Transmission Media.

Transmission media actually provides path. b/w Tx & Rx for communication and are located below the physical layer and are directly controlled by physical layer and can be said as zeroth layer.

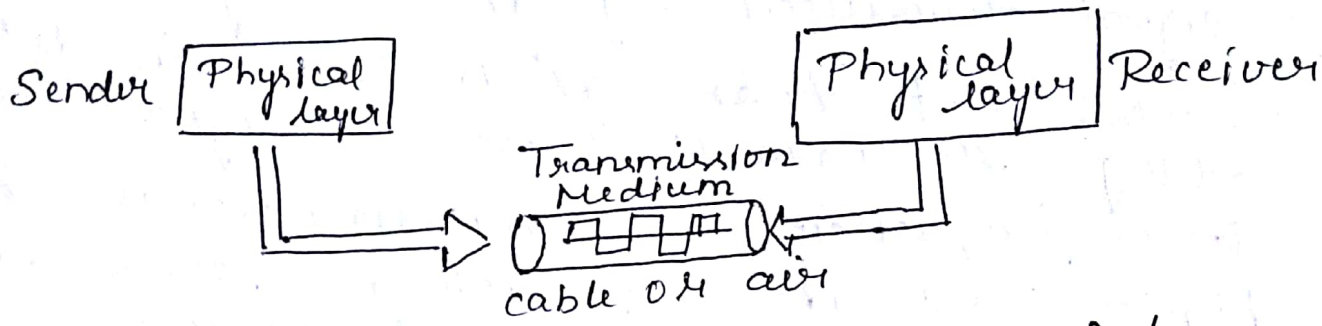
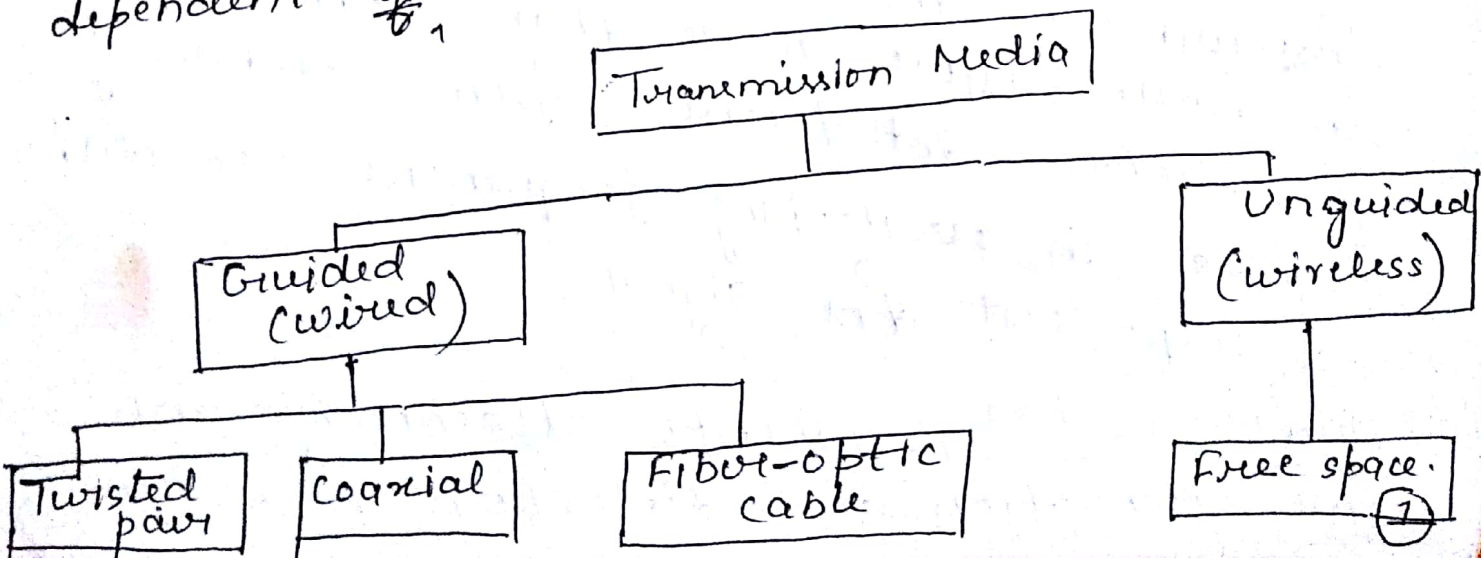


Fig: Transmission medium & Physical Layer.

For data communication the transmission media may be free space, metallic cable, or fiber-optic cable. The information is usually a sign-al that is the result of a conversation of a data from another form.

Long distance communication using electrical signals started with the invention of the telegraph by Morse in 19th century. communication by telegraph was slow and dependent on a metallic medium.



The characteristic and quality of data transmission are determined both by the characteristics of the medium and the characteristics of the signal. In the case of guided media, medium itself is more important in determining the limitations of tx^n.

For unguided medium, the BW of the signal produced by the txing antenna is more imp than tx^n medium in determining tx^n characteristics. Signals at lower frequencies are omnidirectional: At higher freqn it is possible to focus the signal into a directional beam.

For designing data tx^n system data rate and distance are key terms. The greater the data rate, better the distance.

Design factors related to data rate and distance.

Bandwidth: Greater the BW, the higher the data rate can be achieved.

Transmission impairments: Attenuation limits the distance. Twisted pair suffers more impairment than coaxial cable, which in turn suffers more than optical fiber.

