

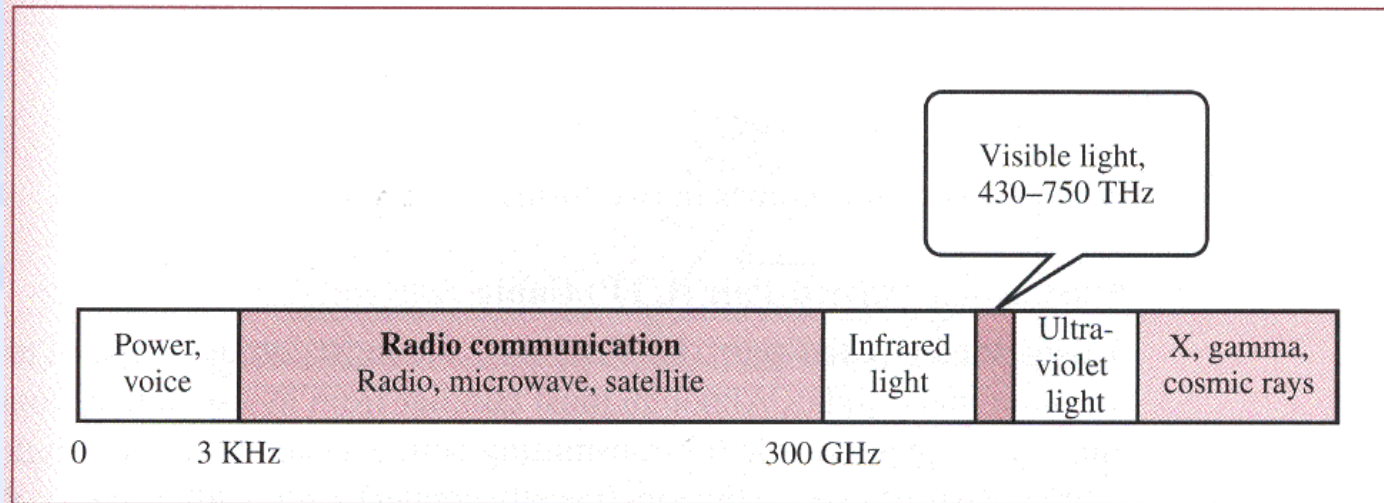


Transmission Media

Transmission Media

- * physical path between transmitter and receiver
- * electromagnetic wave-
 - * Examples of Electromagnetic energy include power, radio waves, infrared light, visible light, ultraviolet light, and X and gamma rays.
- * Guided Media
 - * solid medium, copper twisted pair, coaxial cable, optical fiber
 - * data rate mainly determined by medium
- * Un Guided Media
 - * atmosphere, outer space
 - * wireless transmission
 - * low frequencies : omni directional (all directions)
 - * high frequencies : possible to focus signal(Directional)
 - * transmission characteristics determined by bandwidth

Figure 7.1 *Electromagnetic spectrum*



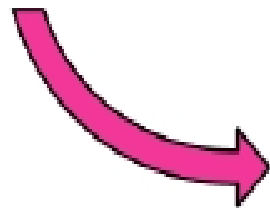
- Not all portion of the spectrum are currently usable for telecommunications
- Each portion of the spectrum requires a particular transmission medium

Factors determining data rate and distance

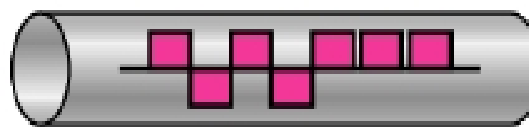
- * Bandwidth
 - * greater bandwidth : higher data rate
- * Transmission impairments
 - * attenuation
 - * »twisted pair > coaxial cable > optical fiber
- * Interference
 - * by unshielded cables
 - * from competing signals in overlapping
- * Number of receivers
 - * Each attachment introduces some attenuation and distortion on the line.

Sender

Physical layer



Transmission medium



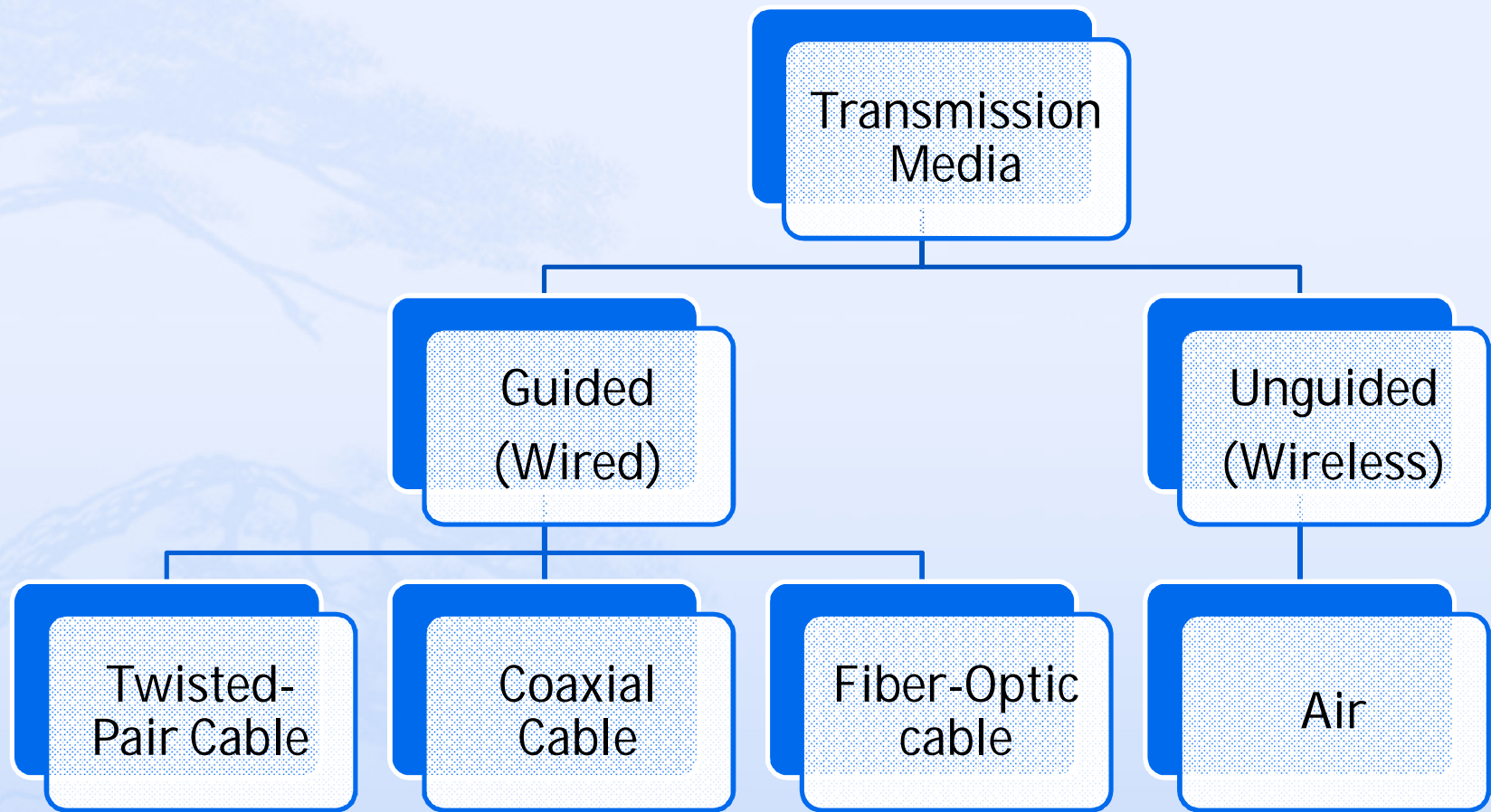
Cable or air



Physical layer

Receiver





Coaxial Cable

- ✿ Coaxial cable have three layers.
 - ✱ Center conductor
 - ✱ Insulator
 - ✱ Outer Conductor
- ✿ The central conductor is usually copper
- ✿ Outside the central conductor is non conductive material usually a plastic that is used to separate the inner and outer conductor.
- ✿ The outer conductor is a fine mesh (net) made from copper. It is used to shield the cable from electro-magnetic interference (EMI)
- ✿ Out side the copper mesh is the final protective cover.
- ✿ The actual data travels through the central conductor in the cable.

