IT-5301-3

Data Communications and Computer Networks

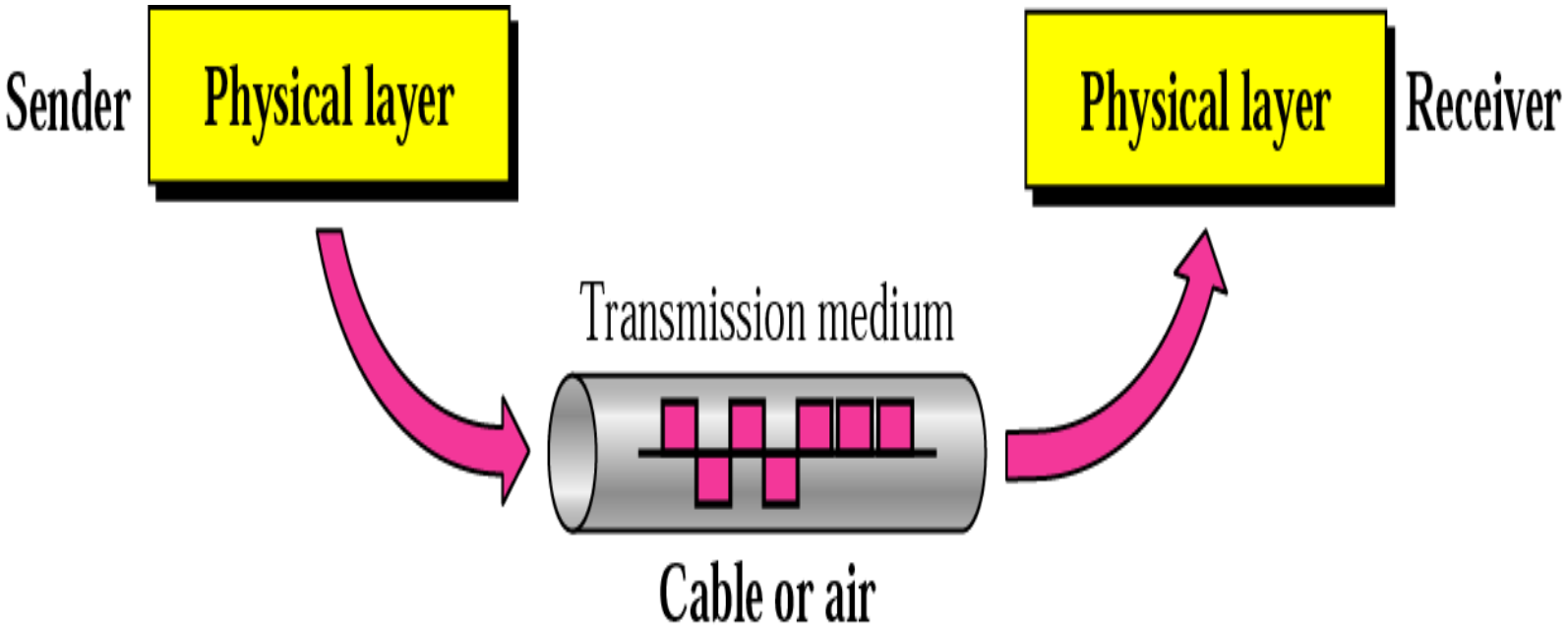
University of Education, Pakistan.

Lecture 08 - Guided Media

Lecture 08 - Roadmap

- Transmission Media
- Introduction
- Design Factors To Select a Media
- Types of Media
  - Guided Media
  - Unguided Media
- Guided Transmission Media
  - Twisted Pair
  - Coaxial Cable
  - Fiber Optics

Transmission Medium and Physical Layer



Introduction

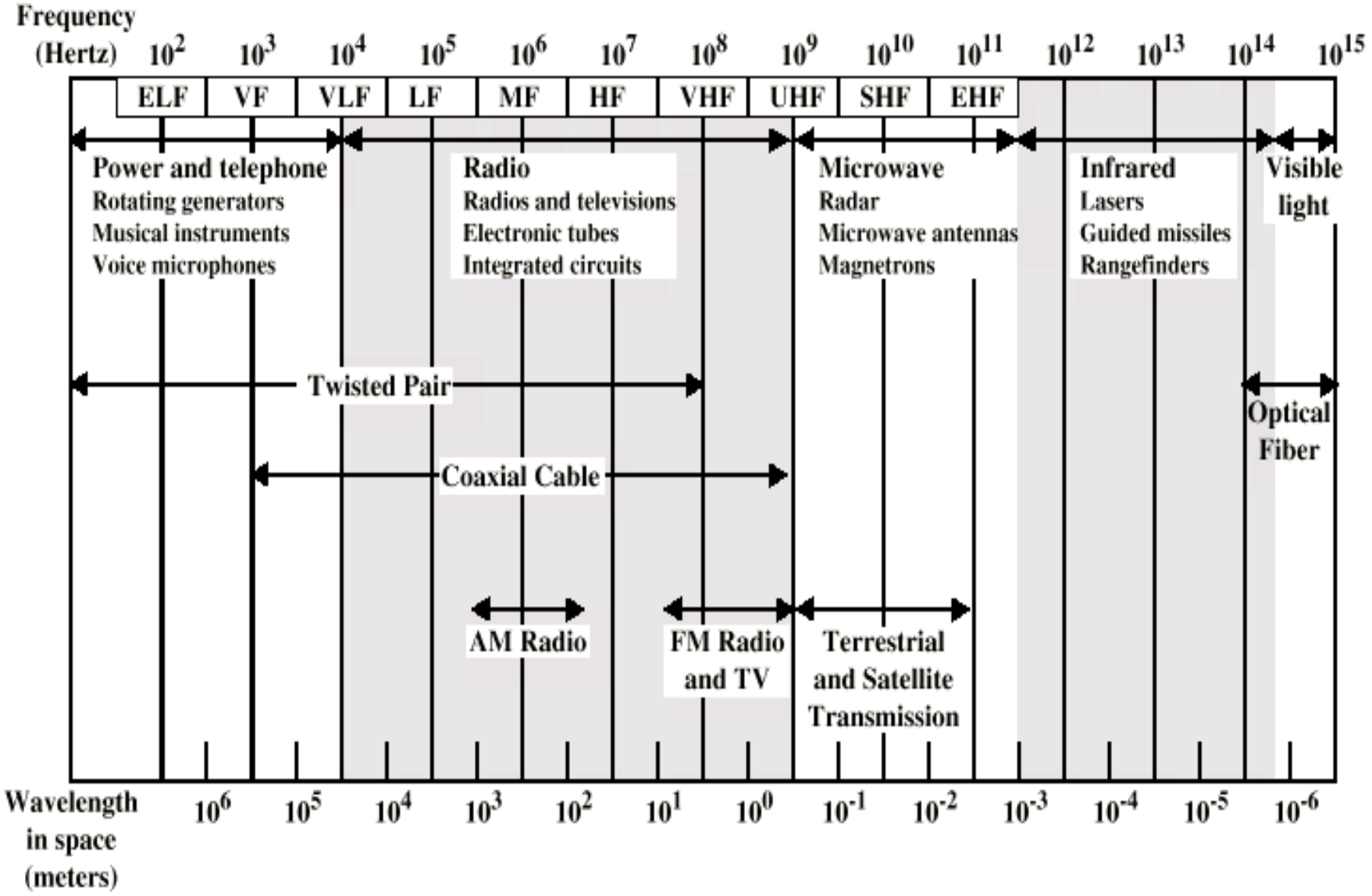
- The world of computer networks and data communications would not exist if there were no medium by which to transfer data.
- The two major categories of media include:
  - Guided Media
  - Unguided Media

Overview

- Characteristics and quality determined by medium and signal
- For guided, the medium is more important
- For unguided, the bandwidth produced by the antenna is more important
- Key concerns are data rate and distance

Design Factors

- Bandwidth
  - Higher bandwidth gives higher data rate
- Transmission impairments
  - Attenuation
- Interference
- Number of receivers
  - In guided media