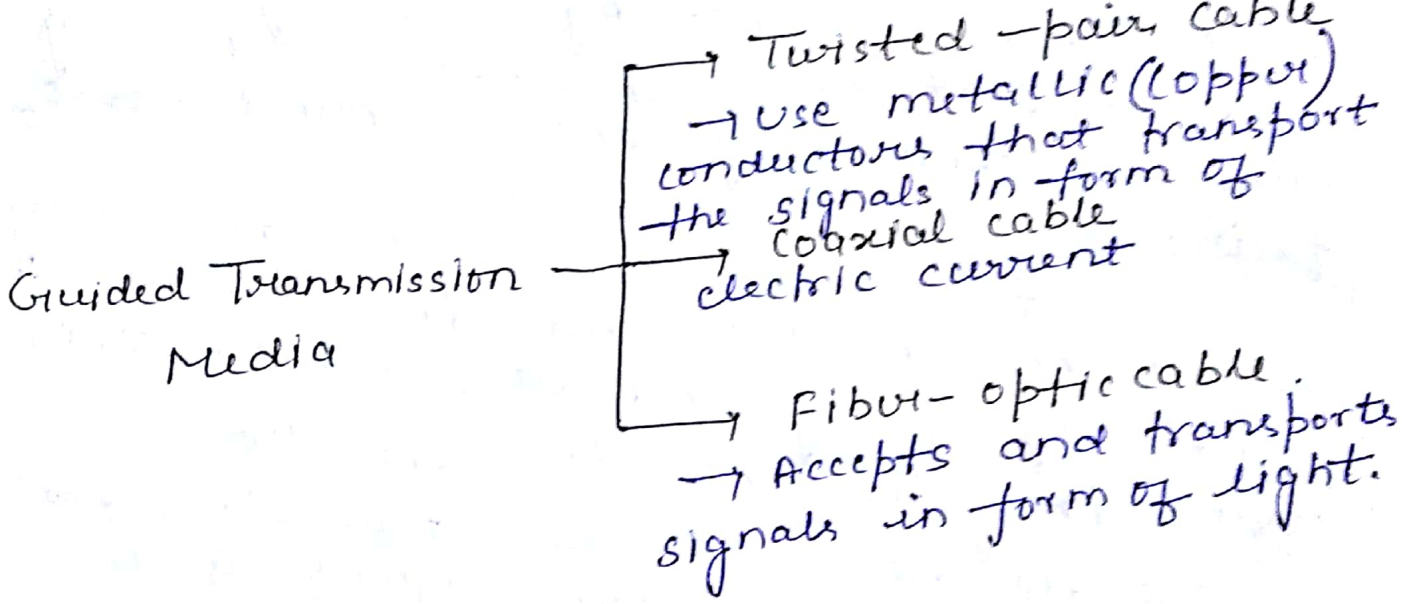
Interference: Interference from competing signals in overlapping frequencies can distort or wipe out a signal.

Number of Rxs - Multiple attachment introduce some attenuation and distortion on the line.

limiting distance or/and data rate.

Guided Transmission Media-

Provides channel from one device to another device for communication. A signal travelling along any of these media is directed and contained by the physical limits of the medium. For guided media the txn capacity (data rate or bandwidth) depends critically on the distance and on whether the medium is point-to-point or multipoint.



Twisted-Pair cable- least expensive and most widely used transmission medium is twisted pair.

Physical Description:- consists of two insulated copper wires, arranged in a regular spiral pattern. A wire pair acts as a single communication link.

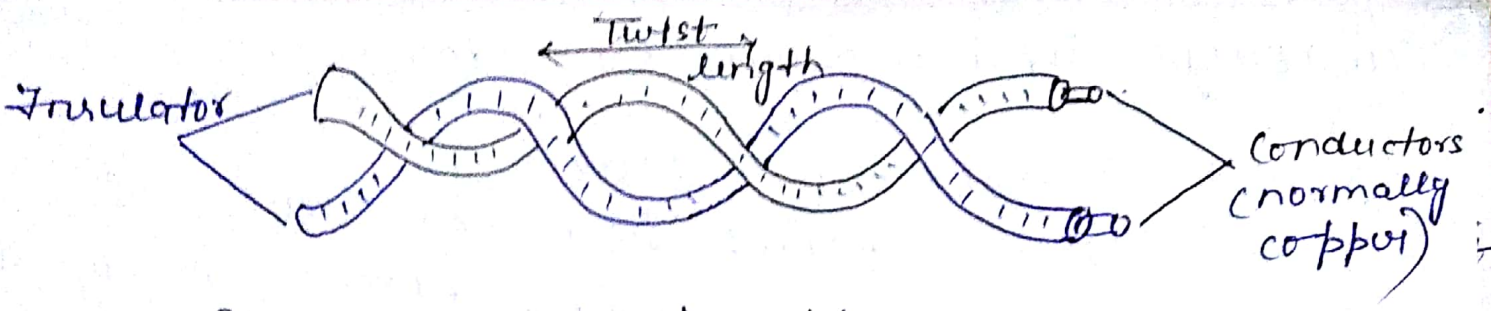


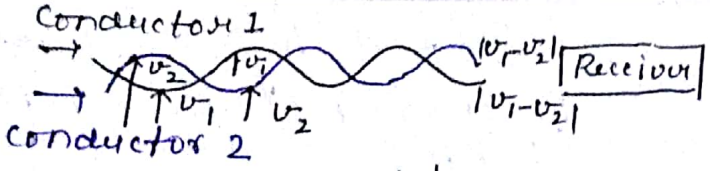
Fig: Twisted Pair cable

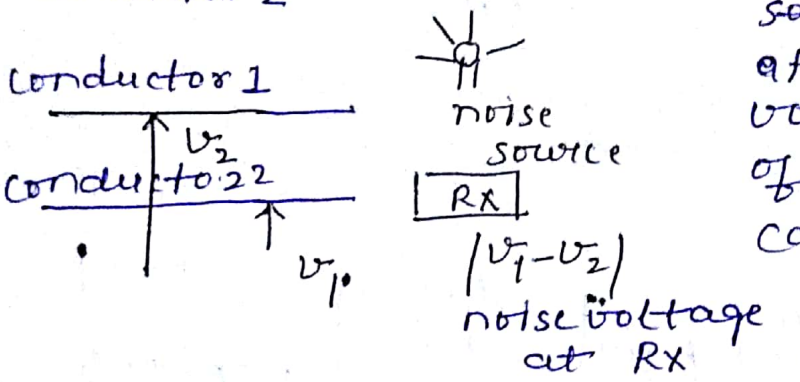
— Separately insulated
— Twisted together
— often "bundled" into cable
— Usually installed in building during construction.