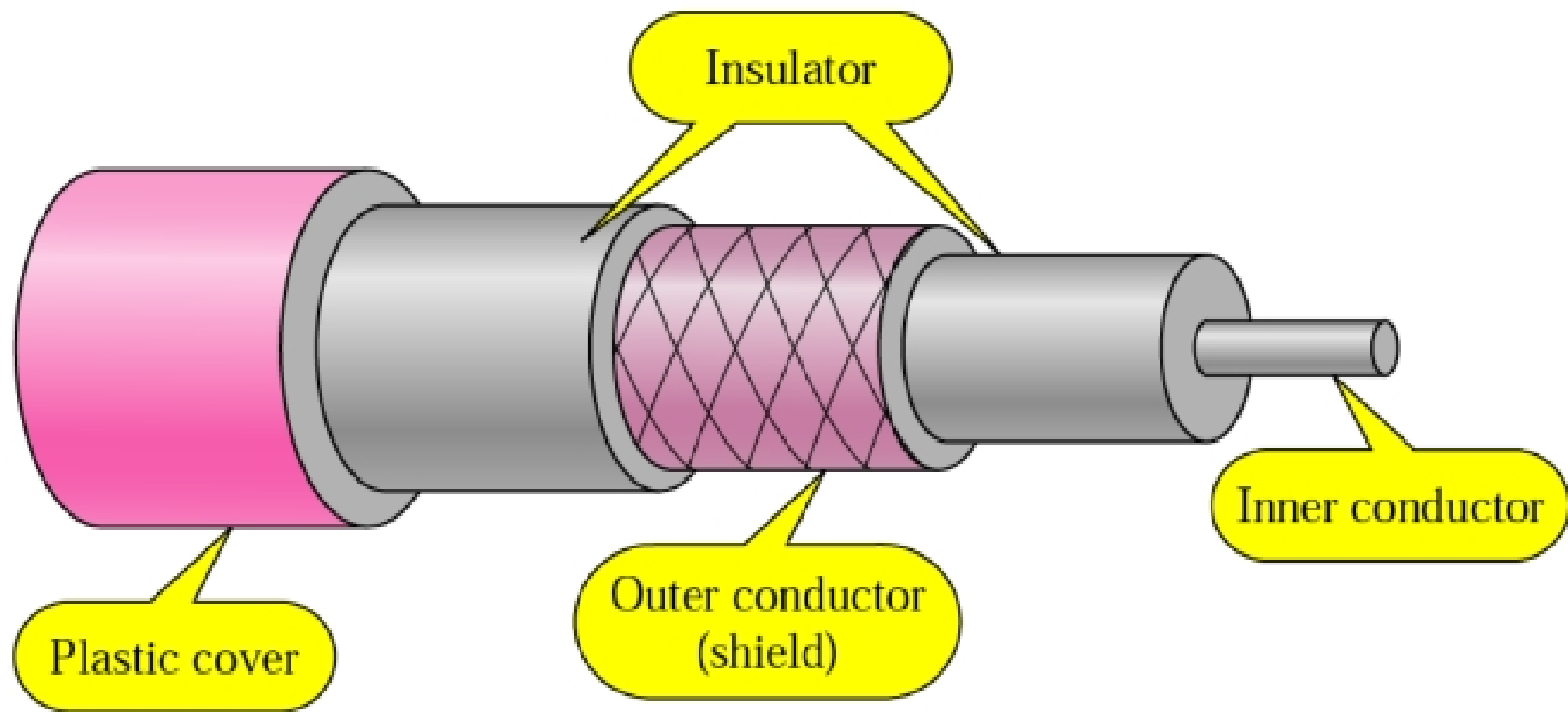
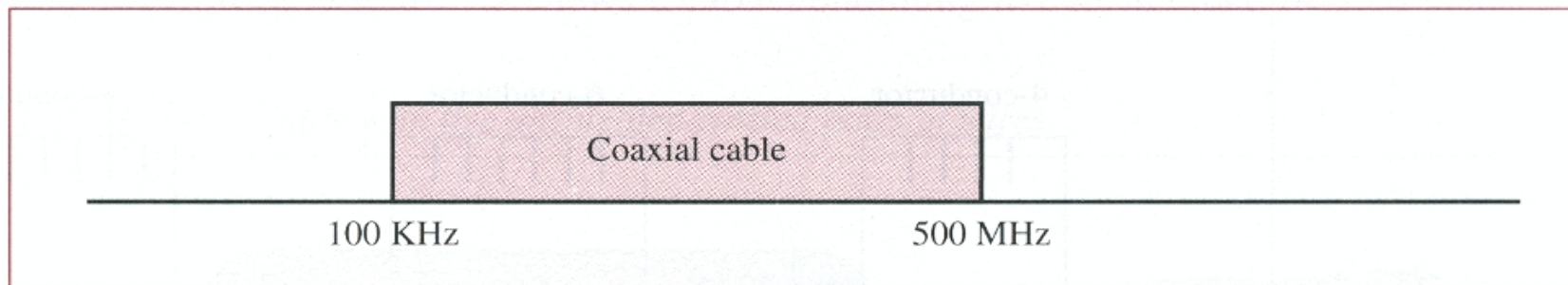


Figure 7.11 *Frequency range of coaxial cable*



- ✿ It carries signals of higher frequency ranges than twisted pair cable.
- ✿ It has a central core conductor of solid wire enclosed in an insulating sheath, which is, in turn, encased in outer conductor of metal foil.
- ✿ Outer metallic wrapping serves both as a shield against noise. This outer conductor is enclosed in an insulating sheath and whole cable is protected by a plastic cover.
- ✿ They are categorized by their radio government (RG) ratings.

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

Advantages & Disadvantage

* Advantages

- * Low cost
- * Easy to install
- * In expensive
- * Easy to expand
- * Moderate level of EMI immunity