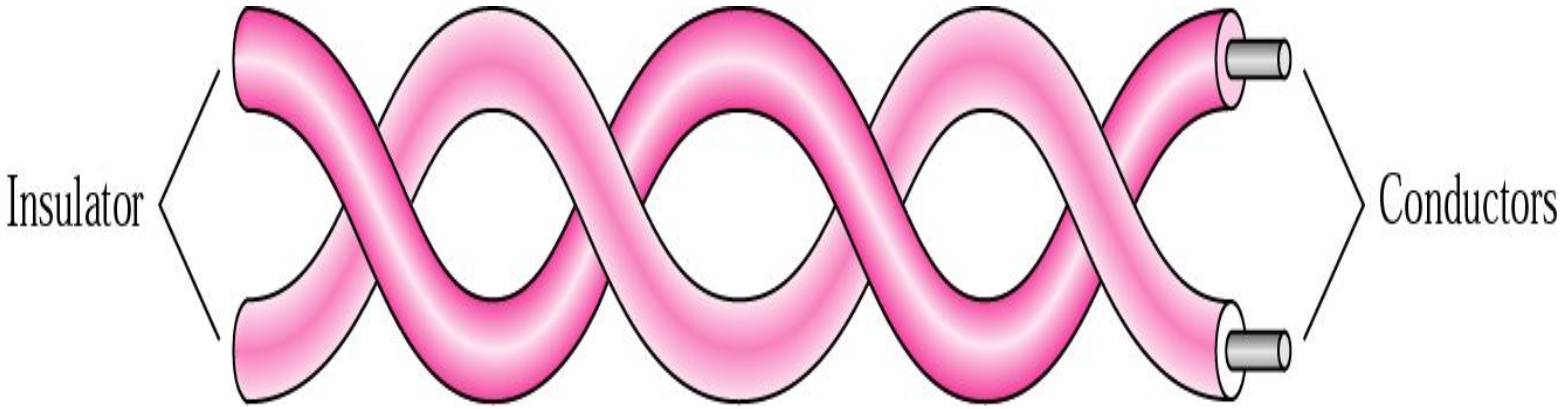
ELF = Extremely low frequency
VF = Voice frequency
VLF = Very low frequency
LF = Low frequency
MF = Medium frequency
HF = High frequency
VHF = Very high frequency
UHF = Ultrahigh frequency
SHF = Superhigh frequency
EHF = Extremely high frequency

Guided Transmission Media

- Guided media, which are those that provide a conduit from one device to another, included
- Twisted Pair
- Coaxial cable
- Optical fiber

Twisted Pair

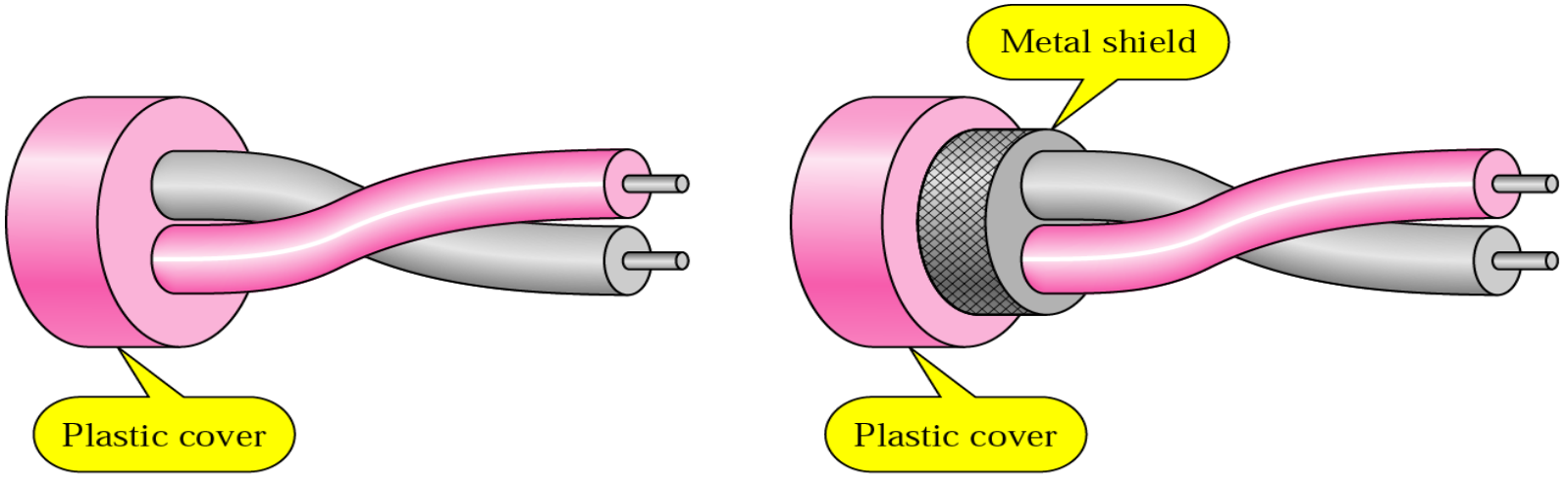
A twisted pair consists of two conductors (normally Copper), each with its own plastic insulation, twisted together. One wire is used to carry signal while other one is used as a reference.



Unshielded and Shielded TP

- **Unshielded Twisted Pair (UTP)**
  - Ordinary telephone wire
  - Cheapest
  - Easiest to install
  - Suffers from external Electro-magnetic interference
- **Shielded Twisted Pair (STP)**
  - Metal braid or sheathing that reduces interference
  - More expensive
  - Harder to handle (thick, heavy)

UTP and STP



a. UTP

b. STP

Categories of unshielded twisted-pair cables

Category	Bandwidth	Data Rate	Digital/Analog	Use
1	very low	< 100 kbps	Analog	Telephone
2	< 2 MHz	2 Mbps	Analog/digital	T-1 lines
3	16 MHz	10 Mbps	Digital	LANs
4	20 MHz	20 Mbps	Digital	LANs
5	100 MHz	100 Mbps	Digital	LANs
5e	100 MHz	100/1000 Mbps	Digital	LANs
6	250 MHz	1000 Mbps	Digital	LANs
6a	500 MHz	10 Gbps	Digital	LANs