A number of these pairs are bundled together into a cable by wrapping them in a tough protective sheath. Over long distances cable may contain hundreds of pairs

One of the wires is used to carry signals to the RX, and the other is used only as a ground reference. The RX uses the difference b/w the two.

If the two wires are parallel, the effect of these unwanted signals is not the same in both the wires. because they are at different locations relative to the noise or crosstalk sources. (e.g. one is closer and other is farther). The results in a difference at the RX. By twisting the pairs, a balance is maintained.





noise voltage at RX

At the RX, it takes difference of two wires. so, the two wires, affected by same noise voltage. So, the effect of noise at the RX gets cancelled.

Thus number of twist per unit length (e.g. inch) has some effect on the quality of cable. On long-distance links, the twist length typically varies from 5 to 15 cm. The wires in a pair have thickness of from 0.4 to 0.9mm.

Twisted-pair comes in two varieties - unshielded and shielded

Unshielded twisted-pair (UTP) cable :- UTP is ordinary telephone wire and least expensive of all the transmission media commonly used for local area n/ws and is easy to work with and easy to install. UTP is subject to external electromagnetic interference, including interference from nearby twisted pair and from noise generated in the environment.

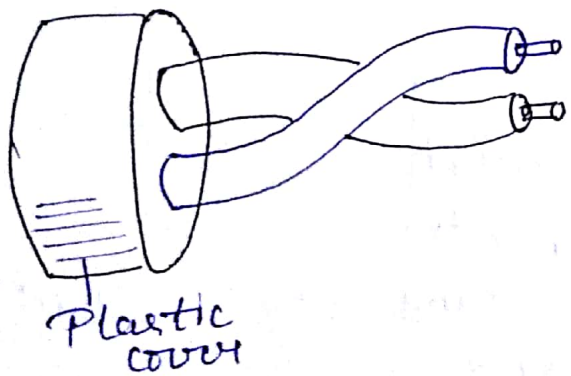


Fig: UTP (Unshielded twisted pair)

Categories of UTP :— (Standard Developed by Electronic Industries Association (EIA))

Table : Categories of UTP cables

Category	Specification	Data Rate (Mbps)	Use
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T-lines	2	T-1 lines
3.	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring Networks	20	LANS
5.	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANS
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANS
6	A new category with matched components coming from the same manufacturer and cable must be tested at a 200-Mbps data rate.	200	LANS

7	sometimes called SSTP (shielded screen twisted-pair). Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield. In addition to the outside sheath. The shield decrease the effect of crosstalk and increases the data rate	600	LANs.

Table: Twisted Pair categories and classes

	Category 3 Class C	Category 5 Class D	Category 5E	Category 6 Class E	Category 7 Class F
Bandwidth	16 MHz	100 MHz	100 MHz	200 MHz	600 MHz
Cable Type	UTP	UTP/FTP	UTP/FTP	UTP/FTP	SSTP
Link cost cat5 = 1	0.7	1	1.2	1.5	2.2

UTP = Unshielded twisted pair
FTP = Foil twisted pair
SSTP = Shielded screen twisted pair

Applications -

1. The most common guided transmission medium for both analog and digital signals.
2. Popularly use for communication within buildings.
3. Used to connect residential telephone sets to the local exchange (end office) and referred to as subscriber loops.
4. UTP were designed to support voice traffic using analog signalling but using modem these facilities can handle data traffic at modest data rates.
5. Most common medium for digital signalling.
6. Use for connections to digital data switch or PBX within a building with a common data rate of 64 kbps.
7. In LANs supporting personal computers with typical data rate of 100 Mbps. (10 Gbps has also been developed but quite limited in terms of no. of devices and geographic scope of the n/w. For long distances it can be used upto 4 Mbps or more.
8. Less expensive and easy to use commonly used guided transmission media in comparison to other guided transmission media like (coaxial cable, optical fiber)

Transmission characteristics:—

1. Used both for analog and digital transmission.
   For analog signals amplifiers are required about every 5 to 6 Km and for digital txn repeaters are required every 2 or 3 Km.

