form of unguided electromagnetic waves.
2.	Twisted pair wires, coaxial cable, optical fiber cables are the examples of wired media	Radio and infrared light are the examples of wireless media.
3.	Used for point to point communication.	Used for radio broadcasting in all directions.
4.	Wired media lead to discrete network topologies.	Wireless media leads to continuous network topologies.
5.	Additional transmission capacity can be procured by adding more wires.	It is not possible procure additional capacity.
6.	Installation is costly, time consuming and complicated.	Installation needs less time and money.
7.	Attenuation depends exponentially on the distance.	Attenuation is proportional to square of the distance.

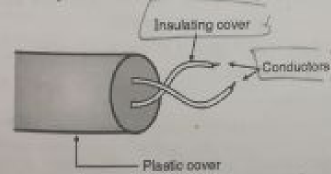
6.1.3 Types of Wired Media :

The most commonly used networking media are :
1. Co-axial cable 2. Twisted pair cable
3. Optical fiber cable.

The selection of networking media depends on various factors such as cost, connectivity, bandwidth, performance in presence of noise, geographical coverage etc.

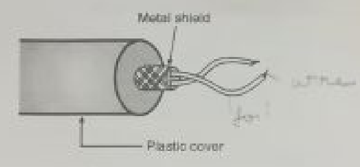
6.2 Twisted Pair Cables :

- The construction of twisted pair cable is as shown in Fig. 6.2.1. This is a very commonly used medium and it is cheaper than the co-axial cable or optical fiber cable.



(a) UTP

(L-574) **Fig. 6.2.1 (Contd..)**



(b) STP

(L-574) **Fig. 6.2.1 : Construction of twisted pair cables**

6.2.1 Types of Twisted Pair Cables :

- The two commonly used types of twisted pair cables are as follows :
  1. Unshielded Twisted Pair (UTP).
  2. Shielded Twisted Pair (STP).
- The construction of UTP and STP cables is shown in Fig. 6.2.1.

UTP :

- A twisted pair consists of two insulated conductors twisted together in the shape of a spiral as shown in Fig. 6.2.1. It can be shielded or unshielded.
- The unshielded twisted pair cables are very cheap and easy to install. But they are badly affected by the electromagnetic noise interference.

STP :

- STP cable as shown in Fig. 6.2.1(b) has a metal foil or braided mesh included in order to cover each pair of twisted insulating conductors.
- This is known as the metal shield which is normally connected to ground so as to reduce the interference of the noise. But this makes the cable bulky and expensive.
- So practically UTP is more used than STP. The STP was developed by IBM and is used primarily for the IBM company only.
- Applications of the twisted pair cables are in point to point and point to multipoint communications, telephone systems etc.
- Twisted pairs can be used for either analog or digital transmission. The bandwidth supported by the wire depends on the thickness of the wire and the distance to be travelled by a signal on it.
- Twisted pairs support several megabits/sec for a few kilometres and are less costly.

Why to twist the wires ?

- Twisting of wires will reduce the effect of noise or external interference. The induced emf into the two wires due to interference tends to cancel each other due to twisting.
- Number of twists per unit length will determine the quality of cable. More twists means better quality.

reduces cross-talk

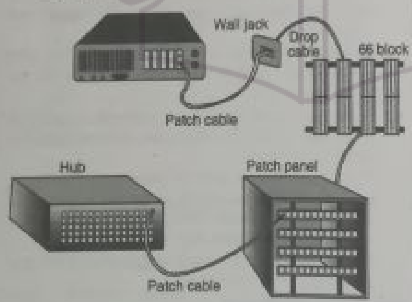
6.2.2 Categories (Cat) of UTP :

- Table 6.2.1 shows various categories of the unshielded twisted pair cables.
- These categories are decided by EIA i.e. electronic industries association. Different category cables are used for different applications.

Table 6.2.1 : Categories of UTP cables

Category	Data rate	Bandwidth	Application
1.	Extremely low upto 100 kbps	Low	Analog applications, telephony.
2.	Moderate upto 2 Mbps.	Moderate upto 2 MHz.	Analog and digital telephony
3.	Upto 10 Mbps	Upto 10 MHz	Local Area Networks (LANs)
4.	Upto 20 Mbps	Upto 20 MHz	Local Area Networks (LANs)
5.	Upto 100 Mbps	Upto 100 MHz	Local Area Networks (LANs)
6.	Upto 200 Mbps	Upto 200 MHz	Local Area Networks (LANs)
7.	Upto 600 Mbps	Upto 600 MHz	Local Area Networks (LANs)

- These cables ensure less crosstalk and a higher quality of signal over longer distances. Therefore these cables are popularly used for high speed computer communication.
- A connection diagram using the UTP is shown in Fig. 6.2.2.