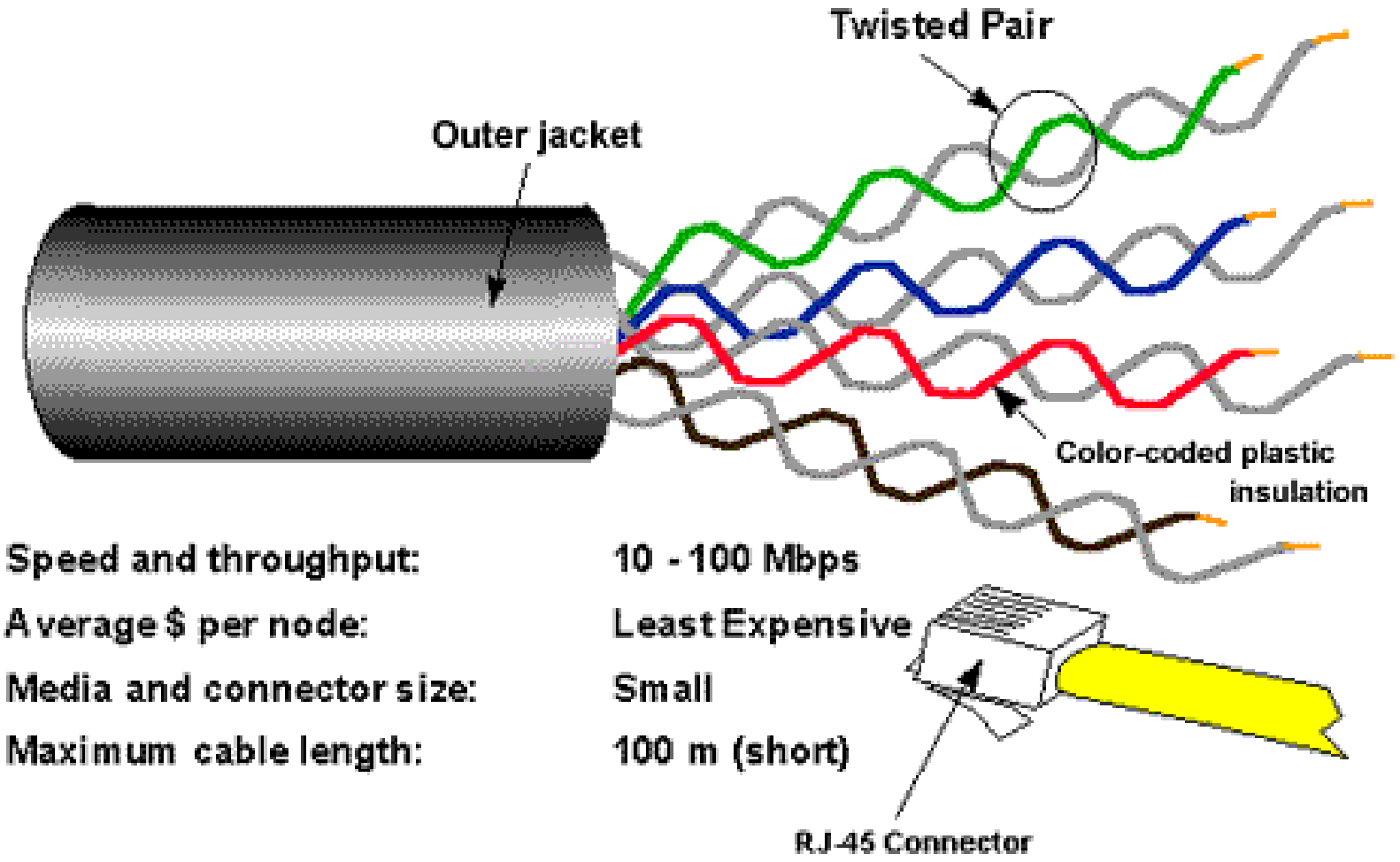
Cat3 vs Cat5

- Key difference is number of twists
- Cat5 is much more tightly twisted
- Twist length of 0.6 to 0.85 cm, compared to 7.5 to 10 cm of Cat3
- Tighter twisting of Cat5 is more expensive but provides much better performance then Cat3

Note:

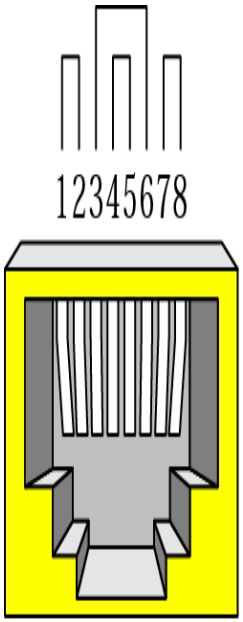
Two conductors are twisted together for the purposes of canceling out electromagnetic interference (EMI) from external sources

Unshielded Twisted Pair (UTP)

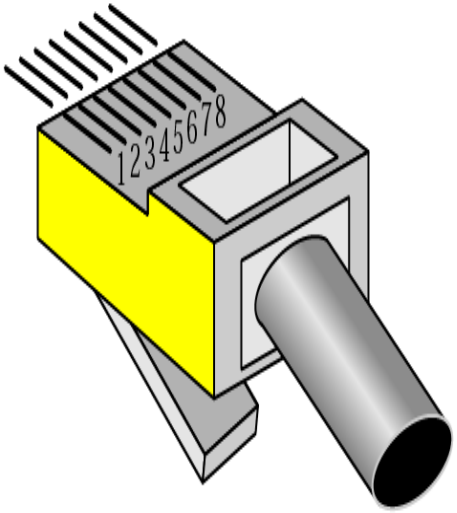


Speed and throughput:	10 - 100 Mbps
Average $ per node:	Least Expensive
Media and connector size:	Small
Maximum cable length:	100 m (short)

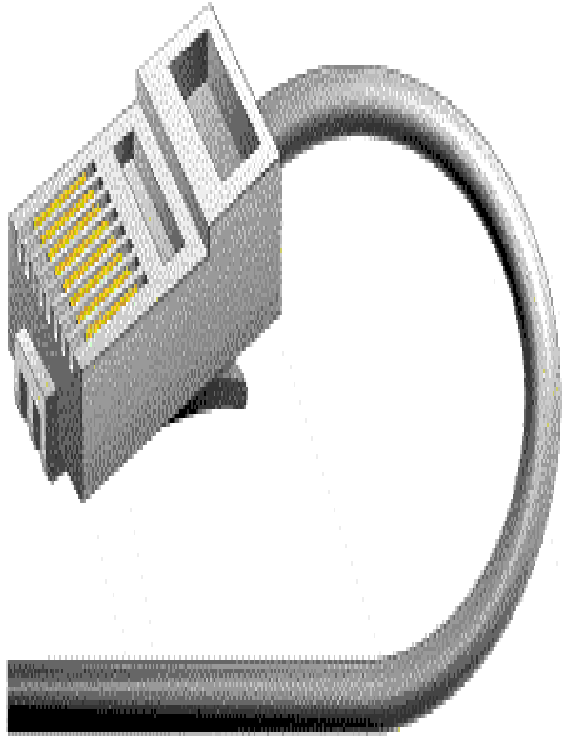
RJ-45 Connector



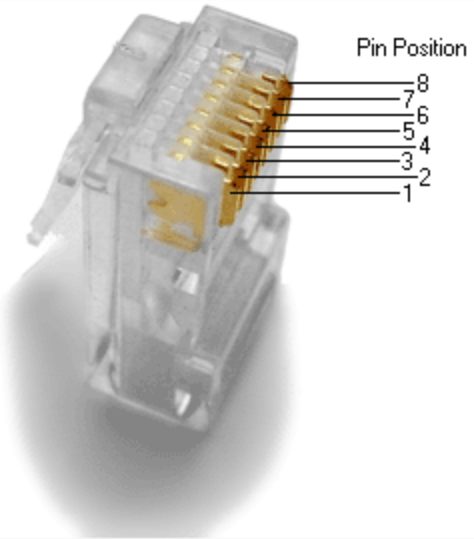
RJ-45 Female



RJ-45 Male



T568A and T568B Wiring

Pin	T568A Pair	T568B Pair	Wire	T568A Color	T568B Color	Pins on plug face (socket is reversed)
1	3	2	tip	white/green stripe	white/orange stripe	
2	3	2	ring	green solid	orange solid	
3	2	3	tip	white/orange stripe	white/green stripe	
4	1	1	ring	blue solid	blue solid	
5	1	1	tip	white/blue stripe	white/blue stripe	
6	2	3	ring	orange solid	green solid	
7	4	4	tip	white/brown stripe	white/brown stripe	
8	4	4	ring	brown solid	brown solid	

Twisted Pair - Applications

- Most common medium
- Telephone network
  - Between house and local exchange (subscriber loop)
- Within buildings
- For local area networks (LAN)
  - 10Mbps or 100Mbps

Twisted Pair - Conclusions

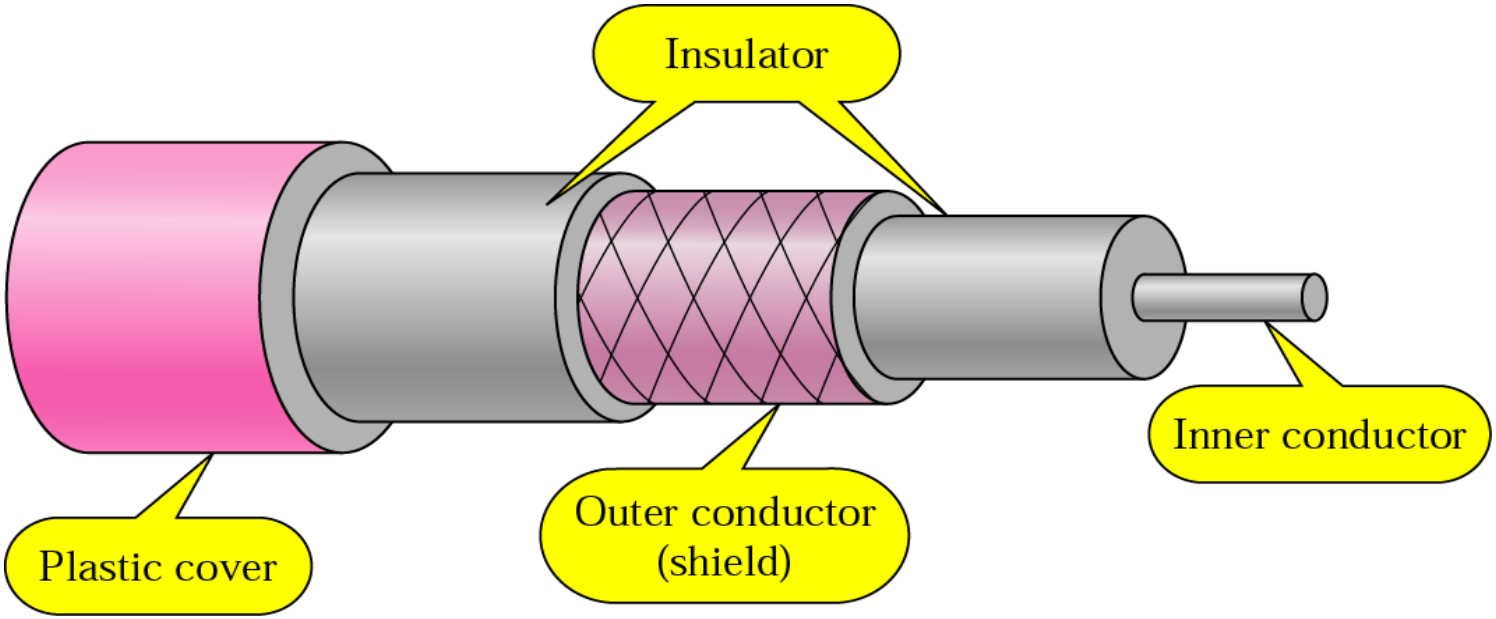
- Cheap
- Easy to work with
- Low data rate
- Short range
- Speed and throughput 10-100 Mbps
- Maximum Cable length 100m