* Disadvantages

- * Single cable failure can take down the entire network

Coaxial Cable

* Applications

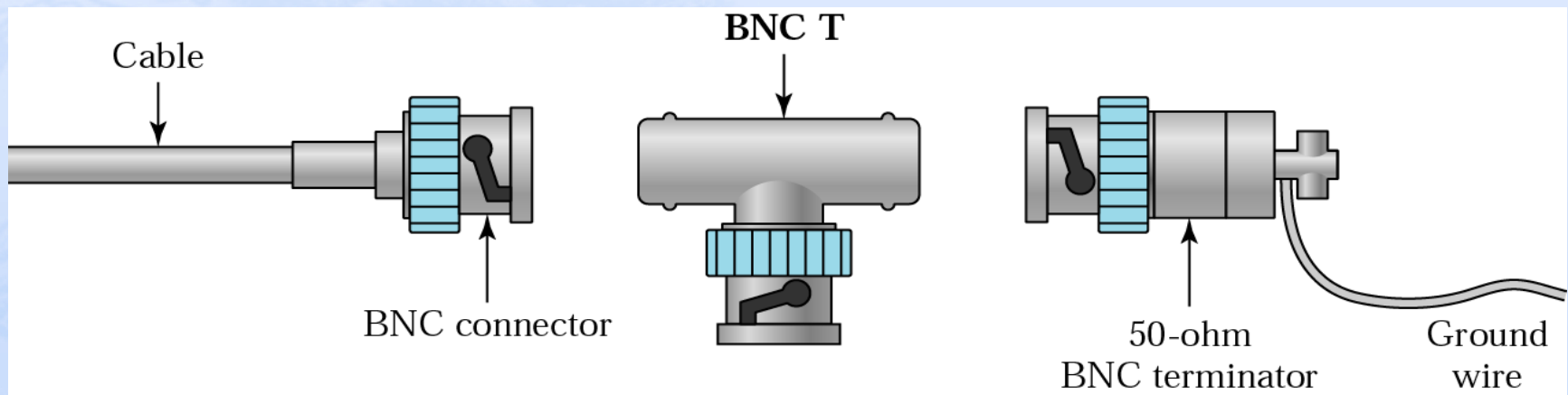
- * TV distribution (cable TV)
- * long distance telephone transmission
 - * »inferior to optical fiber
- * short-run computer system links
 - * »high speed I/O
- * local area networks (LAN)

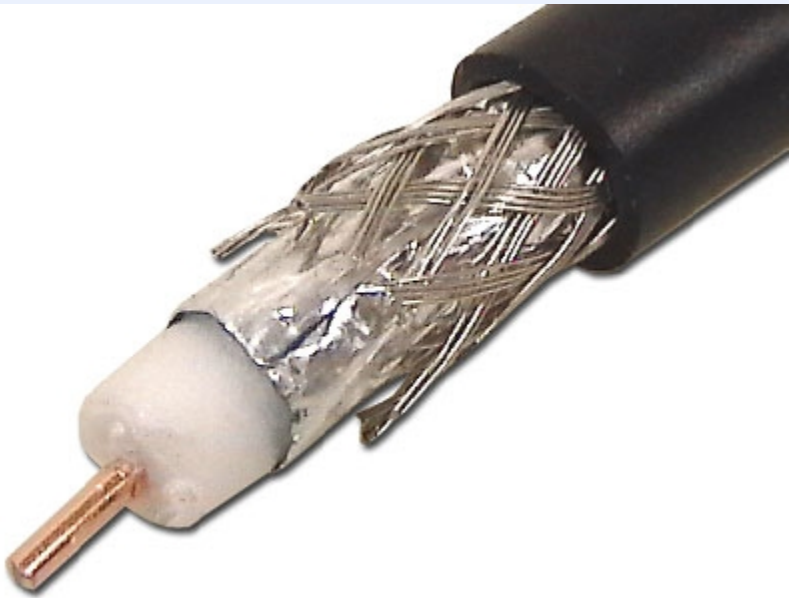
* Transmission characteristics

- * much better than twisted pair in attenuation, thermal noise, and intermodulation noise
- * analog signals : amplifiers every few km
- * digital signals : repeaters every km

BNC connectors

- To connect coaxial cable to devices, it is necessary to use coaxial connectors. The most common type of connector is the Bayone-Neill-Concelman, or BNC, connectors. There are three types: the BNC connector, the BNC T connector, the BNC terminator. Applications include cable TV networks, and some traditional Ethernet LANs like 10Base-2, or 10-Base5.

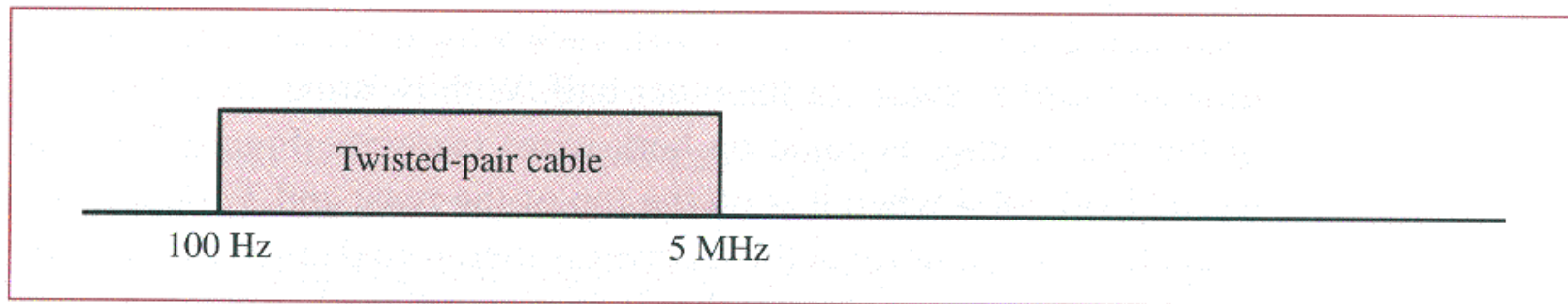




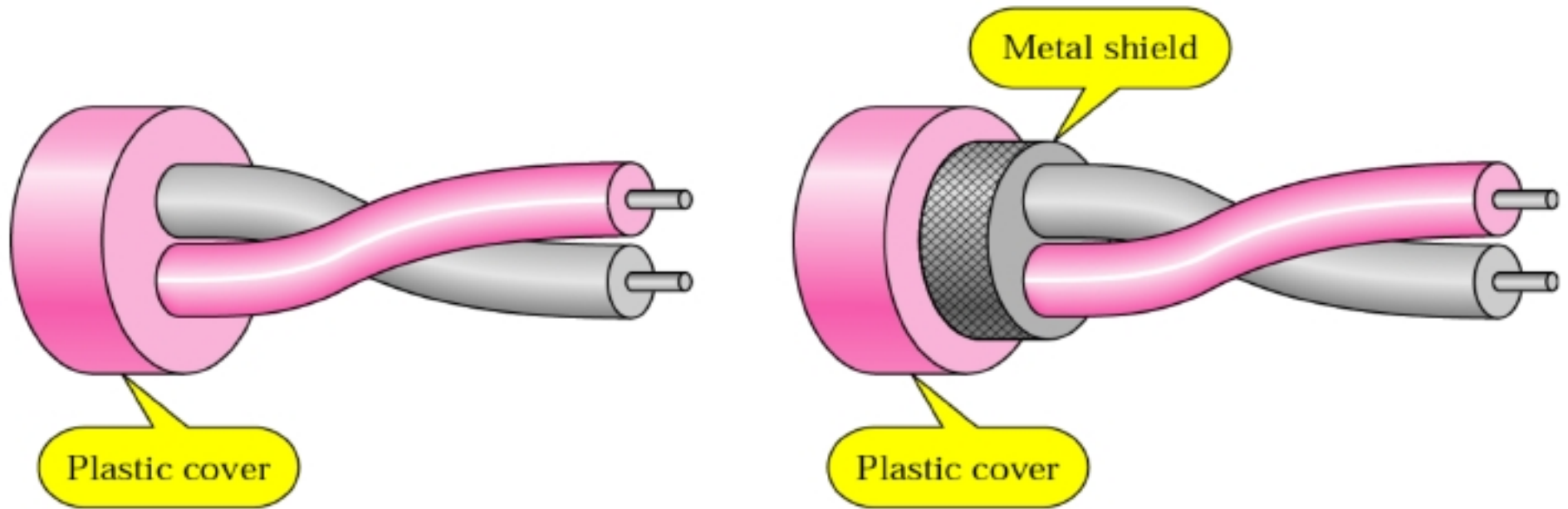
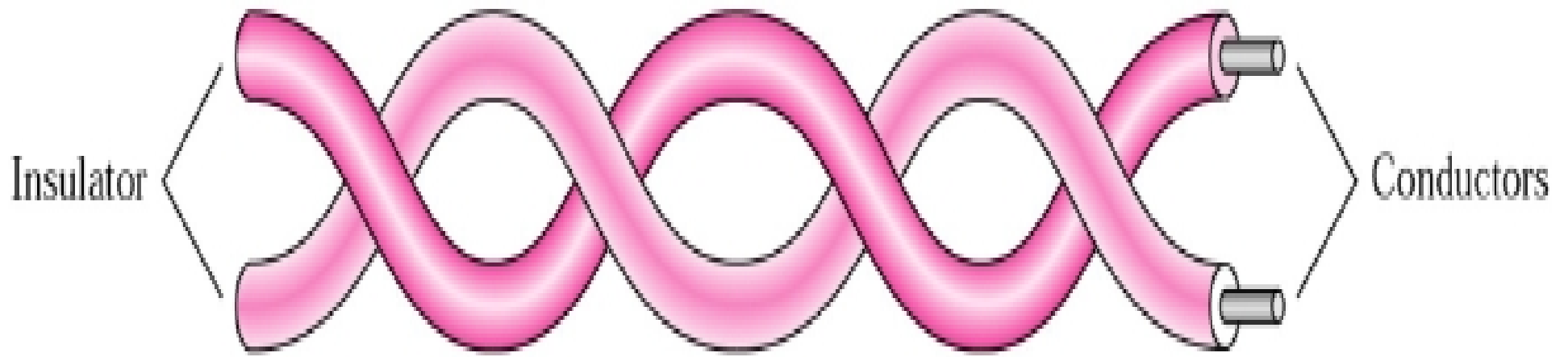
Twisted pair cabling