(L-575) **Fig. 6.2.2 : A common UTP installation**

6.2.3 Category 3 and Category 5 (Cat 3 and Cat 5) UTP Cables :

- Most office buildings have been wired with twisted pair cable for telephones which is commonly called as voice grade UTP.
- Because these cables are already in place we can use them easily as LAN medium. The disadvantage of these voice grade twisted pair cables are low data rates and limited distances.
- Hence in 1991 the EIA published a new standard called EIA-568 in order to specify the use of voice grade unshielded twisted pair as well as shielded twisted pair for the in-building data applications.
- These standards were specified for the data rates upto 16 Mbps for LAN. But in the subsequent years, the LANS became faster with a data rate upto 100 Mbps.
- Hence a new standard EIA-568 A was published in 1995. EIA-568 A defined three categories of UTP cabling as follows :
  1. **Category 3 :** Characteristics of UTP cables and associated connecting hardware are specified upto 16 MHz.
  2. **Category 4 :** Under this category, the characteristics of UTP cables and associated connecting hardware have been specified for the data rates upto 20 MHz.
  3. **Category 5 :** Under this category, the characteristics of UTP cables and associated connecting hardware were specified for the data rates upto 100 MHz.
- The cat 3 and cat 5 cables were the most popular cables for LAN applications. Cat 3 cables are popularly used for the office building applications.
- The data rates upto 16 Mbps can be achieved by cat-3 cables provided that it is well designed and used over a limited distance.
- Cat-5 is a data-grade cable that can be used for data rates upto 100 Mbps if the distance is limited.

6.2.4 Category 6 (Cat 6) UTP :

Construction :

- Cat 6 UTP cable consists of 4-pairs of copper conductors. i.e. total 8-conductors. The jacket is made of thermoplastic polylefin or Fluorinated Ethylene Propylene (FEP).
- The material used for outside sheath of this cable can be of PVC, a fire retardant polyolefin or fluoropolymers.
- The design and manufacturing is done by taking a lot of care. Advanced connector design is essential.
- It is the best available UTP.
- Cat-6 that can operate upto 200 MHz and further increase is possible in the near future.

6.2.5 Category 7 (Cat 7) Shielded Screen Twisted Pair (SSTP) :

Construction :

- It is also called as PiMF (Pairs in Metal Foil) SSTP of 4 pairs of 22-23 copper conductors. The jacket is made of thermoplastic polyolefin or Fluorinated Ethylene Porpylene (FEP).
- A separate and improved shielding has been provided to each pair of conductors. Thus shielding has been improved.

Expected performance :

Cat-7 cable has a very large bandwidth between 6000 to 1200 MHz.

6.2.6 Applications of Twisted Pair Cables :

Some of the applications of twisted pair cables are as follows :

1. Local area networks for connecting computers to each other.
2. In the ISDN (Integrated Services Digital Network).
3. In the digital subscriber line (DSL).
4. In the analog telephony (conventional telephone line) to carry voice and data signals.
5. In digital telephony system (T_1 system)

Note :

- A modular RJ-45 telephone connector is used to connect a four-pair cable.
- A modular RJ-11 telephone connector is used to connect a two pair cable.
- Shielded twisted pair (STP) cables were introduced by IBM corporation.

6.2.7 Comparison of Twisted Pair Cables :

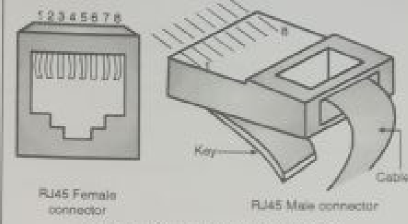
Sr. No.	Factors	UTP	STP
1.	Bandwidth	1 – 155 Mbps (typically 10 Mbps)	1 – 155 Mbps (typically 16 Mbps)
2.	Number of node connected per segment	2	2
3.	Attenuation	High	High
4.	Electromagnetic interference	Very high	High
5.	Ease of Installation	Easy	Fairly easy
6.	Cost	Lowest	Moderate

6.2.8 Connectors :

- For connecting one computer to the other, we need to use some transmission medium such as a cable.
- The cables are of different types such as twisted pair cables, coaxial cables or fiber optic cables.
- For connecting these cables between two computers we have to use connectors on both ends of a cable.
- Generally the connectors are male-female type to ensure reliable connection.