UTP pros and Cons

- Advantages
- a high installed base
- cheap to install
- easy to terminate

- Disadvantages:
- very noisy
- limited in distance
- suffers from interference

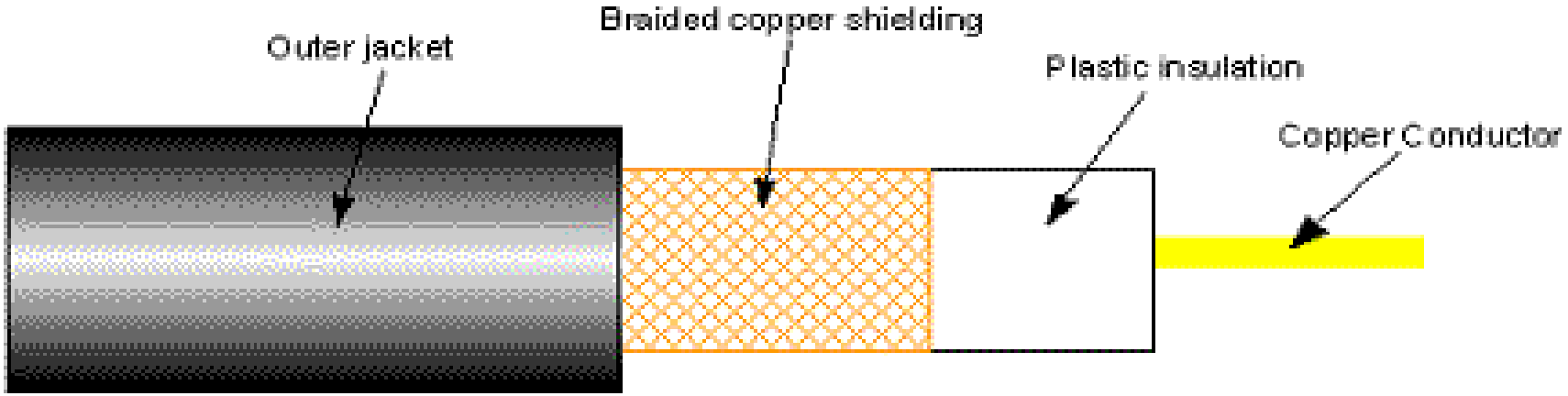
Coaxial Cable



Categories of coaxial cables

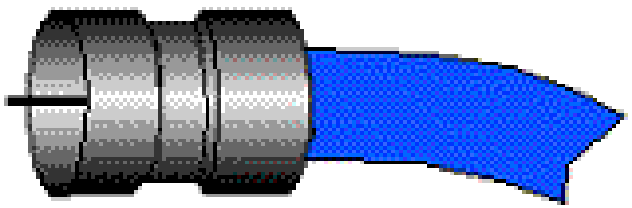
Category	Impedance	Use
RG-59	**75 Ω**	**Cable TV**
RG-58	**50 Ω**	**Thin Ethernet**
RG-11	**50 Ω**	**Thick Ethernet**

Coaxial Cable

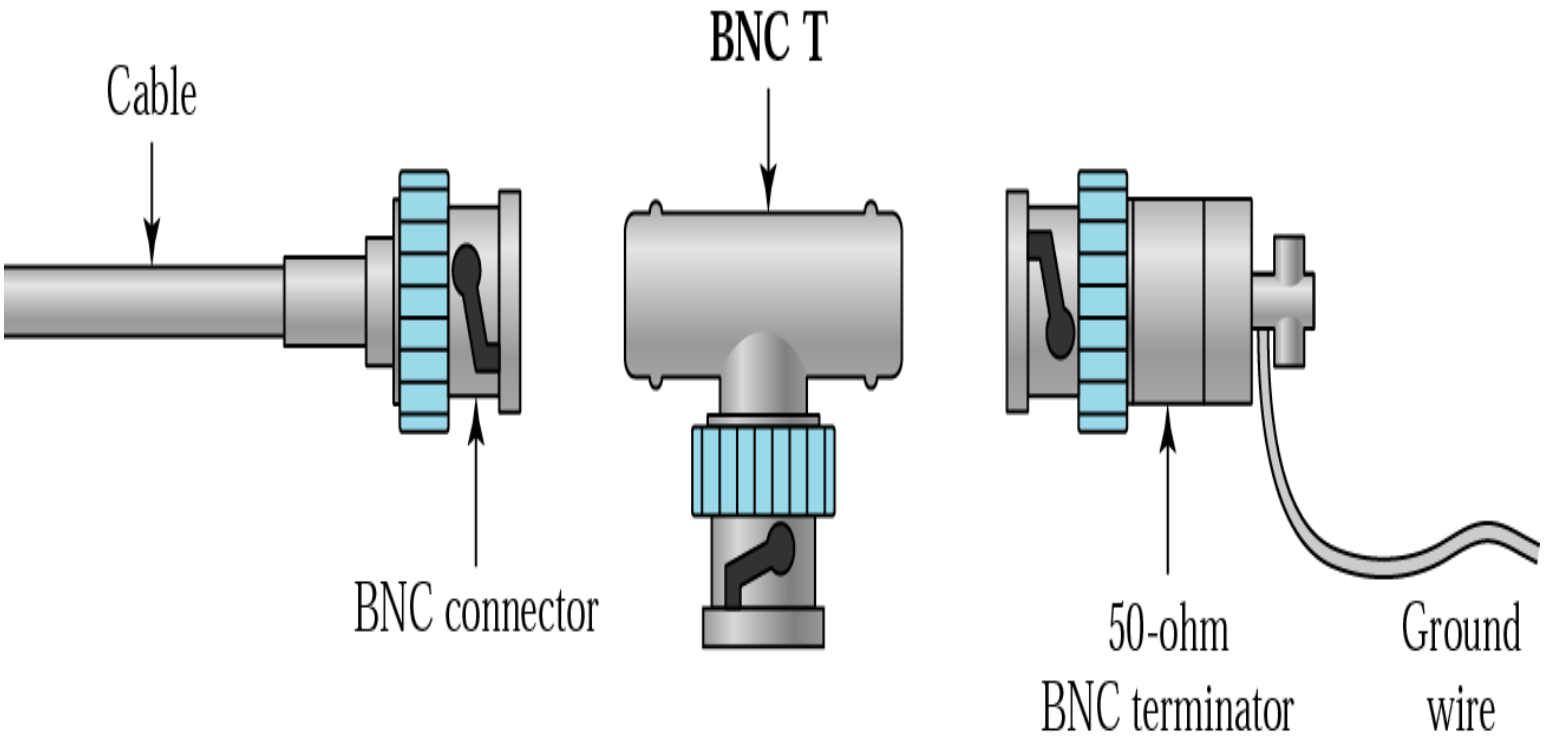


BNC connector

Speed and throughput:	10 - 100Mbps
Average $ per node:	Inexpensive
Media and connector size:	Medium
Maximum cable length:	500 m (medium)



BNC Connectors



Coaxial Cable Applications

- Most versatile medium
- Television distribution
  - Cable TV
- Long distance telephone transmission
  - Can carry 10,000 voice calls simultaneously
  - Being replaced by fiber optic
- Short distance computer systems links
- Local area networks
- Maximum cable length 500m in case of Thick Ethernet and 185 m in Thin Ethernet.
- Speed 10-100 Mbps

Coaxial Cable

- A single wire wrapped in a foam insulation surrounded by a braided metal shield, then covered in a plastic jacket. Cable can be thick or thin.
- Base band coaxial technology uses digital signaling in which the cable carries only one channel of digital data.
- Broadband coaxial technology transmits analog signals and is capable of supporting multiple channels of data.