- * They are the most popular type of cabling as they are light-weight, easy to install and inexpensive.
- * There are two category of twisted pair cabling.
 - * Unshielded Twisted Pair
 - * Shielded Twisted Pair

Figure 7.4 *Frequency range for twisted-pair cable*



- * One of the wires is used to carry signals to the receiver and other is used as a ground reference. Receiver uses the difference between the two levels.
- * In addition to the signal sent by the sender, noise may affect both wires and create unwanted signals. Receiver operates only on the difference between these unwanted signals.
- * If they are affected equally, then receiver will be immune from interference.
- * If two wires are parallel, the effect of these unwanted signals is not same because they are at the different locations relative to noise source.
- * Twisting makes it probable that both wires are equally affected by external influences.



a. UTP

b. STP



Unshielded Twisted Pair

- * Characteristics of UTP
 - * Low cost (but slightly higher than coaxial)
 - * Easy to install
 - * High Speed
 - * There are five categories of UTP
 - * Category –1 to category -5

Unshielded Twisted Pair

- * Category –1: This category is intended for use in telephone lines and low speed data cable.
- * Category –2 :This also include cabling for lower speed network. These can support upto 4 mbps.
- * Category –3:This is popular cable of LAN and supports upto 16 Mbps .
- * Category –4:This cable is used for longer distance and higher speed and can support upto 20 mbps.
- * Category –5:This cable is intended for high performance data communication. It can support upto 100 mbps.

Categories of unshielded twisted Table twisted-pair cables

- ✱ DSL lines that are used by the telephone companies to provide high data rate connections use high bandwidth capability of UTP cables.

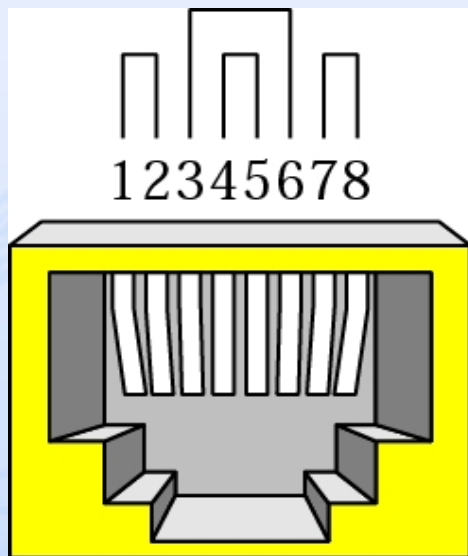
Category	Bandwidth	Data Rate	Digital/Analog	Use
1	very low	< 100 kbps	Analog	Telephone
3	16 MHz	10 Mbps	Digital	LANs
4	20 MHz	20 Mbps	Digital	LANs
5	100 MHz	100 Mbps	Digital	LANs
6 (draft)	200 MHz	200 Mbps	Digital	LANs
7 (draft)	600 MHz	600 Mbps	Digital	LANs

Unshielded Twisted Pair

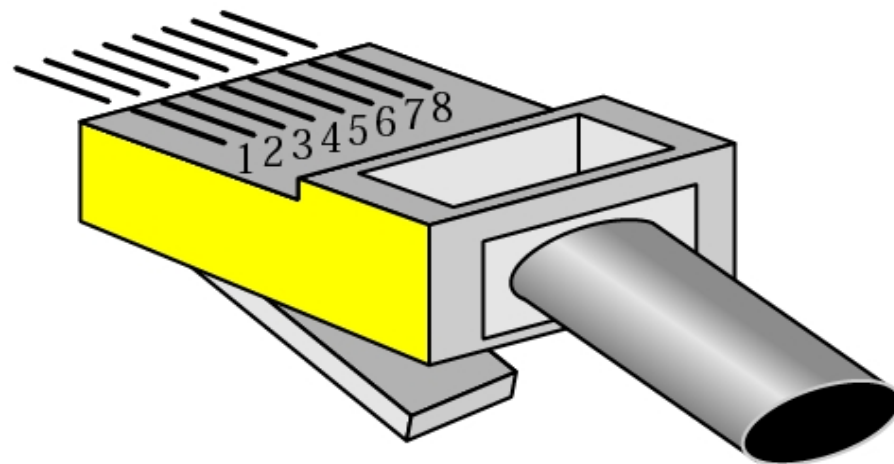
- ✿ UTP consist of two or four pair of twisted cables.
- ✿ Cables with two pair uses RJ-11 connectors and cables with four pairs uses RJ-45 connectors
- ✿ It is easy and inexpensive to wire a UTP