2. Limited in BW, distance and data rates.

3. Attenuation is a strong fn of freqn.

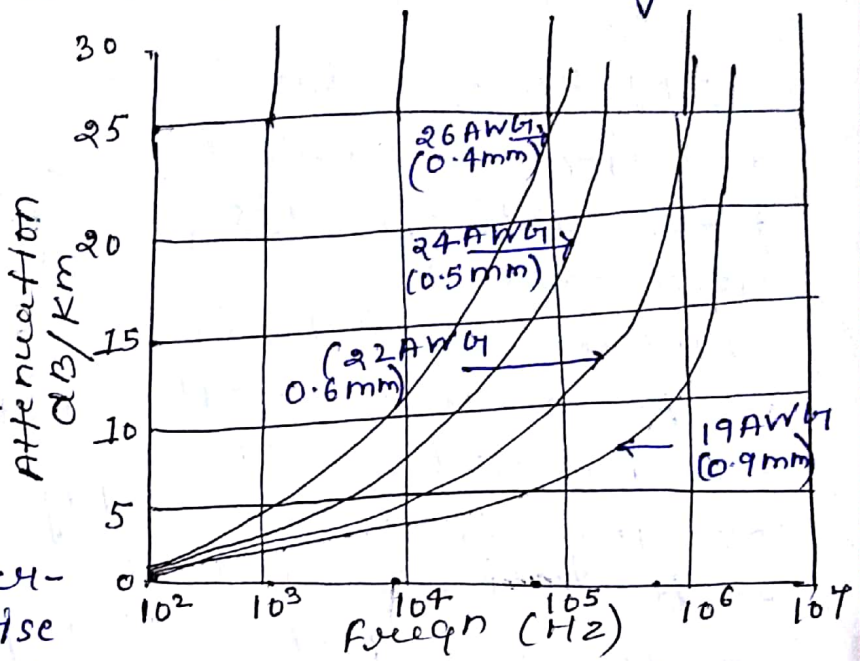


Fig a) Twisted pair transmission characteristic

4. Medium is quite susceptible to interference and noise bcoz of easy coupling with EM signals. (fields)

5. Impulse noise easily intrudes into TP.

6. Shielding the wire with metallic braid or sheathing reduces interferences.

7. The twisting of the wire reduces low-freqn interference, and the use of different twist lengths in adjacent pairs reduces crosstalk.

8. For P2P analog signaling, a BW of upto about 1MHz is possible. This accomodates a number of voice channels.

9. For long distance digital P2P signalling, data rates only upto few Mbps is possible.

10: For very short distances, data rate upto 10 Gbps have been achieved in commercially available products.

Shielded Twisted-Pair :—

IBM has produced a version of twisted-pair cable for its used called 'shielded-twisted-pair'. It has a metal foil or braided mesh covering that encases each pair of insulated conductors. Metal casing improves the quality of cable by preventing the penetration of noise or crosstalk. It is bulkier and more expensive. STP is often generally used within IBM.

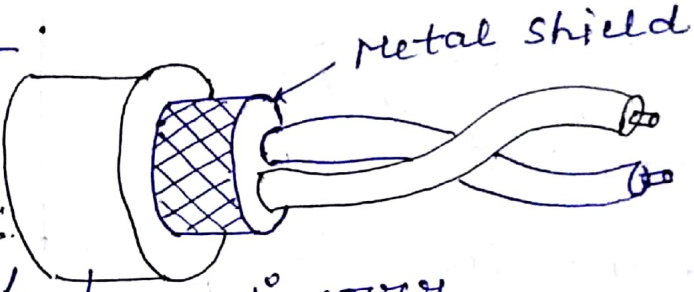


Fig: Unshielded Twisted-Pair cable.

"Gauge is the measure of thickness of the wire."

Connectors :— The most common UTP connector is RJ45 (RJ stands for standard jack). The RJ45 is a keyed connector, means the connector can be inserted in only one way.

	Attenuation (dB per 100m)			Near-End Crosstalk (dB)		
Freqn (MHz)	Cat 3 UTP	Cat 5 UTP	150-ohm STP	Cat 3 UTP	Cat 5 UTP	150-ohm STP
1	2.6	2.0	1.1	41	62	58
4	5.6	4.1	2.2	32	53	58
16	13.1	8.2	4.4	23	44	50.4
25	—	10.4	6.2	—	41	47.5
100	—	22.0	12.3	—	32	38.5
300	—	—	21.4	—	—	31.3

Table: Comparison of Shielded and Unshielded Twisted pair

Coaxial cable:—

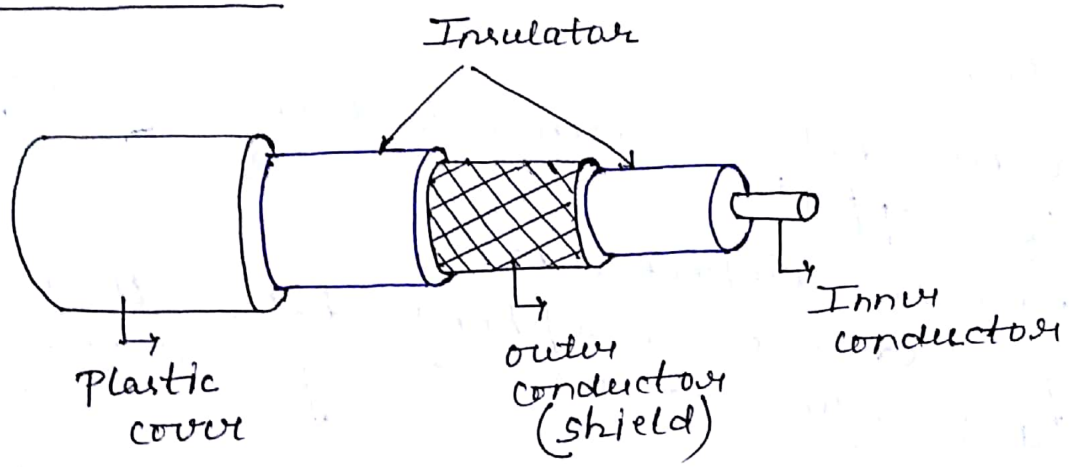
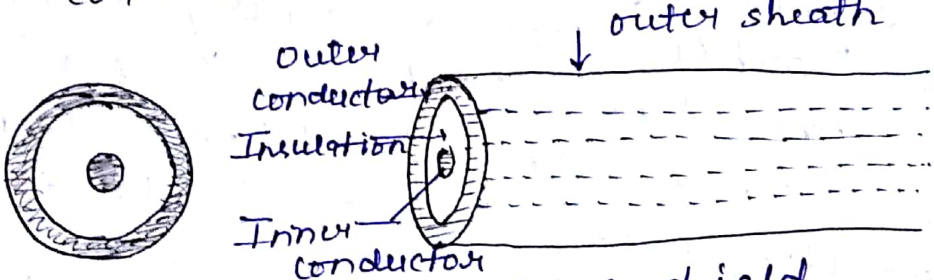


Fig: Coaxial Cable



- Outer conductor is braided shield
- Inner conductor is solid metal
- separated by insulating material
- covered by padding

coaxial cable has a central core conductor of solid or standard wire (usually copper) enclosed in an insulating sleath, which is in turn, encased in an outer conductor of metal foil, braid, or a combn. of the two. The outer metallic wrapping serves both as a shield against noise and as a second conductor, which completes the ckt. This outer conductor is also enclosed in an insulating sleath, and the whole cable is protected by a plastic cover. The single coaxial cable has a diameter of from 2.1 to 2.5 cm. coaxial cable can be used over longer distances and support more stations on a shared line than TP.