Coaxial Cable

- Advantages
- cheap to install
- conforms to standards
- widely used

- Disadvantages
- limited in distance
- limited in number of connections
- terminations and connectors must be done properly

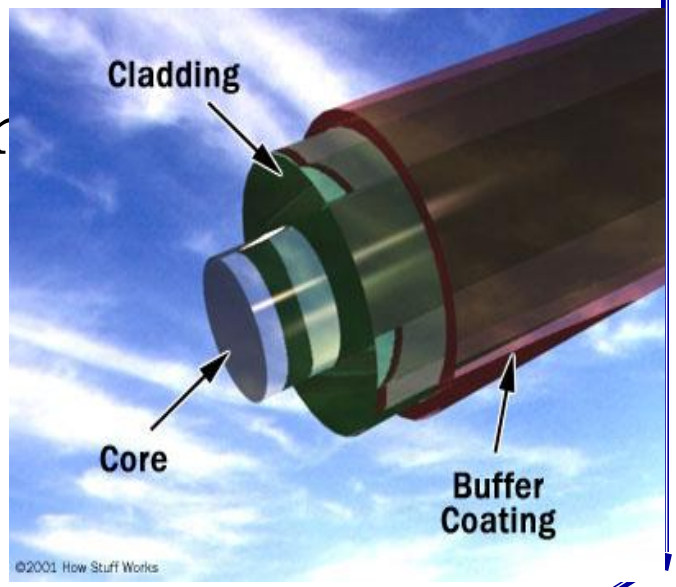
Fiber Optic

There are three main components of Fiber optic cable

Core – thin glass center of the fiber where light travels.

Cladding – outer optical m surrounding the core

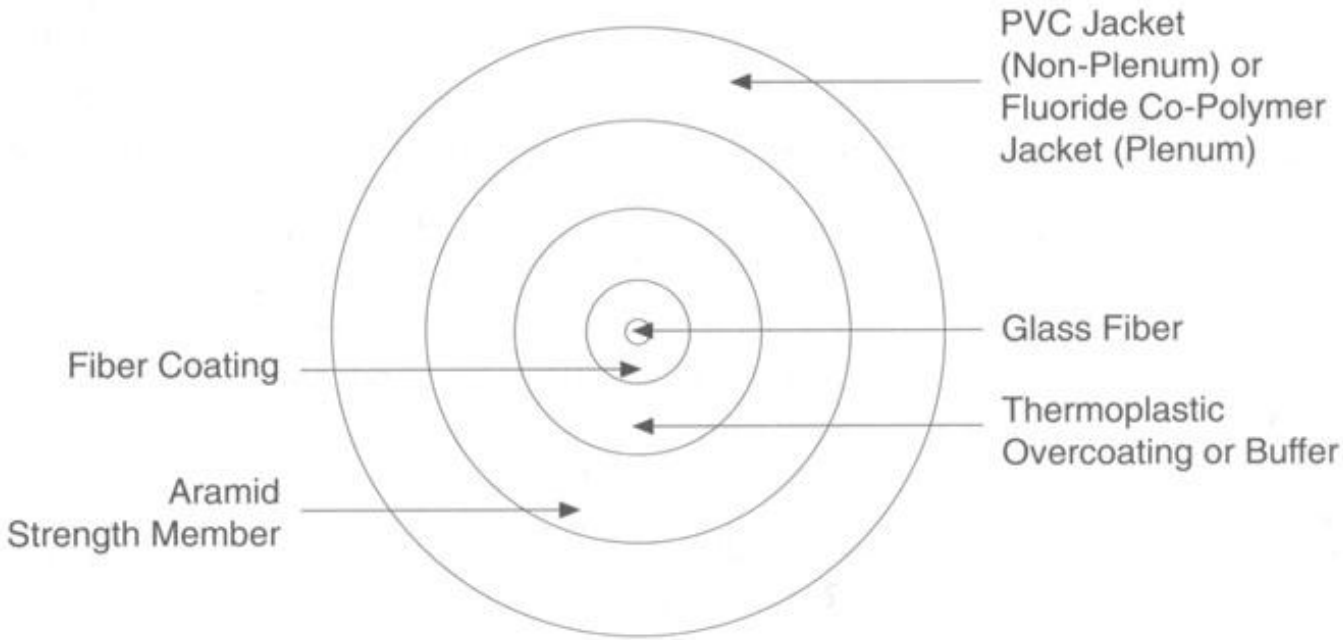
Jacket – plastic coating that protects the fiber.



Fiber Optic

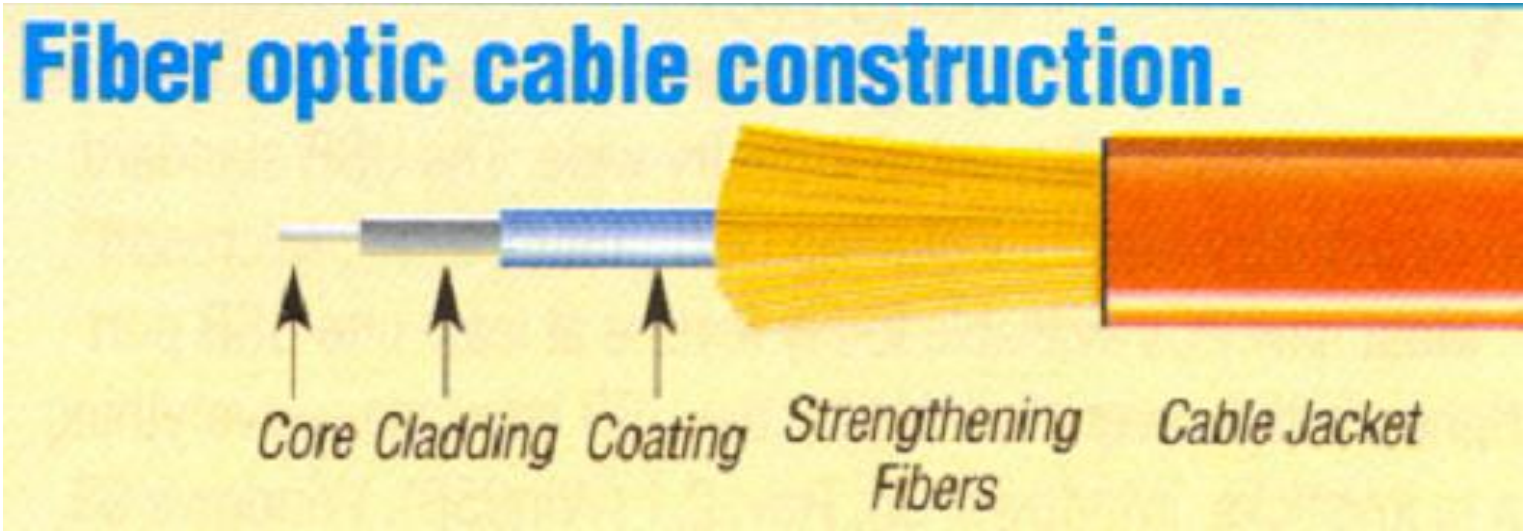
- Optical fiber is thin (2 to 125 um)
- Capable of guiding an optical ray
- Used to carry signals in the form of light over distances up to 50 km.
- Glasses and plastics can be used to make optical fibers
- Plastic fiber is less costly and can be used for short links.