UTP connectors

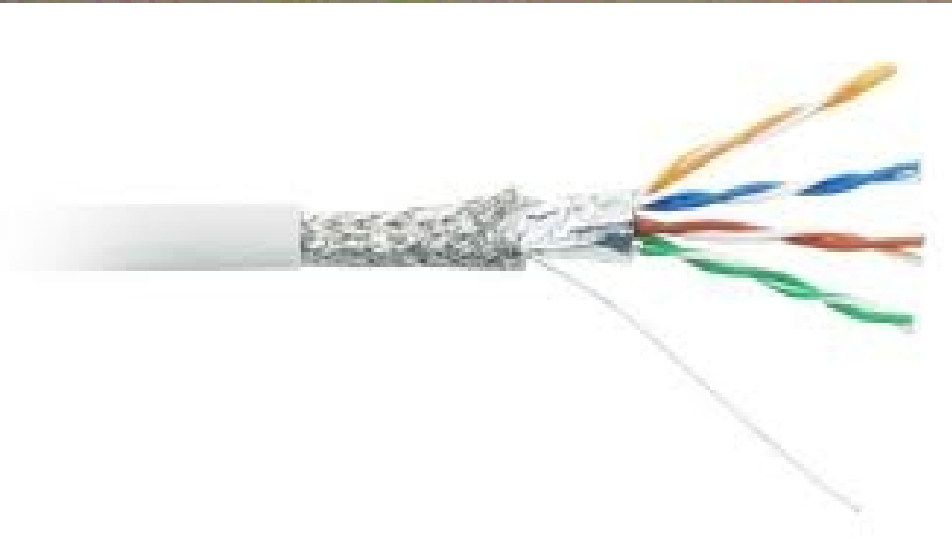
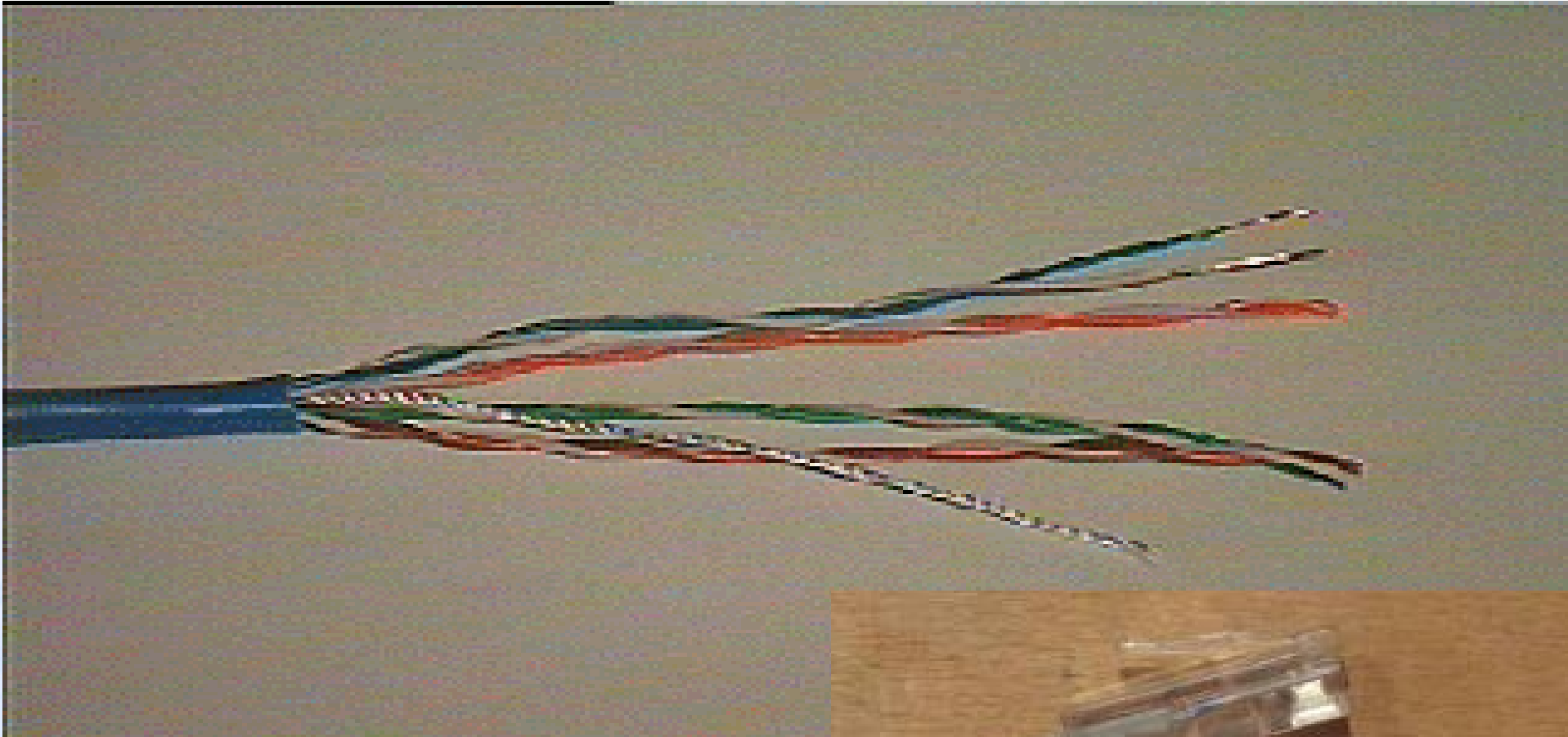
The most common UTP connector is RJ45 (RJ stands for Registered Jack).



RJ-45 Female



RJ-45 Male



Advantages & disadvantages of UTP

Advantages

- * Low cost
- * High Speed
- * Easy Installation(set up)

Disadvantages

- * Short distance due to Attenuation

Shielded Twisted Pair

- * Shielded twisted pair (STP) is similar to UTP except that it has a mesh shielding that protects it from EMI, which allows for higher transmission rate and longer distance without errors.
- * There are different level of categories defined for STP
 - * Type 1
 - * Type 2
 - * Type 6
 - * Type 7
 - * Type 9

- ✿ The STP since it is shielded reduces the effect of EMI
- ✿ •Because of the extra bulk of the shielding, it is harder to install(set-up)
- ✿ •STP at the same time are costlier than UTP