6.2.9 Connector for Twisted Pair Cable :

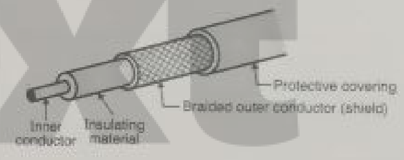
- The Unshielded Twisted Pair (UTP) cable is the most commonly used cable in computer communication.
- RJ45 is the most commonly used UTP where RJ is the short form of Registered Jack. It is a male-female type keyed connector as shown in Fig. 6.2.3.
- This connector can be inserted in only one way.



(G-346) **Fig. 6.2.3 : UTP RJ45 connector**

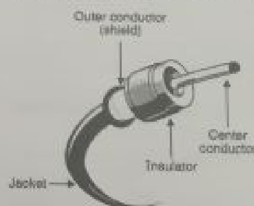
6.3 Co-axial Cables :

- The construction of co-axial cable is as shown in Fig. 6.3.1. It consists of two concentric conductors namely an inner conductor and a braided outer conductor separated by a dielectric material.
- The external conductor is in the form of metallic braid and used for the purpose of shielding. The co-axial cable may contain one or more co-axial pairs.



(L-577) **Fig. 6.3.1 : Construction of a co-axial cable**

- The construction of a co-axial cable with other accessories such as connector, jacket etc. is shown in Fig. 6.3.2.
- The wire mesh (braided conductor) protects the inner conductor from Electromagnetic Interference (EMI). It is often called a shield.
- A tough plastic jacket forms the cover of the cable as shown in Fig. 6.3.2 providing insulation and protection.



(L-577) **Fig. 6.3.2 : Co-axial cable**

- The co-axial cable was initially developed for analog telephone networks. A single co-axial cable would be used to carry more than 10,000 voice channels at a time.

- The digital transmission systems using the co-axial cable were developed in 1970s. These systems operated in the range of 8.5 Mb/s to 565 Mb/s.
- The most popular application of a co-axial cable is in the cable TV system. The existing co-axial cable system has a range from 54 MHz to 500 MHz.
- Other important application is cable modem, with the Cable Modem Termination System (CMTS).
- One more application is Ethernet LAN using the co-axial cable. The co-axial cable is used for its large bandwidth and high noise immunity.

6.3.1 Characteristics of a Co-axial Cable :

The important characteristics of a co-axial cable are as follows :

- Two types of cables having 75 Ω and 50 Ω impedance are available.
- Due to the shield provided, this cable has excellent noise immunity.
- It has a large bandwidth and low losses.
- This cable is suitable for point to point or point to multipoint applications. In fact this is the most widely used medium for local area networks.
- These cables are costlier than twisted pair cables but they are cheaper than the optical fiber cables.
- It has a data rate of 10 Mbps which can be increased with the increase in diameter of the inner conductor.
- The specified maximum number of nodes is upto 100.
- The attenuation is less as compared to the twisted pair cable.
- Co-axial cables are easy to install.
- Co-axial cables are relatively inexpensive (as compared to the optical fiber cable).

6.3.2 Co-axial Cable Standards :

Table 6.3.1 shows the co-axial cable standards. The co-axial cables are categorised by their RG ratings where RG stands for Radio Government.

Table 6.3.1 : Categories of co-axial cables

Category	Impedance	Application
RG-11	50 Ω	LAN
RG 58	50 Ω	LAN
RG 59	75 Ω	Cable TV.

6.3.3 Applications of Co-axial Cables :

1. Analog telephone networks.
2. Digital telephone network.
3. Cable TV.
4. Traditional Ethernet LANs.
5. Digital transmission.
6. Fast Ethernet.

6.3.4 Baseband Co-axial Cable :

The baseband co-axial cable is the one that makes use of digital signaling. The original Ethernet scheme makes use of baseband co-axial cable.