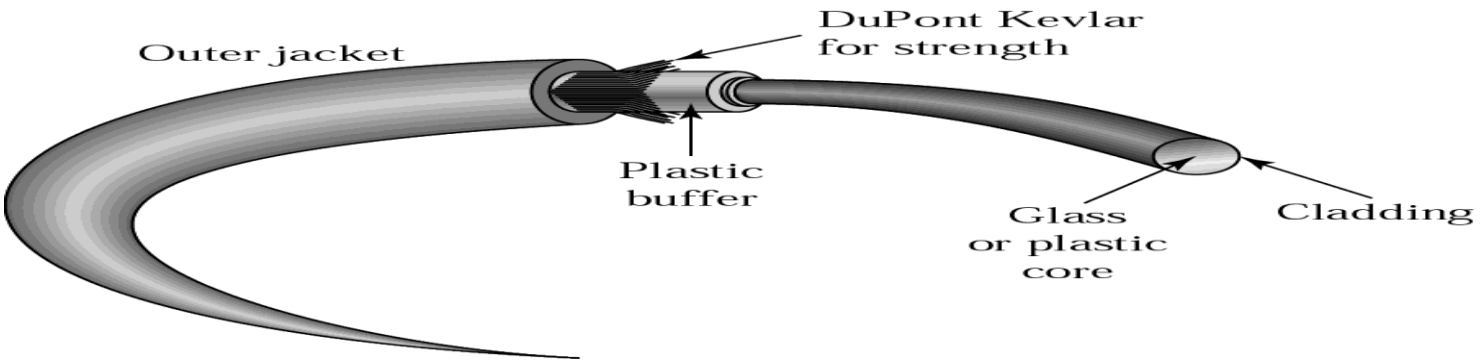
Fiber Optic



Tight-Buffered Cable

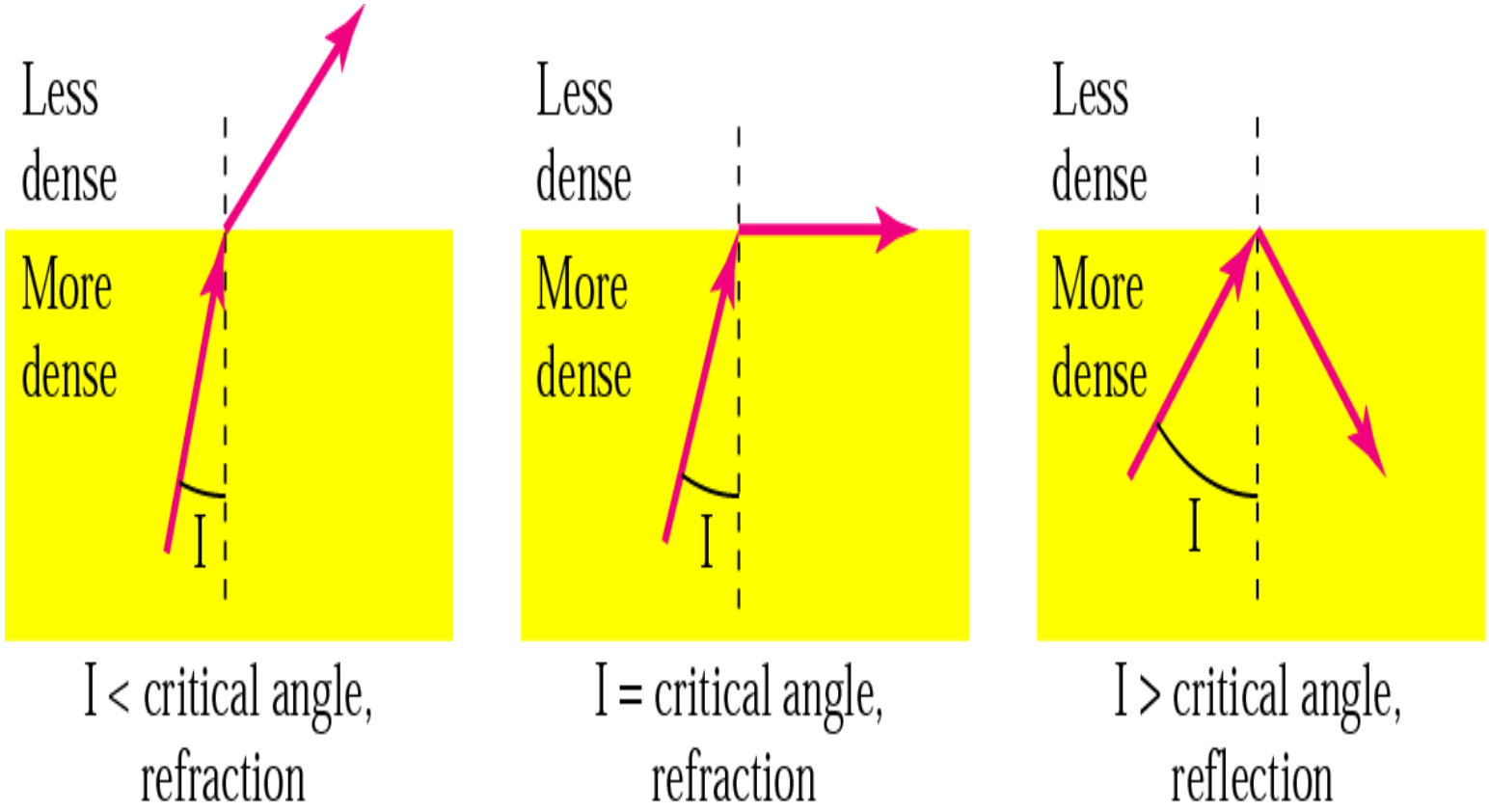
Optical Fiber



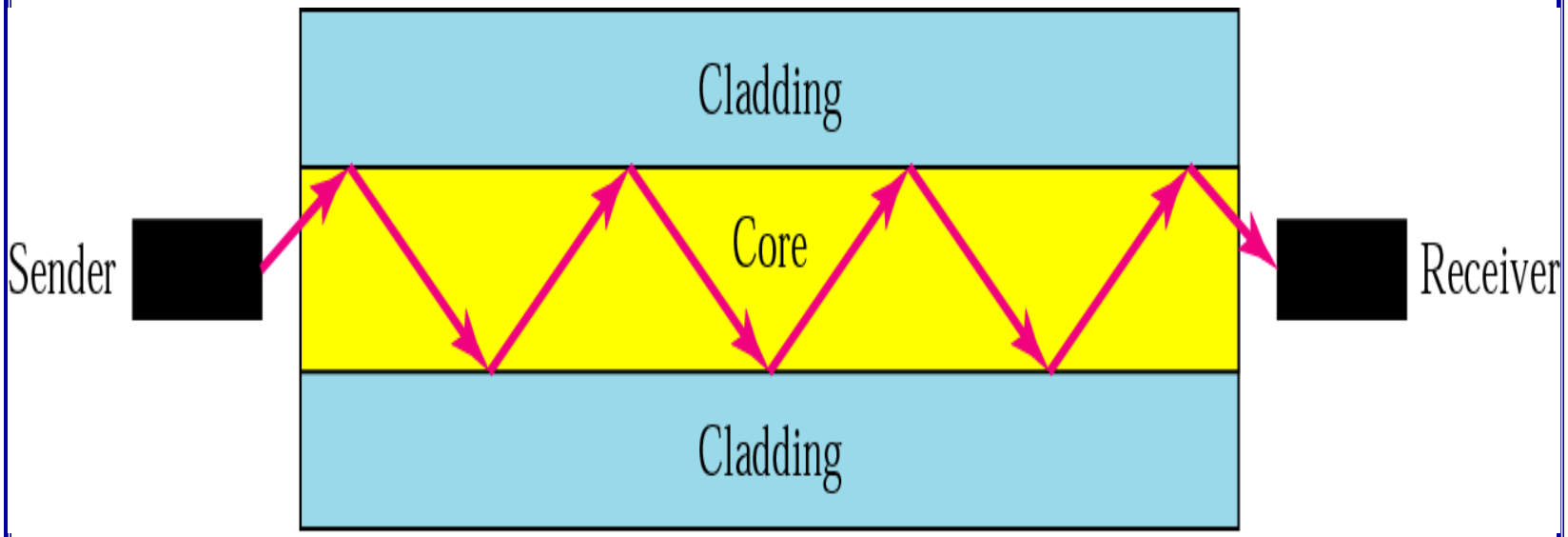


Fiber Optic Cable

Bending of Light Ray

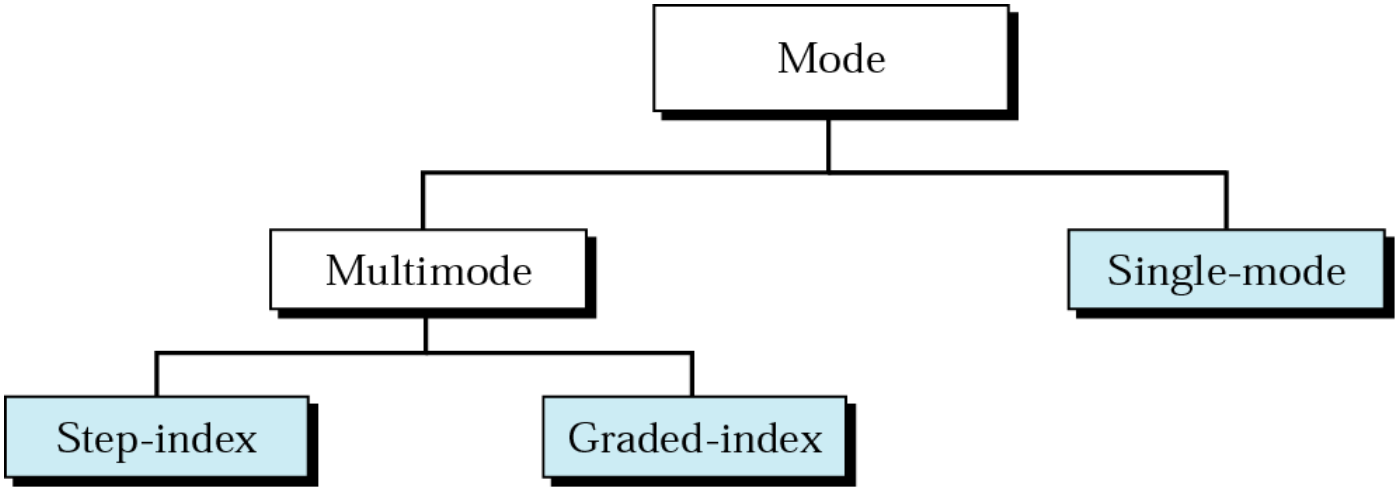


Optical Fiber

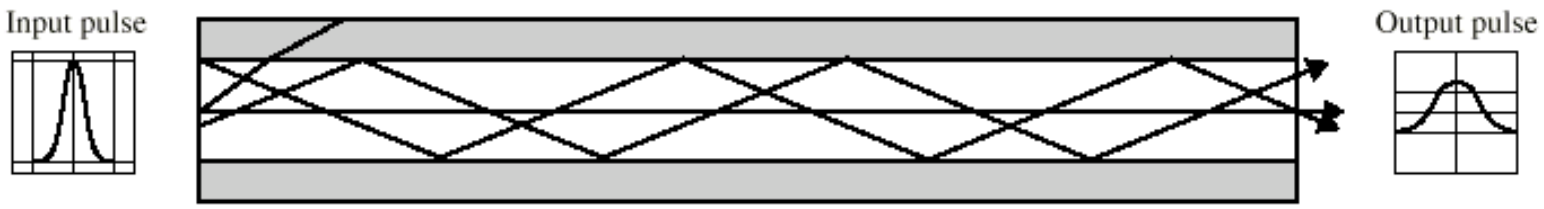


Fiber Optics Propagation Modes

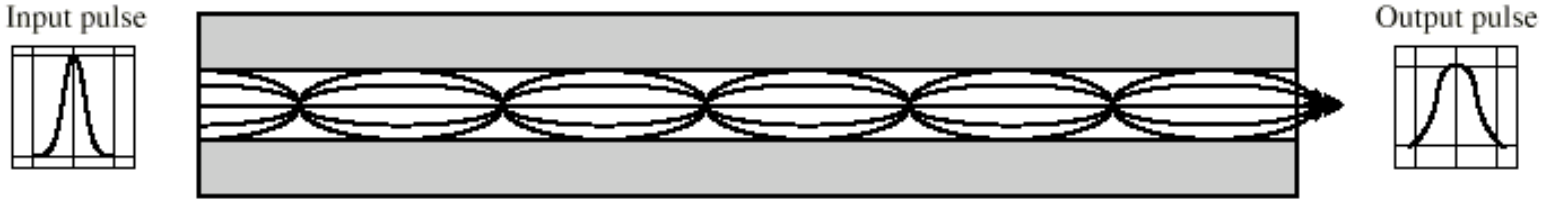
- Optical fibers come in two types:
  - Single-mode fibers
  - Multi-mode fibers



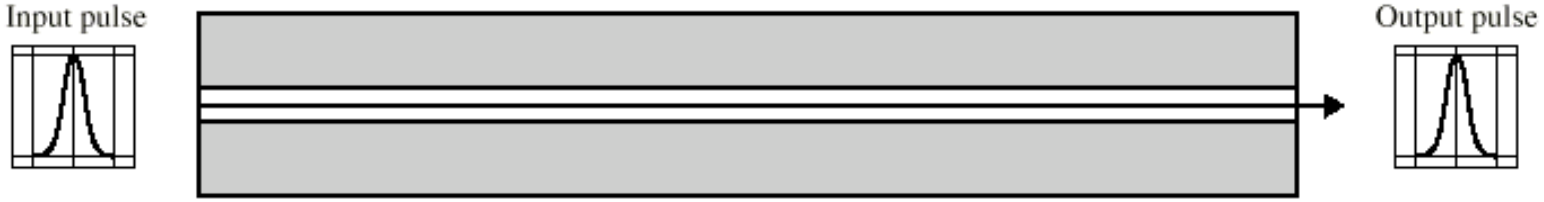
Optical Fiber Transmission Modes



(a) Step-index multimode

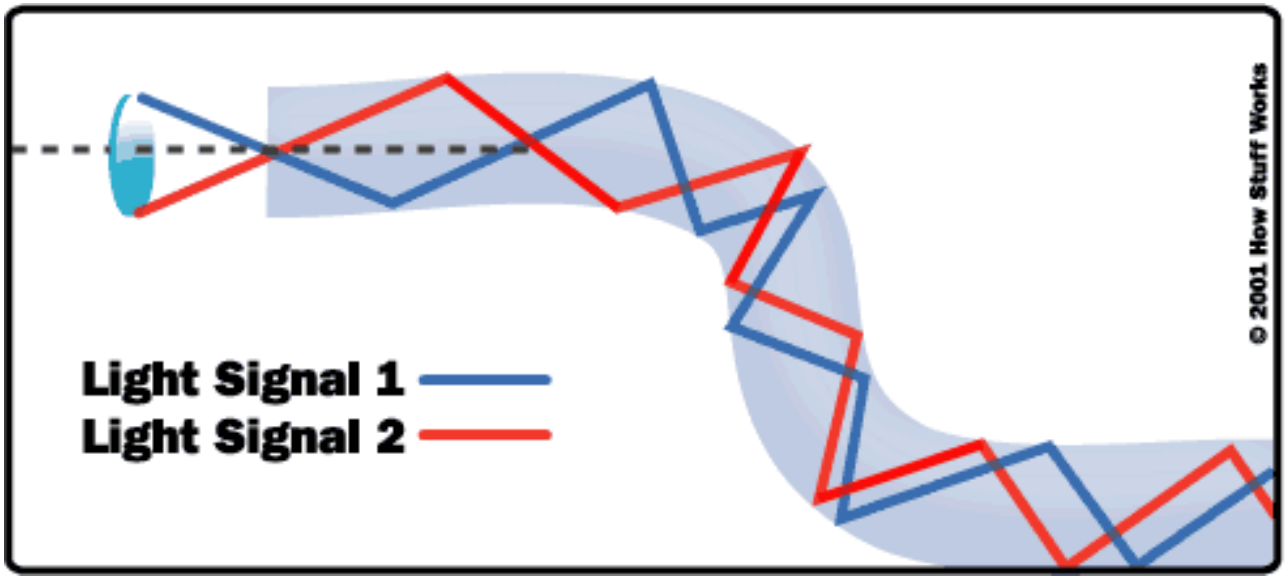


(b) Graded-index multimode



(c) Single mode

Optical Fiber Transmission Modes



Single Mode Vs Multimode (1)

- An optical fiber that supports only one propagation mode. (I.e. the light travels in only one ray)
- Single-mode fibers have small cores (9 microns in diameter)
- Laser is used as light source to transmit infrared laser light.

- An optical fiber that supports more than one modes (I.e. the light travels in the core in many rays called modes)
- Multi-mode fibers have larger cores (62.5 microns in diameter)
- Light emitting diodes (LEDs) are used as light source.