Advantages & Disadvantages of STP

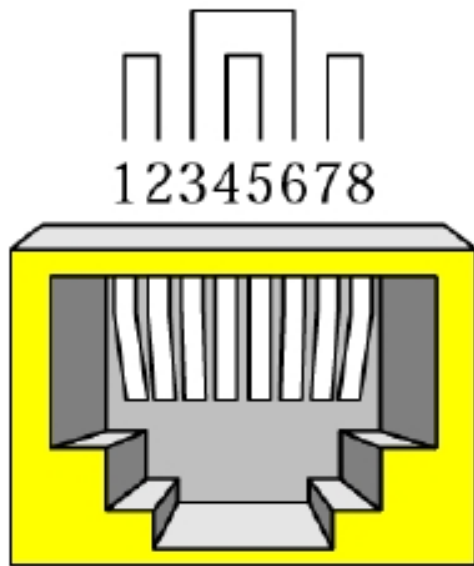
- * Advantages

- * Shielded

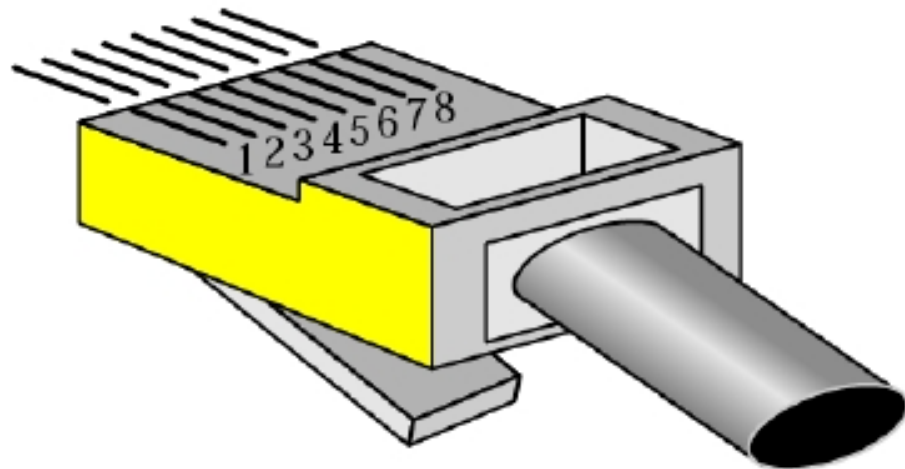
- * Disadvantages

- * Expensive
- * Difficult Installation(Set up)
- * High Attenuation

UTP connector



RJ-45 Female



RJ-45 Male

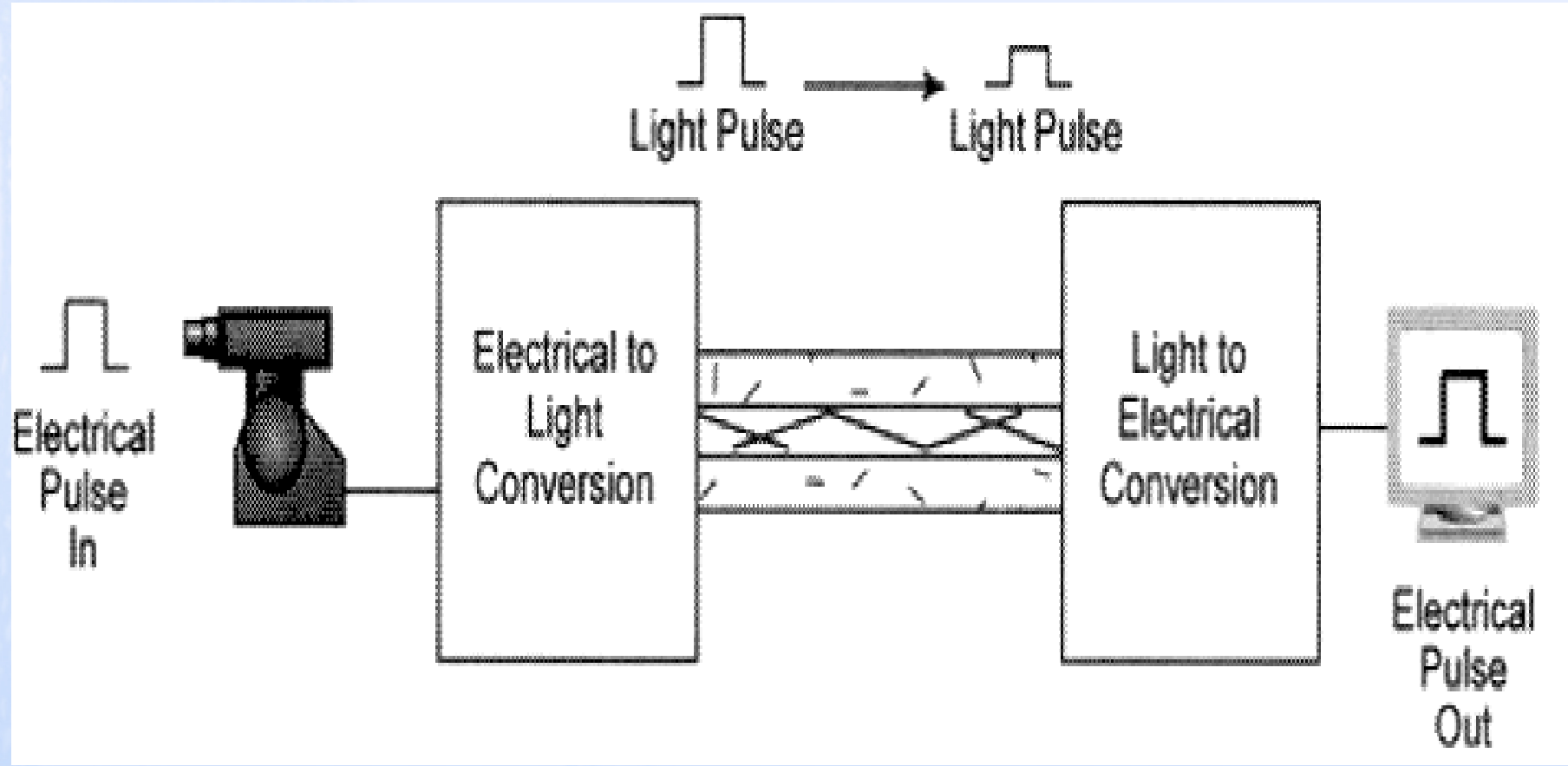
- * RJ-registered Jack.
- * It is a keyed connector, meaning it can be inserted only in one way.

FIBER-OPTIC CABLE

- ✿ **It is made up of glass and transmits signals in the form of light.**

- * Fiber optics are different from other, instead of using electrical signals to transmit data, it uses light.
- * In a fiber-optic cable, light moves only in one direction and that is why there are two strands (fiber) of cables.
- * Each strand is responsible for one direction of communication.
- * In the center of the fiber cable is the glass strand or core. The light travels through this glass.
- * Around the core, there is a reflective material known as cladding. Because of this cladding no light escapes.

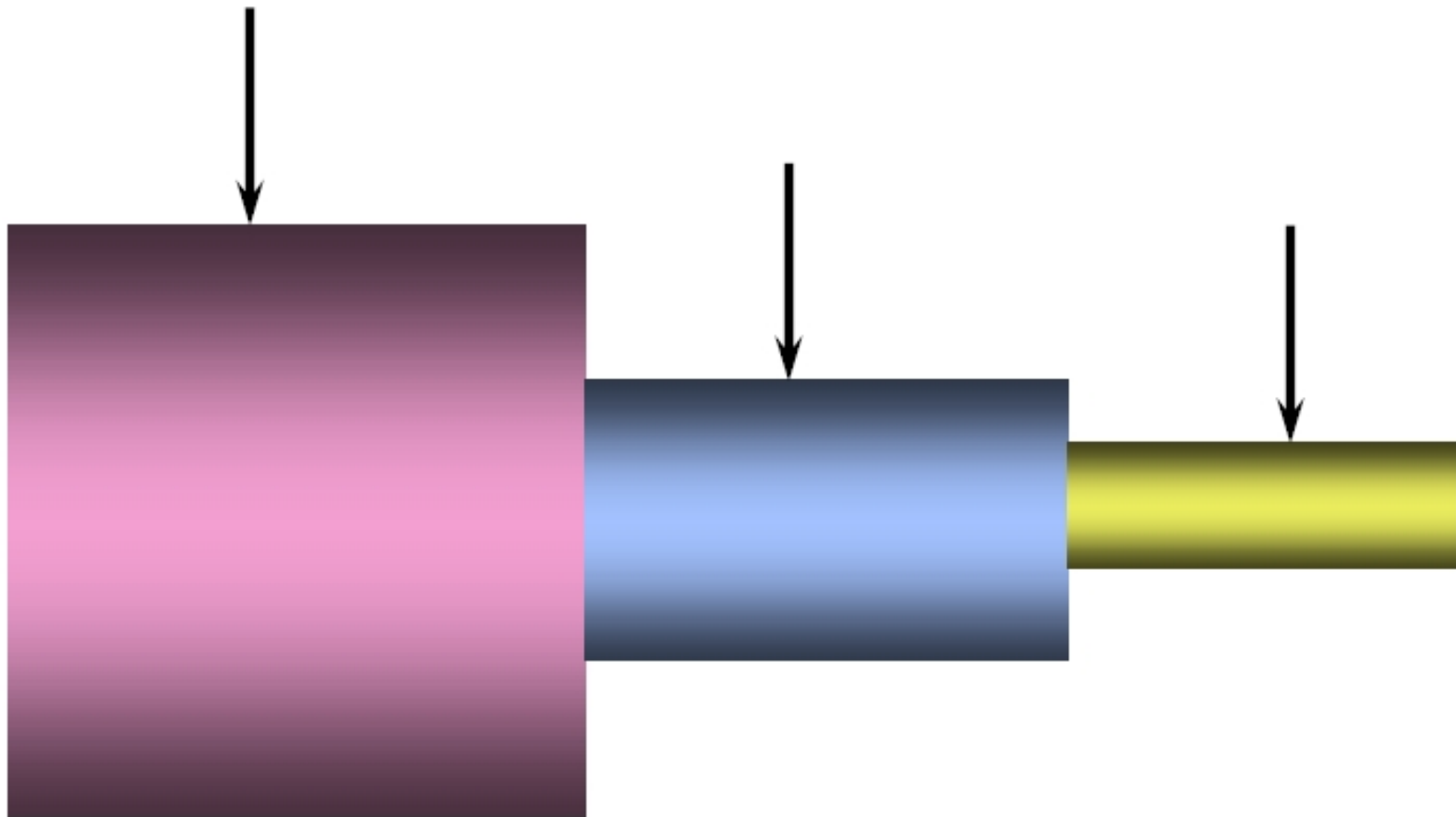
- ✿ The fiber optic cables have a bandwidth of 2 Gbps
- ✿ There is no problem of attenuation.
- ✿ There is no electromagnetic interference . since the transmission occurs over light.
- ✿ The installation of fiber-Optic are the most difficult because of the special connectors that are used.