Applications:—

1. Versatile txn medium, used in a wide variety of applns.
2. Television distribution
3. Long distance telephone txn. A single coaxial n/w could carry 10,000 voice signals.
4. In digital telephone n/ws a single coaxial cable could carry digital data upto 600 Mbps. Nowdays coaxial cable in telephone networks has largely been replaced with Foc.
5. short term computer system links.
6. Local area networks.
7. Cable TV distribution. cable TV uses RG-59 coaxial cable.

8) Long-distance telephone n/w. A coaxial cable can carry 10,000 voice channels simultaneously.

9) Bcoz of its high BW, and high data rate, coaxial cable was chosen for digital txn in early Ethernet LANs.

10 Base-2 → Thin Ethernet → RG-58 coaxial cable with BNC connectors to transmit data at 10 Mbps with a range of 85 m.

10 Base-5 → Thick Ethernet → RG-11 (thick coaxial cable) to transmit 10 Mbps with a range of 5000 m.

coaxial cable standards:-

coaxial cables are categorized by their Radio Government (RG) ratings. Each RG number denotes a unique set of physical specifications, including the wire gauge of the inner cond^{r}, the thickness and type of the inner insulator, the construction of the field, and the size and type of the outer casing. Each cable defined by an RG rating is adapted for a specialized function, as shown in table below:-

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

Table: categories of coaxial cables.

Coaxial cable connectors:—

To connect coaxial cable to devices, we need coaxial connectors. The most ~~common~~ commonly used is Bayone-Neill-Concelman (BNC) connector. Popular types are BNC, BNC-T, BNC terminator.

BNC— used to connect the end of the cable to a device, such as a TV set.

BNC T— used in Ethernet networks to branch out a connection to a computer or to or other devices.

BNC Terminator — used at the end of the cable to prevent the reflection of the signal.

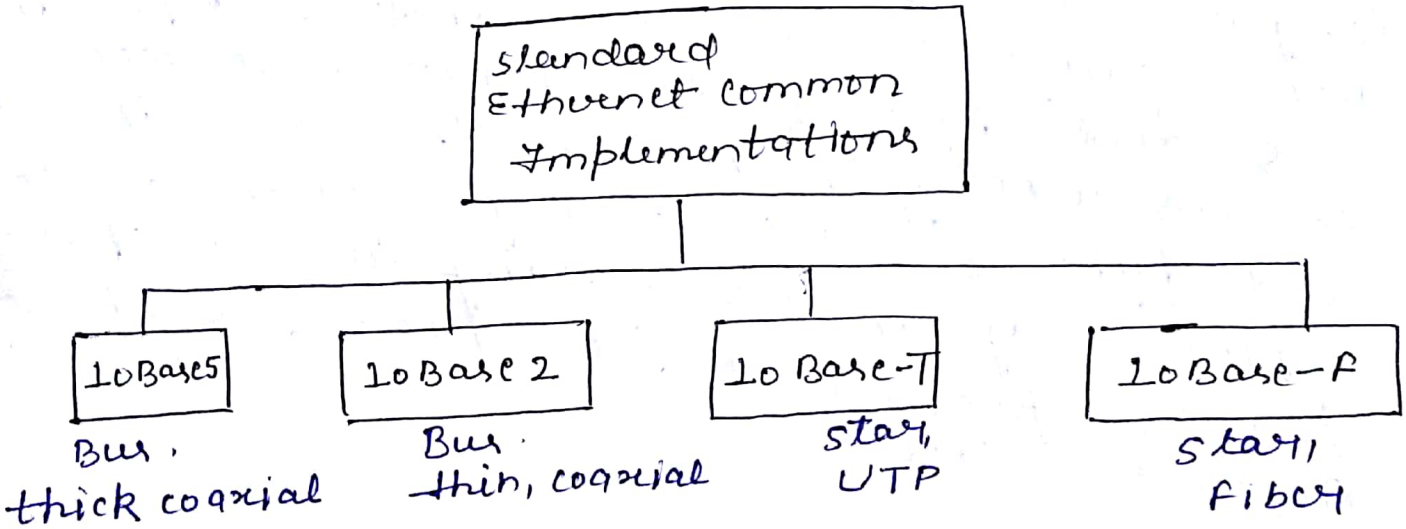
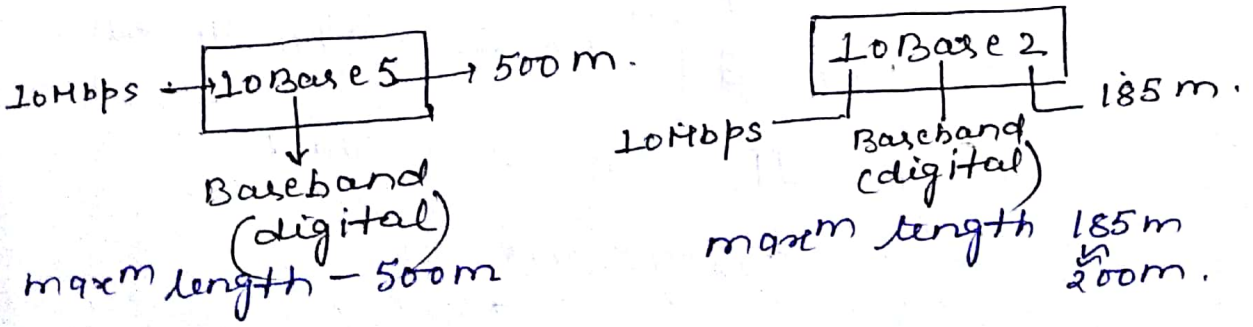
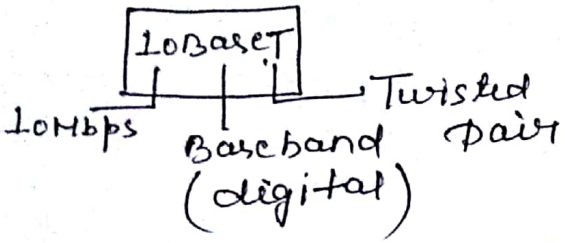


Fig: categories of Standard Ethernet





maxm length 100m.