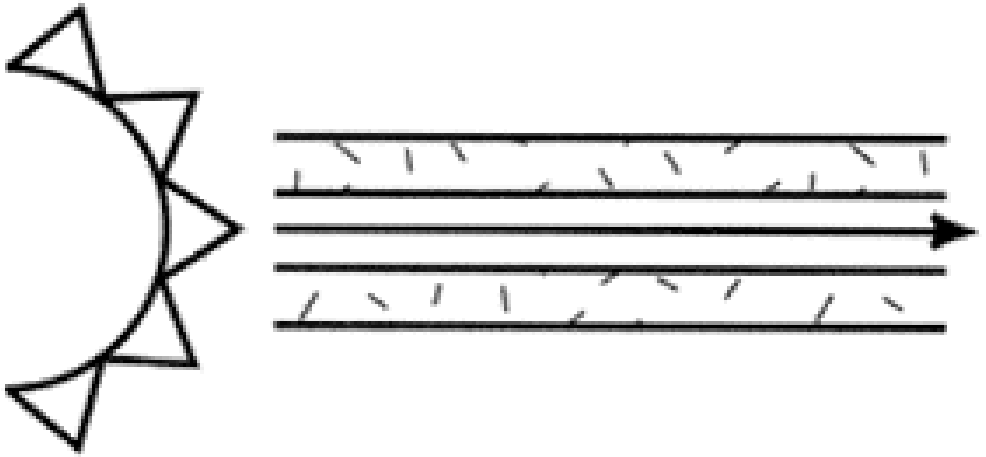
Single Mode Vs Multimode (2)

- Single-mode fiber gives you a higher transmission rate and up to 50 times more distance than multimode
- Used by telephone and cable TV companies for long distance applications
- More expensive than multimode

- Multimode fiber gives you high bandwidth at high speeds over medium distances but less than single mode.
- Used for slower local area networks (LANs)
- Less Expensive than single mode

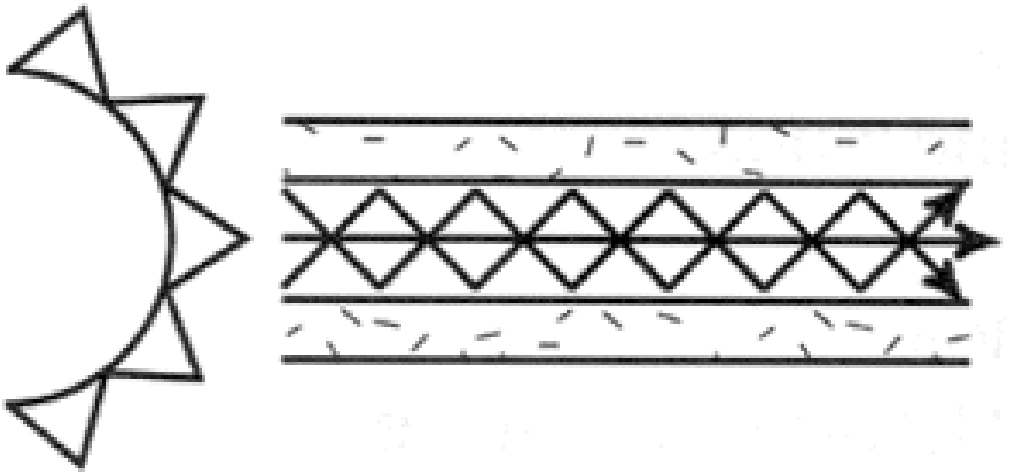
Single Mode figure

"Single mode fiber"
single path through the fiber



Multimode figure

"Multimode fiber"
multiple paths through the fiber

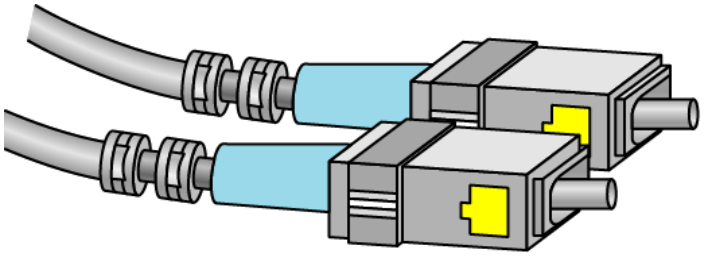


Single mode and Multimode …

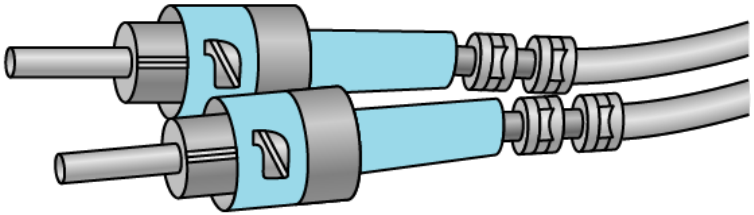
Micron: A micron is one one-millionth of a meter and 125 microns is 0.005 inches- a bit larger than the typical human hair.

- In Single mode optical fiber due to the small core and single light-wave any distortion is virtually eliminated that could result from overlapping light pulses, providing the least signal attenuation and the highest transmission speeds of any fiber cable type.
- Plastic Optical Fiber (POF) is large core (about 1mm) fiber that can only be used for short, low speed networks.

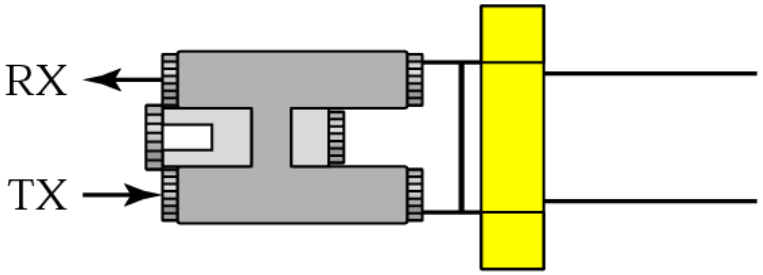
Fiber-optic connectors



SC connector



ST connector



MT-RJ connector

Fiber-optic connectors

Fiber Connector Styles

ST Connector
A slotted bayonet type connector. This connecto is one of the most popular styles.

SC Connector
A push/pull type connector. This connector has emerged as one of the most popular styles.

FC Connector
A slotted screw-on type connector. This connector is pop-ular in singlemode applications.

SMA Connector
A screw-on type connector. This connector is waning in popularity.

FDDI Connector
A push/pull type dual connector. This connector is one of the more popular styles.

Mini-BNC Connector
A bayonet style connector using the traditional BNC connection method.

Biconic Connector
A screw-on style connector. This connector is almost obsolete.

MT-RJ Connector
A new RJ style housing fiber connector with two fiber capability.

ST Feedthru
A slotted bayonet type feedthru. ST connectors are one of the most popular styles.

SC Feedthru
A push/pull type feedthru. SC connectors are one of the most popular styles.

FDDI Feedthru
A push/pull type feedthru. FDDI connectors are popular in both singlemode and multimode applications.

FC Feedthru
A slotted screw-on type feedthru. FC connectors are popular in singlemode applications.

Optical Fiber - Benefits

- Greater capacity
  - Data rates of hundreds of Gbps
- Smaller size & weight
- Lower attenuation
  - Today's optical fiber attenuation ranges from 0.5dB/km to 1000dB/km depending on the optical fiber used
- Electromagnetic isolation
- Greater repeater spacing
  - 10s of km at least
- Maximum cable length: up to 50 km or more
- Each fiber is a one way (simplex) channel for the light pulses
  - i.e. two fibers needed for a two-way (duplex) connection

Fiber Optics

- Advantages
- high capacity
- Do not suffer from electric interference
- can go long distances
- Higher bandwidth and data rates

- Disadvantages
- costly
- difficult to join
- Supports simplex connection only
- Must be handled with care
- Bending is not easy

Optical Fiber - Applications

- Long-haul trunks
  - Average 1500 KM in length
  - 20,000 to 60,000 voice channels
- Metropolitan trunks
  - Average length of 12 KM
- Rural exchange trunks
  - Ranging from 40 to 160 KM.
- Subscriber loops
- LANs

Fiber types

Type	Core	Cladding	Mode
50/125	50	125	Multimode, graded-index
62.5/125	62.5	125	Multimode, graded-index
100/125	100	125	Multimode, graded-index
7/125	7	125	Single-mode