plastic jacket

**glass or plastic
cladding**

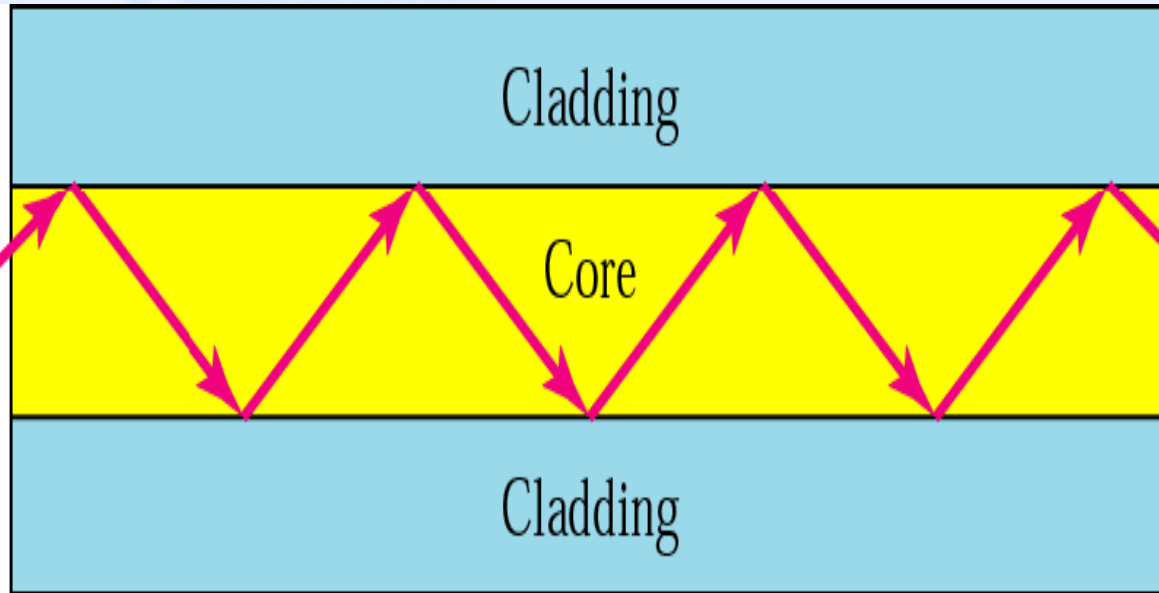
fiber core



Optical fiber

- * Optical fibers use reflection to guide light through a channel. Glass or plastic core is surrounded by a cladding of less dense glass or plastic. Difference in density of two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted.

Sender



Cladding

Core

Cladding



Receiver



Fiber-Optic Cables

- * The operation of an optical fiber is based on the principle of total internal reflection. Light reflects (bounces back) or refracts (alters its direction while penetrating a different medium), depending on the angle at which it strikes a surface.

Optical Fiber

- * Metal cables transmit signals in the form of electric current.
- * Optical fiber is made of glass or plastic and transmits signals in the form of **light**.
- * Light, a form of electromagnetic energy, travels at 300,000 Kilometers/second (186,000 miles/second), in a vacuum.
- * The speed of the light depends on the density of the medium through which it is traveling (the higher density, the slower the speed).

Fiber types

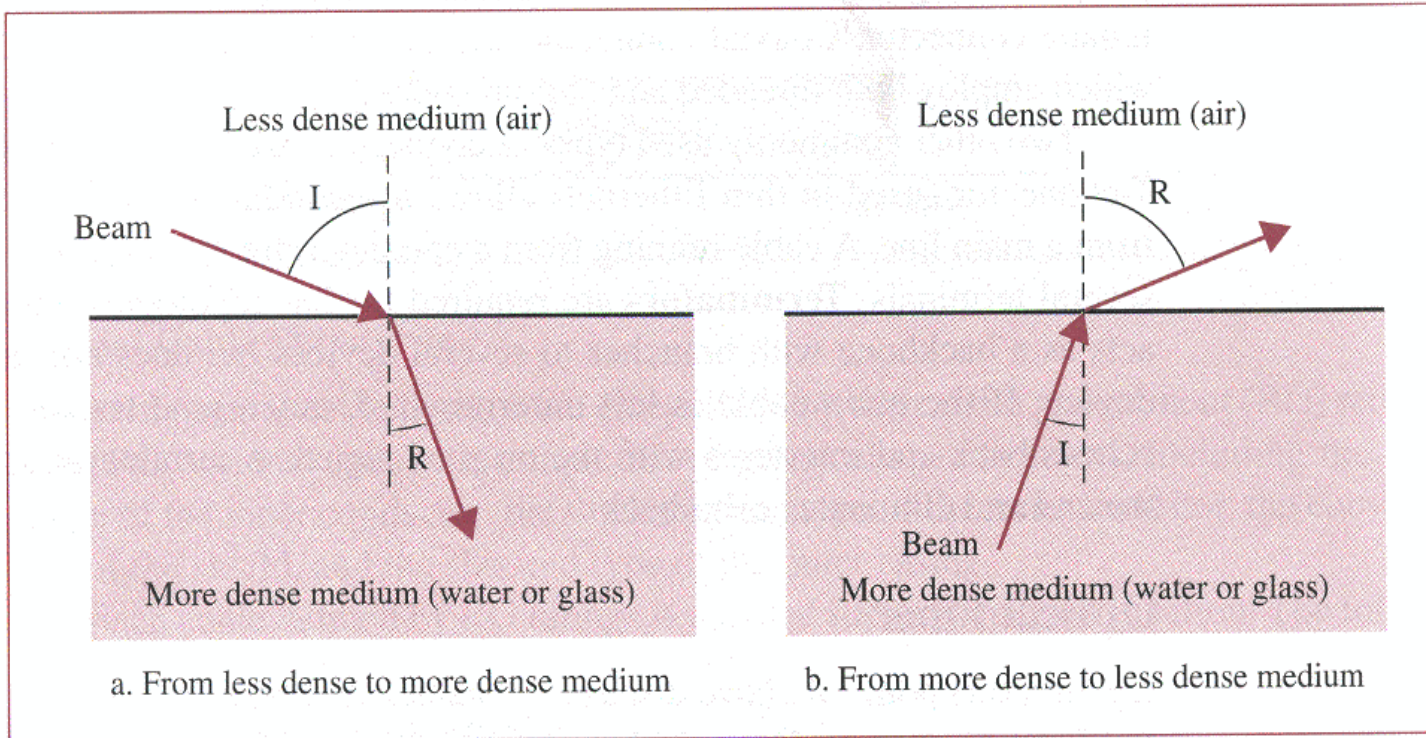
Type	Core	Cladding	Mode
50/125	50	125	Multimode, graded-index
62.5/125	62.5	125	Multimode, graded-index
100/125	100	125	Multimode, graded-index
7/125	7	125	Single-mode

The Nature of the 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 (less or more dense) substance, its speed changes abruptly, causing the ray to change direction. This change is called **refraction**.