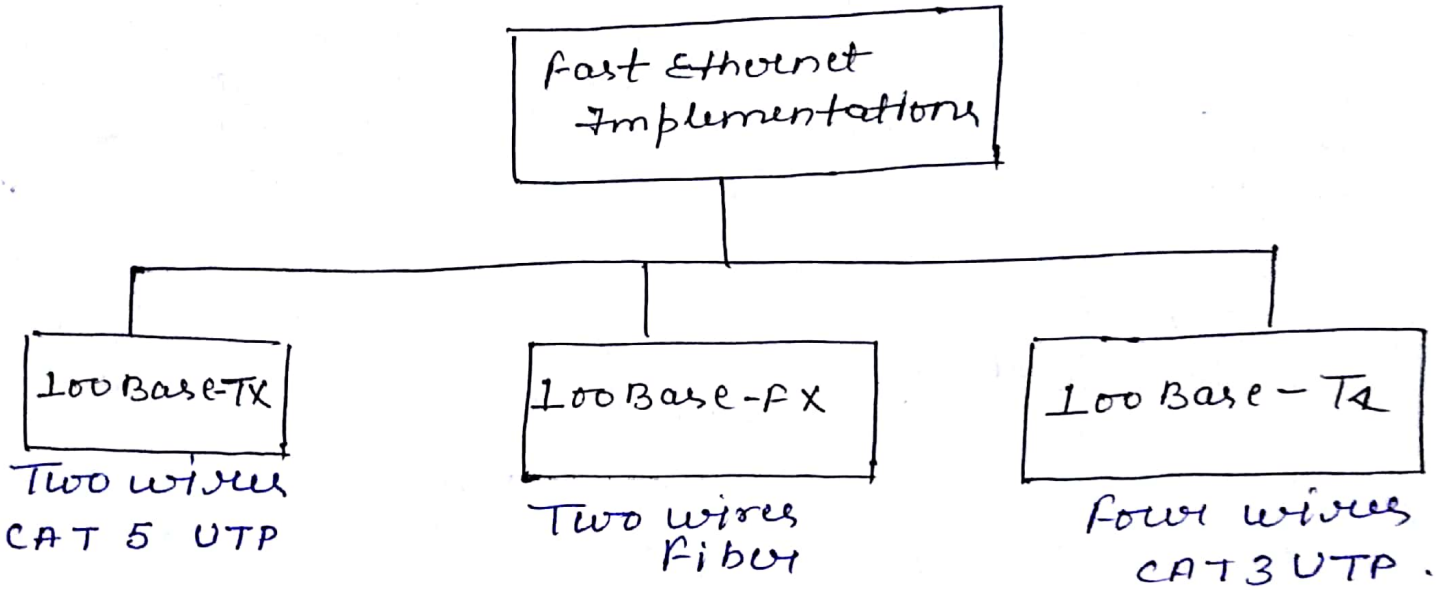


Fig: Fast Ethernet Implementations.

Fiber-Optic Cable A fiber-optic cable is made of glass or plastic and transmits signal in the form of light.

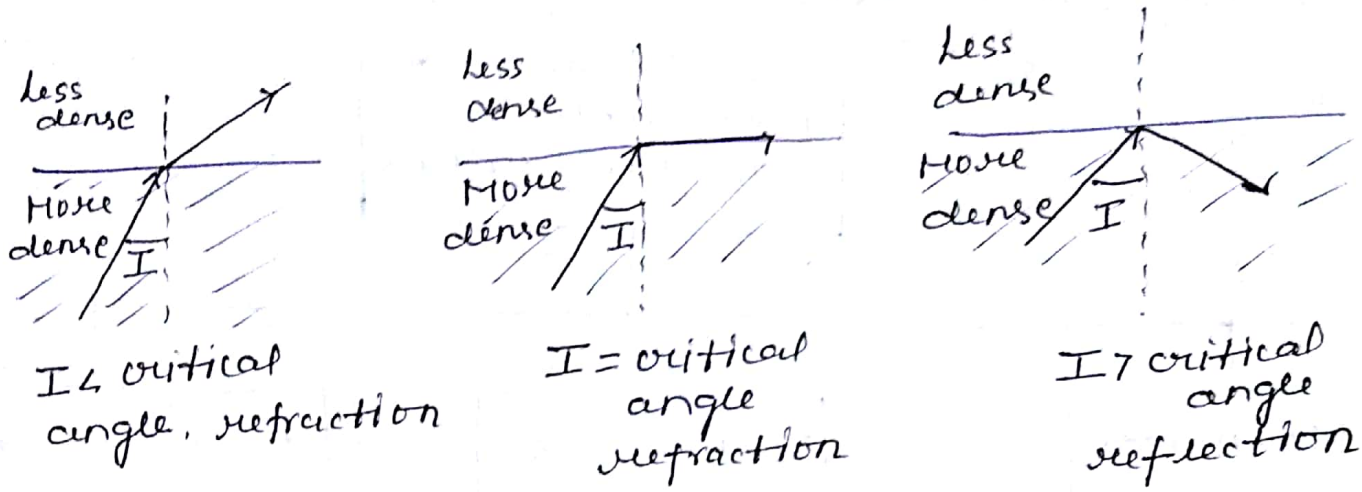


Fig: Bending of light Ray.

critical angle is property of **substance**.