Characteristics of baseband co-axial cable :

- The baseband co-axial cables are used to allow digital signaling for the data.
- The digital signal used for data transfer on these cables is encoded using Manchester or Differential Manchester coding.
- The digital signals need larger bandwidth. Hence the entire frequency spectrum of the cable is consumed. So it is not possible to transmit multiple channel using FDM.
- The transmission of digital signal on the cable is bi-directional.
- The baseband co-axial cable was originally used for the Ethernet system that operates at 10 Mbps.
- These cables have a characteristic impedance of 50 Ω rather than 75 Ω of the cable TV co-axial cables.
- The maximum length of baseband co-axial cable between two repeaters is dependent on the data rates.
- Lower the data rate longer is the cable. The length has to be reduced with increased data rates so as to reduce the probability of errors getting introduced.
- There are two baseband coaxial cable used in bus LANs namely 10 BASE 5 and 10 BASE 2 which are compared based on various factors in Table 6.3.2.

Table 6.3.2 : IEEE 802.3 specifications for 10 Mbps baseband co-axial cable Bus LAN

Sr. No.	Parameter	10 BASE 5	10 BASE 2
1.	Data rate	10 Mbps	10 Mbps
2.	Maximum segment length	500 m	185 m
3.	Network span	2500 m	1000 m
4.	Nodes per segment	100	30
5.	Node spacing	2.5 m	0.5 m
6.	Cable diameter	1 cm	0.5 cm

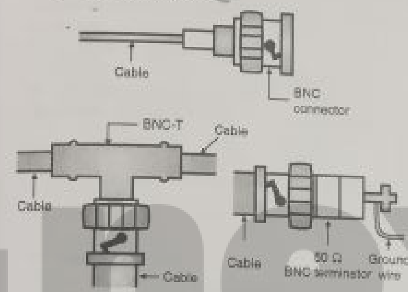
6.3.5 Broadband Co-axial Cable :

- This is the co-axial cable which is used in the cable TV system. It has higher bandwidth compared to the baseband cable.
- The type of signaling is analog at radio frequencies.
- This cable has certain disadvantages such as it is more expensive, more difficult to install and maintain as compared to the baseband co-axial cable.
- IEEE 802.3 standards have specified this as an option but practically the broadband co-axial cables are not popular.

6.3.6 Connector for Co-axial Cable :

- Coaxial cable is another important type of guided transmission media. It has higher bandwidth as compared to that of twisted pair cable.

- The coaxial cable connectors are required for connecting a coaxial cable to a computer or any other device.
- The most popular connector used for coaxial cables is the Bayone-Neill-Concelman or BNC connectors.
- Fig. 6.3.3 shows the various types of BNC connectors. The BNC connectors are available in three different types :
  1. BNC connector
  2. BNC–T connector
  3. BNC terminator.

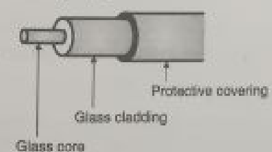


(G-341) **Fig. 6.3.3 : BNC connectors of different types**

6.4 Optical Fiber Cables :

Construction :

- The construction of an optical fiber cable is as shown in Fig. 6.4.1.
- It consists of an inner glass core surrounded by a glass cladding which has a lower refractive index and a protective covering.
- Digital signals are transmitted in the form of intensity - modulated light signal.



(G-103) **Fig. 6.4.1 : Construction of optical fiber cable**

- Light is launched into the fiber at one end using a light source such as a light emitting diode (LED) or laser.
- It is detected on the other side using a photo detector such as a phototransistor or photodiode.
- The optical fiber cables are costlier than the other two types but they have many advantages over the other two types.

6.4.1 Light Sources for Fiber :

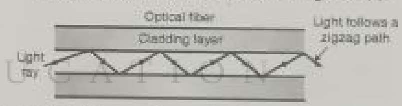
- For data transmission to take place, the sending device that is the transmitter must be capable of inducing data bits 0 to 1 into the light source. At the receiver a photodiode is used to translate this light back into data bits as shown in Fig. 6.4.2.

(G-104) **Fig. 6.4.2**

- The two light sources which are used popularly are :
  1. LED (Light Emitting Diode).
  2. Injection Laser Diode (ILD).
- The LED is cheaper but has a disadvantage that it provides an unfocussed light which hits the core boundaries and gets diffused.
- So LED is preferred only for short distances.
- The laser diode can provide a very focused beam which can be used for a long distance communication.

6.4.2 Principle of Light Propagation in a Fiber :

- The light enters into a glass fiber from one end, and gets reflected within the fiber. It follows a zigzag path along the length of the fiber as shown in Fig. 6.4.3(a).



(a) Light follows a zigzag path within the optical fiber

(b) Reflection at the interface of core and cladding

(G-105) **Fig. 6.4.3**

- Fig. 6.4.3(b) illustrates the principle of light travel through the optical fiber.
- When the light enters into a glass fiber from one end, most of it propagates along the length of the fiber and comes out from the far end.
- A small portion of the incident light escapes through the side walls of the fiber.