Optical fiber uses total internal reflection to guide light through a channel. A glass or plastic core surrounding 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.

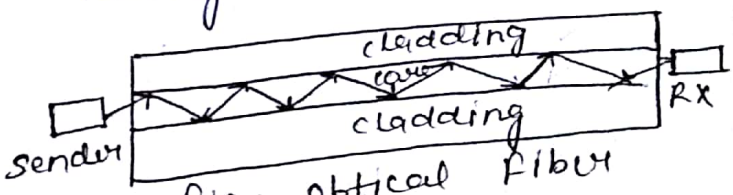


Fig: optical fiber

Propagation modes:—

current technology supports two modes (single mode and multimode) for propagation of light along optical channels, each requiring fiber with different characteristics. Multimode can be implemented in two forms: (step-index or graded-index)

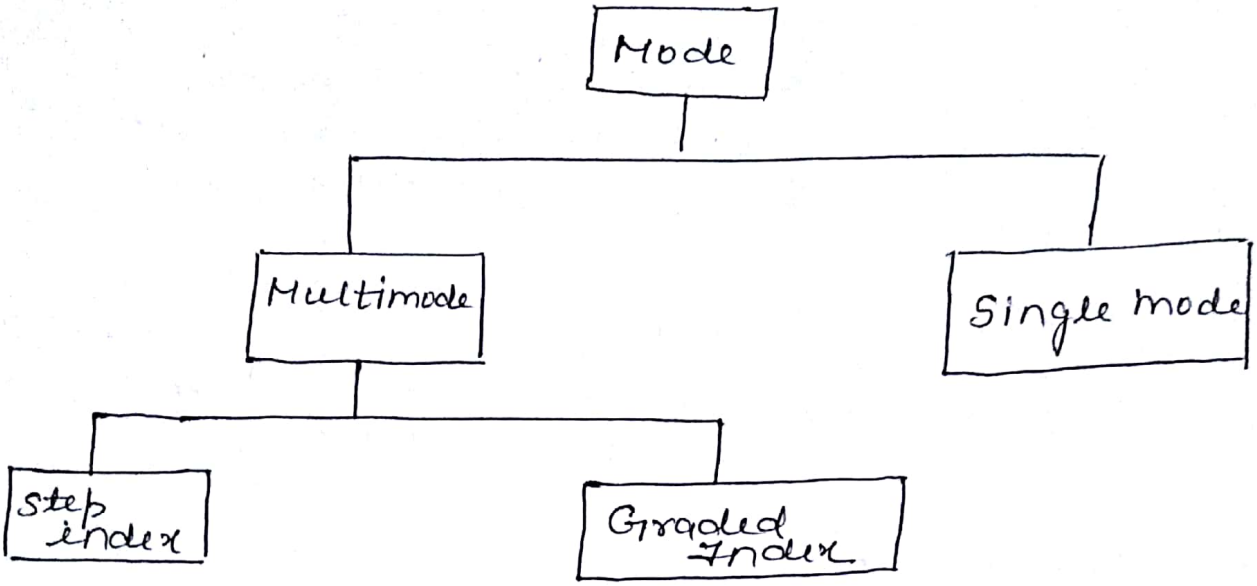


Fig: Propagation modes.

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

Fig: Single mode fiber

Multimode-fiber :-

Multiple beams from a light source move through the core in different paths.

Beam movement within the cable depends on the structure of the core.

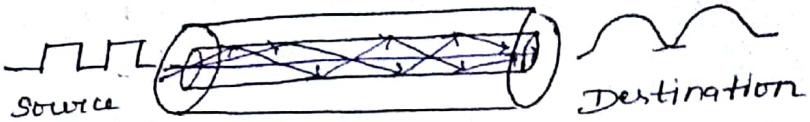


Fig: Multimode, step index

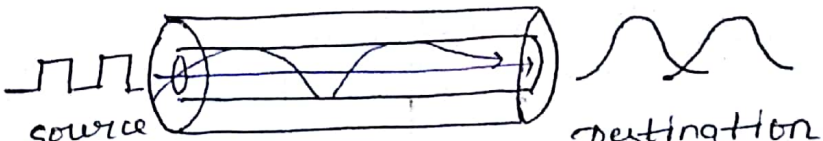


Fig: Multimode, graded index

In MM-step-idex fiber, the density of the core remains constant from the centre to the edge. At the interface of core and cladding, 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 contribute to the distortion of the signal as it passes through the fiber.

In multimode graded-index fiber, density is highest at the centre of the core and decreases gradually to its lowest at the edge. MM-graded-index fiber decreases the distortion of the signal through the cable. The word index refers to the index of refraction.

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

Type	core(um)	cladding (um)	Mode
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	"
100/125	100.0	125	"
7/125	7.0	125	Single mode

Cable composition :-

As shown in adjacent figure, the outer jacket is made of either PVC or Teflon. Inside the jacket are kevlar strands for strengthen the cable. Kevlar is a strong material used in fabrication of bulletproof vests. Below the kevlar is another plastic coating to cushion the fiber. the fiber is at the centre of the cable, and it consists of cladding and core.