- The light which travels from one end to the other end of the glass fiber is said to have "guided" through the fiber.
- The light stays inside the fiber and does not escape through the walls because of the "total internal reflection" taking place inside the fiber.
- This total internal reflection can take place only if the following two conditions are satisfied :
  1. The glass fiber core must have a refractive index which is higher than the refractive index of the cladding around the core ($n_1 > n_2$).
  2. The angle of incidence of the light entering the fiber must be greater than the critical angle "ϕ_c".

$$\sin \phi_c = \frac{n_2}{n_1}$$

This is as shown in Fig. 6.4.3.

Observations from Fig. 6.4.3(b) :

Some of the important observations from Fig. 6.4.3(b) are as follows :

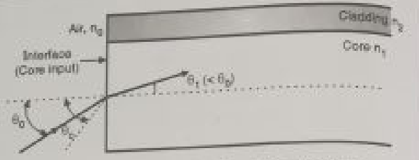
1. The angle of incidence (angle made by the incident ray) i.e. ϕ is greater than the critical angle ϕ_c. Therefore the incident light ray will be reflected within the core totally. The reflected ray is at same angle as that of the incident ray.
2. If the incident light makes an angle which is less than the critical angle ϕ_c then it gets refracted as shown in Fig. 6.4.4. The refracted ray enters into the cladding and gets lost.

(G-106) **Fig. 6.4.4 : Refraction takes place at the core cladding interface if $\phi < \phi_c$**

6.4.3 Relation between Incident Angle and Emerging Angle :

Let us obtain the relation between the incident angle θ_0 and the emerging angle θ_1 by referring to Fig. 6.4.5.

- Assume that the refractive index of air is "n_0" and that of the fiber core is "n_1" such that $n_1 < n_0$.
- As shown in Fig. 6.4.5 the light ray enters the fiber core at an angle θ_0, through the air-core interface. The angle θ_0 is measured between the light ray and the dotted line which is normal to the air-core interface.



(G-107) **Fig. 6.4.5 : Refraction at the interface**

- When the incident light ray enters the core of refractive index, it undergoes refraction and makes an angle θ_1 with the dotted line normal to the air-core interface as shown in Fig. 6.4.5. This angle θ_1 is called as the emerging angle.
- The relation between the incident angle θ_0 and emerging angle θ_1 is given by "Snell's relationship" which states that,

$$n_0 \sin \theta_0 = n_1 \sin \theta_1 \quad ...(6.4.1)$$

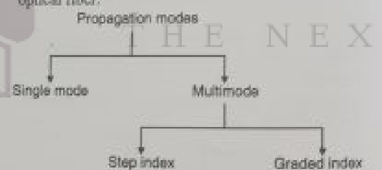
- Therefore the emerging angle θ_1 is given by,

$$\sin \theta_1 = \frac{n_0}{n_1} \sin \theta_0 \quad ...(6.4.2)$$

- As $n_0 < n_1$, $\frac{n_0}{n_1} < 1$ therefore the emerging angle will be less than the angle of incidence θ_0.

6.4.4 Modes of Propagation :

- The number of paths followed by light rays inside the optical cable is called as modes.
- Fig. 6.4.6 shows different modes of operation of an optical fiber.



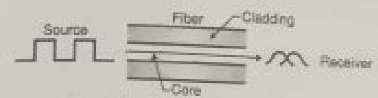
(G-108) **Fig. 6.4.6 : Propagation modes in optical fibers**

- There are two types namely single mode and multimodes fibers.
- In single mode light follows a single path through the core whereas in multimode, the light takes more that one paths through the core.

6.4.5 Single Mode Fibers :

- These are called as single mode fibers because they support on one mode of propagation (TE, TM or TEM).
- The optical signal travelling inside this fiber has only one group velocity.
- Due to single mode travelling, the amount of dispersion is less than that introduced in multimode fibers.

- These fibers can have either step index or graded index profile. They are high quality fibers used for wideband long haul communication and they are fabricated from doped silica to reduce internal attenuation.
- The light travel in a single mode fiber is shown in Fig. 6.4.7. This beam travel's almost horizontally and follows only one path from source to destination, as shown in Fig. 6.4.7. The critical angle of incident highly focused light beam is nearly equal to 90°.
- In the single mode fibers the delays are negligible and the signal reconstruction at the receiver is easier which results in almost no signal distortion.

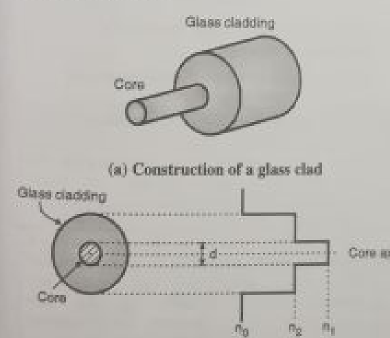


(G-109) **Fig. 6.4.7 : Single mode fiber**

6.4.6 Multimode Fibers :

- These are called as multimode fibers because they support simultaneous propagation of many modes and the incident light follows different paths from the source to destination.
- Each mode has its own group velocity and each mode will follow its own path while travelling from the transmitter to receiver.
- Due to presence of more than one modes, the intermodal dispersion will exist.
- Multimode fibers can have the step index or graded index profile and they are fabricated using the multicomponent glasses or doped silica.

Step index fibers :



(a) Construction of a glass clad

(b) Cross sectional view **(c) Index profile core type fiber**

(G-110) **Fig. 6.4.8**

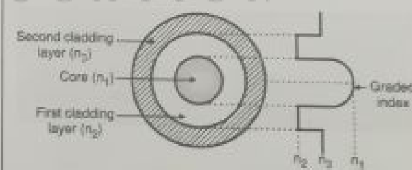
- The construction of an optical fiber with a core and glass cladding is as shown in Fig. 6.4.8(a).
- The refractive index of the core is n_1 and that of the glass cladding is n_2, with $n_1 > n_2$. Therefore the index profile of glass clad core fiber is as shown in Fig. 6.4.8(c).
- Due to the sudden change in refractive index at the boundary of core and cladding, this fiber is called **step index** fiber.
- Fig. 6.4.9 illustrates the propagation of light over a step index fiber.
- Multiple beams will follow different zigzag paths as shown in Fig. 6.4.9. The number of reflections that a beam undergoes, depends on the angle of incidence of that beam.

(G-111) **Fig. 6.4.9 : Multimode step index fiber**

- Hence, at the destination, all the beams do not reach simultaneously. This leads to diffusion of signal at the receiver.
- The step index multimode fibers are therefore not used for long distance communications.

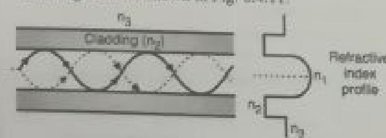
Graded index fibers :

- As shown in Fig. 6.4.10, the refractive index of the fiber core does not remain constant throughout its bulk.
- Instead it is maximum at the center of the core and reduces gradually towards the walls of the core. In order to get this type of index profile the material in the fiber core is modified.



(G-112) **Fig. 6.4.10 : Refractive index profile of a graded index fiber**

- Due to the modification in the index profile, the light gets refracted inside the fiber core and does not travel in straight line as shown in Fig. 6.4.11.



(G-113) **Fig. 6.4.11 : Propagation of light in a graded index fiber**

- Instead the light rays are curved towards the center of the core.
- These rays have been launched into the core within the acceptance cone. The acceptance cone of a graded index core is larger than that of the step index core.
- In graded index fibers as well different beams result in different curves or waveforms.

6.4.7 Characteristics of Optical Fiber Cables :

Fiber optic cables have the following characteristics :

1. Fiber optic cabling can provide extremely high bandwidths in the range from 100 Mbps to 2 Gbps because light has a much higher frequency than electricity.
2. The number of nodes which a fiber optic can support does not depend on its length but on the hub or hubs that connect cables together.
3. Fiber optic cable has much lower attenuation and can carry signal to longer distances without using amplifiers and repeaters in between.
4. Fiber optic cable is not affected by EMI effects and can be used in areas where high voltages are passing by.
5. The cost of fiber optic cable is more as compared to twisted pair and co-axial.
6. The installation of fiber optic cables is difficult and tedious.

Note :

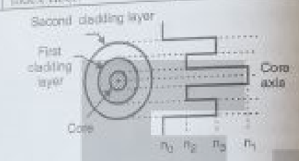
- Three wavelength bands are used for fiber optic communication respectively 850 nanometer, 1300 nanometer, 1550 nanometer.
- Single mode fiber devices are more expensive and more difficult to install than multi-mode devices.
- Fiber optic cable connectors and splice (joint) attenuate the signals.
- Fiber optic cable supports 75 nodes in an Ethernet network.
- Single mode fiber optic cable are used to provide network links of several hundred kilometres in length.
- Fiber optic cable does not leak signals so it is immune to eves dropping (tapping of signals).
- Fiber optic cable does not require a ground, hence it is not affected by potential shifts in the electrical ground, nor does it produce sparks.