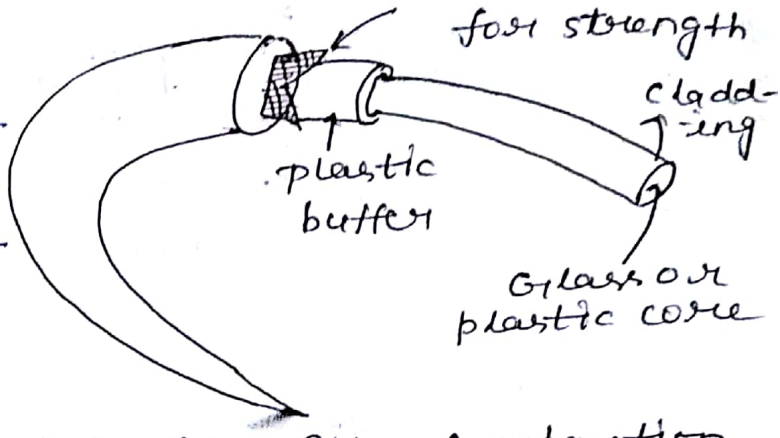


Fig: Fiber construction

Fiber-Optic Cable Connectors :- Three types of connectors for FOC.

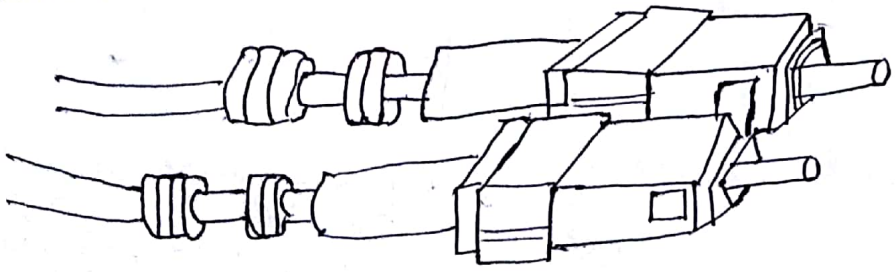


Fig: SC connector

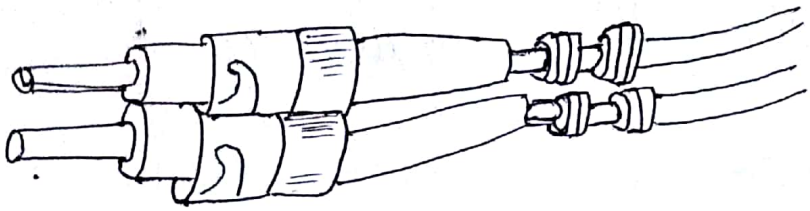
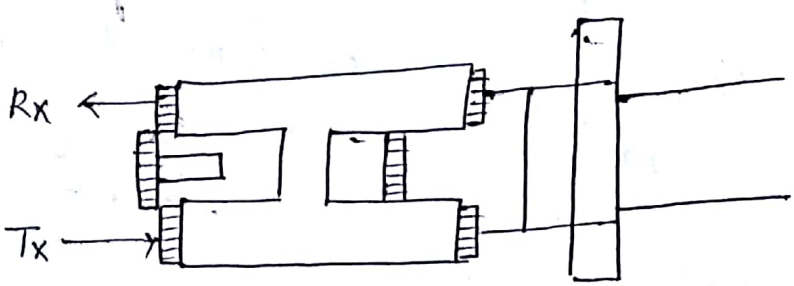


Fig: ST connector



MT-RJ connector

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 connector is same size as RJ45.

Performance

Loss at 1400 nm is maximum. Attenuation is flatter than in case of twisted-pair cable and coaxial cable. we need 10 time less repeater when we use FOC.

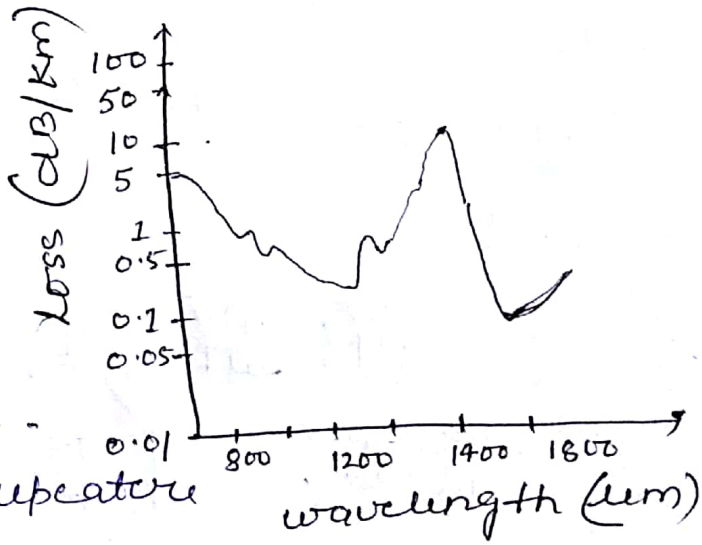


Fig: optical fiber performance

Applications:- FOC is often found in backbone n/ws bcoz its wide BW is cost-effective. Using WDM data at a rate of 1600Gbps can be transferred. The SONET n/w provides such backbone.

Some cable TV companies are a combⁿ of optical fiber and coaxial cable, thus creating a hybrid n/w. FOC provides the backbone structure while coaxial cable provides connections to the user premises. This is the cost-effective configuration since the narrow BW requirement at the user end does not justify the use of FOC.

Local-area n/ws such as 100Base-FX n/w (Fast Ethernet) and 100Base-X also use FOC.

Advantages of FOC:-

1. Higher BW than either twisted-pair or coaxial cable.
2. Less signal attenuation — less no. of repeaters are required, (at 50 kms) while coaxial or twisted pair cables require repeaters at every 5 km.
3. Immunity to electromagnetic interference — ie — EM noise can't effect FOCs.
4. Resistance to corrosive materials. (than copper)

5. Light weight
6. Greater immunity to tapping — copper cables create antenna effects that can easily be tapped.

Disadvantages —

1. Installation and maintenance — require expertise due to being new technology.
2. Unidirectional light propagation — two fibers are needed for bi-directional communication.
3. cost — The cable and interfaces are relatively more expensive than those of other guided media. If the demand of BW is not high, often the use of FOC cannot be justified.