6.5 Comparisons :

6.5.1 Comparison of Step Index and Graded Index Fibers :

Table 6.5.1 : Comparison of step index and graded index fibers

Sr. No.	Step index fibers	Graded index fibers
1.	The refractive index changes in steps or abruptly.	The refractive index changes gradually.
2.	The light rays travel in straight line through the step index fibers.	The light rays do not travel in straight line through the graded index fibers.
3.	Index profile : Refer Fig. A	Index profile : Refer Fig. B
4.	The light rays travel in a straight line due to constant refractive index of the fiber throughout the bulk of the core.	The light rays do not travel in straight line due to the continuous refraction. This is due to the continuously changing refractive index throughout the core bulk.
5.	Acceptance cone of these fibers is smaller than that of the graded index fiber.	Acceptance cone of these fibers is larger than that of the step index fiber.



(L-595) Fig. A

(L-595) Fig. B

6.5.2 Comparison of Single Mode and Multimode Fibers :

Table 6.5.2 : Comparison of single mode and multimode fibers

Sr. No.	Single mode fiber	Multimode fiber
1.	These fibers support only one mode of propagation (TE or TM or TEM).	These fibers support the propagation of many modes.
2.	The travelling signal inside the fiber has only one group velocity.	The different modes have different group velocities and each mode will follow its own path between the transmitter and receiver.
3.	The amount of dispersion introduced is less than that introduced in the multimode fibers.	The intermodal dispersion exists due to different group velocities of various modes.
4.	These fibers can have either a step index or graded index profile.	These fibers can have either step index or graded index profile.
5.	These are high quality fiber for wideband long haul transmission and are fabricated from doped silica for reducing the attenuation.	These are fabricated using the multicomponent glasses or doped silica.

6.5.3 Comparison of Optical Fiber with Coaxial and Twisted Pair Cables :

Sr. No.	Twisted pair cable	Co-axial cable	Optical fiber
1.	Transmission of signals takes place in the electrical form over the metallic conducting wires.	Transmission of signals takes place in the electrical form over the inner conductor of the cable.	Signal transmission takes place in an optical form over a glass fiber.
2.	Noise immunity is low. Therefore more distortion.	Higher noise immunity than the twisted pair cable due to the presence of shielding conductor.	Highest noise immunity as the light rays are unaffected by the electrical noise.
3.	Affected due to external magnetic field.	Less affected due to external magnetic field.	Not affected by the external magnetic field.
4.	Short circuit between the two conductors is possible.	Short circuit between the two conductors is possible.	Short circuit is not possible.
5.	Cheapest	Moderately expensive	Expensive
6.	Can support low data rates.	Moderately high data rates	Very high data rates.
7.	Power loss due to conduction and radiation.	Power loss due to conduction	Power loss due to absorption, scattering, dispersion and bending.
8.	Low bandwidth	Moderately high bandwidth	Very high bandwidth
9.	Node capacity per segment is 2	Node capacity per segment is 30 to 100	Node capacity per segment is 2.
10.	Attenuation is very high	Attenuation is low	Attenuation is very low.
11.	Installation is easy	Installation is fairly easy	Installation is difficult.
12.	Electromagnetic interference (EMI) can take place	EMI is reduced due to shielding	EMI is not present.

6.6 Advantages and Disadvantages of Fiber Optical Fibers :

6.6.1 Advantages of Optical Fibers :

Some of the advantages of fiber optic communication over the conventional means of communication are as follows :

1. **Small size and light weight :**
   The size (diameter) of the optical fibers is very small (it is comparable to the diameter of human hair). Therefore a large number of optical fibers can fit into a cable of small diameter.
2. **Easy availability and low cost :**
   The material used for the manufacturing of optical fibers is "silica glass". This material is easily available. So the optical fibers cost lower than the cables with metallic conductors.
3. **No electrical or electromagnetic interference :**
   Since the transmission takes place in the form of light rays the signal is not affected due to any electrical or electromagnetic interference.
4. **Large bandwidth :**
   As the light rays have a very high frequency in the GHz range, the bandwidth of the optical fiber is extremely large. This allows transmission of more number of channels. Therefore the information carrying capacity of an optical fiber is much higher than that of a co-axial cable.
5. **Other advantages :**
   In addition to the advantages discussed earlier, the optical fiber communication has the following other advantages :
   - No cross-talk inside the optical fiber cable.
   - Signals at higher data rates can be sent.
   - Intermediate amplifier are not required as the transmission losses in the fiber are low.
   - Ground loops are absent.
   - Installation is easy as the fiber optic cables are flexible.

– These cables are not affected by the drastic environmental conditions. Because of all these advantages the optical fiber cable is replacing the conventional metallic conductor cable rapidly in many areas.

6.6.2 Disadvantages of Optical Fibers :

Some of the disadvantages of optical communication system are :

1. Sophisticated plants are required for manufacturing optical fibers.
2. The initial cost incurred is high.
3. Joining the optical fibers is a difficult job.

6.6.3 Applications :

1. Optical fiber transmission systems are widely used in the backbone of networks.
2. Optical fibers are now used in the telephone systems.
3. In the Local Area Networks (LANs).

Review Questions

Q. 1 Name the layer which is associated with the transmission media.

Q. 2 Explain the classification of transmission media.

Q. 3 What is the difference between guided and unguided transmission media ?

Q. 4 State the types of guided media.

Q. 5 Explain the difference between UTP and STP.

Q. 6 What is the effect of twisting the wires in UTP cables ?

Q. 7 Give applications of co-axial cable.

Q. 8 What is the advantage of using shielding ?

Q. 9 Compare the guided transmission media.

Q. 10 State advantages of optical fiber cable.

Q. 11 State the three ways of wireless transmission.

Q. 12 Write a note on microwave communication.

Q. 13 State the applications of microwave communication.

Q. 14 Write a note on : Infrared transmission.

Q. 15 State applications of infrared transmission.

Q. 16 Compare twisted pair (UTP and STP).

Q. 17 Compare twisted pair, co-axial and fiber optic cable.

□□□

CHAPTER 7

Unit II

Switching

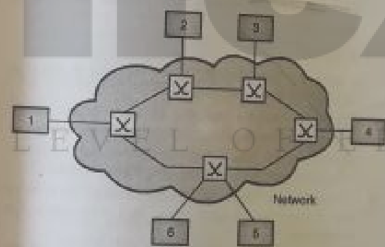
Syllabus :
Three methods of switchings, Circuit switched networks, Packet switching.

7.1 Introduction :

– A network consists of many switching devices. In order to connect multiple devices, one solution could be to have a point to point connection between each pair of devices. But this increases the number of connections.

– The other solution could be to have a central device and connect every device to each other via the central device (Star topology).

– Both these methods are wasteful and impractical for very large networks. The other topologies also cannot be used.



(L-616) **Fig. 7.1.1 : Switched network**

– Hence a better solution is **switching**. A switched network is made of a series of interconnected nodes called switches.

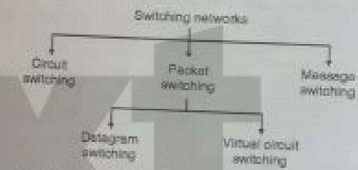
– Switch is a device that creates temporary connections between two or more devices. Fig. 7.1.1 shows a switched network.

7.2 Switching Methods :

– The three basic methods of switching are :
  1. Circuit switching
  2. Packet switching
  3. Message switching

– Out of these, the circuit and packet switching are commonly used today but the message switching has been phased out in general communication but is still used in the networking applications.

– Fig. 7.2.1 shows the classification of switching methods.



(L-617) **Fig. 7.2.1 : Classification of switching methods**

7.3 Circuit Switching Networks :

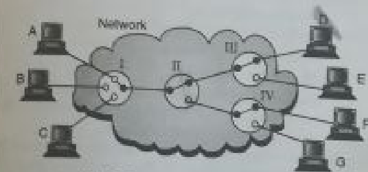
– Circuit switching is used in public telephone networks. It was developed to handle voice traffic but it can also handle digital data.

– However circuit switching cannot handle digital data efficiently.

– Using the circuit switching, a dedicated path is established between two stations for communication.

– The telephone network provide telephone service which involves the two way, real-time transmission of voice signals across a network.

– The network connection allows electrical current and the associated voice signal to flow between the two users. The end to end connection is maintained for the duration of the call.



(L-618) **Fig. 7.3.1 : Circuit-switched network**

– The telephone networks are connection oriented because they require the setting up of a connection before the actual transfer of information can take place.