Refraction

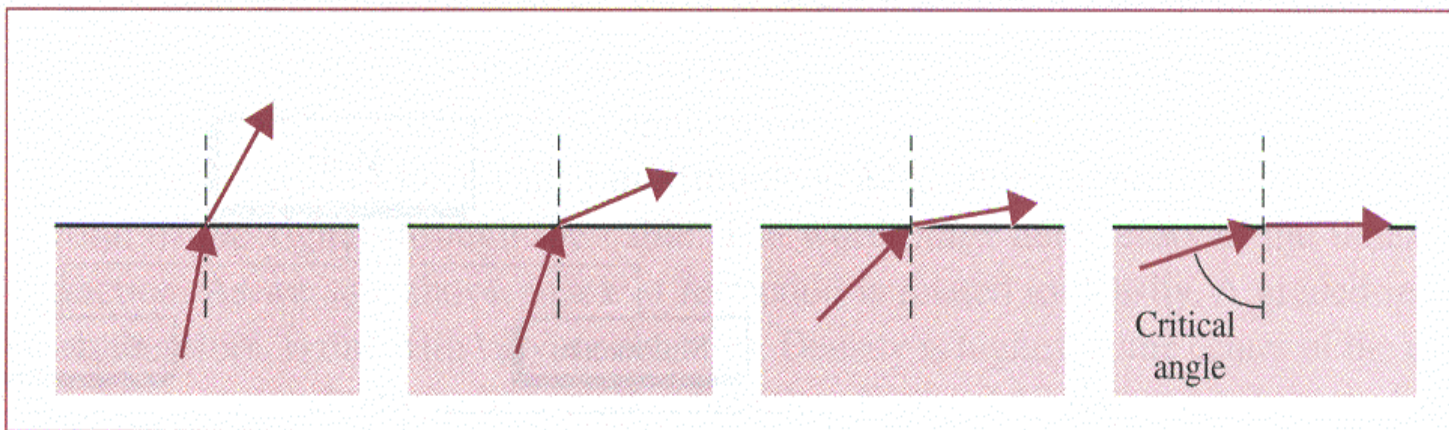
Figure 7.13 Refraction



Critical angle

- If the angle of incidence increases, so does the angle of refraction.
- The **critical angle** is defined to be an angle of incidence for which the angle of refraction is 90 degrees.

Figure 7.14 *Critical angle*



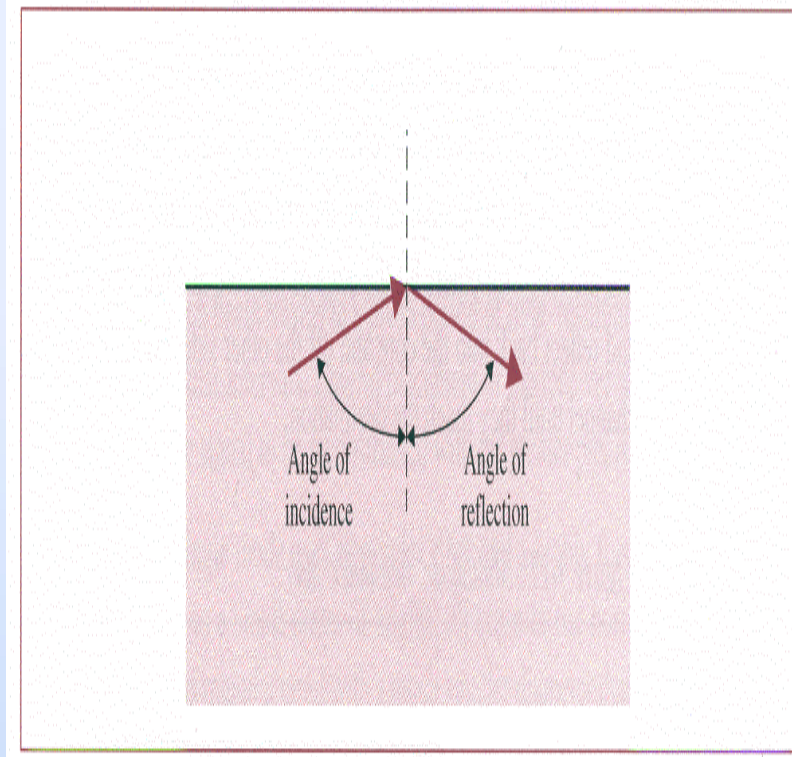
At some point in this process, the change in the incident angle results in a refracted

Reflection

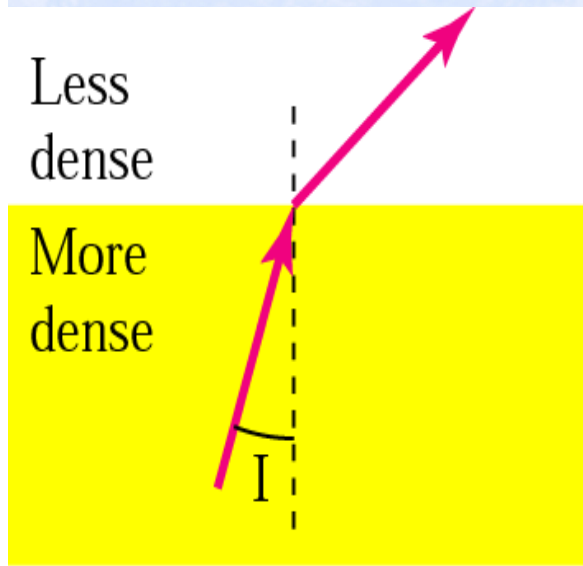
- ✿ When the angle of incidence becomes greater than the critical angle, a new phenomenon occurs called **reflection**.
- ✿ Light no longer passes into the less dense medium at all.

<http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=32>

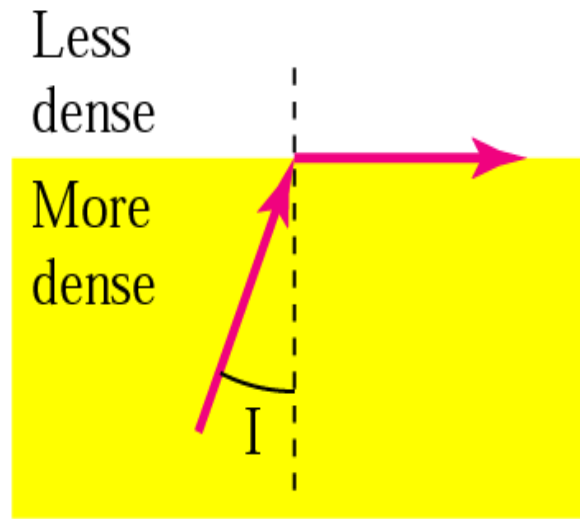
Figure 7.15 Reflection



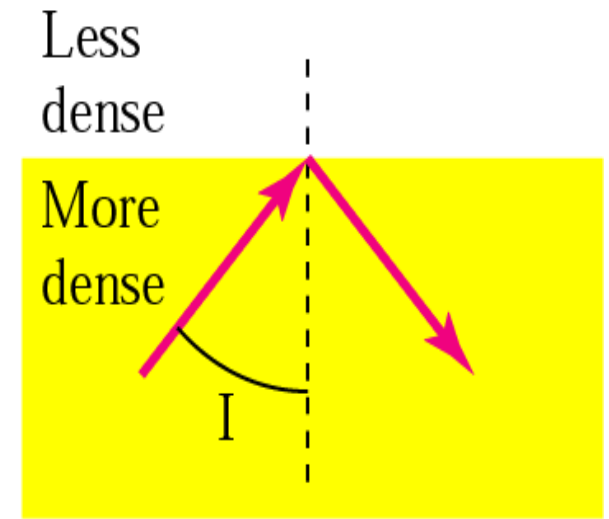
FIBER-OPTIC CABLE



$I < \text{critical angle,}$
refraction



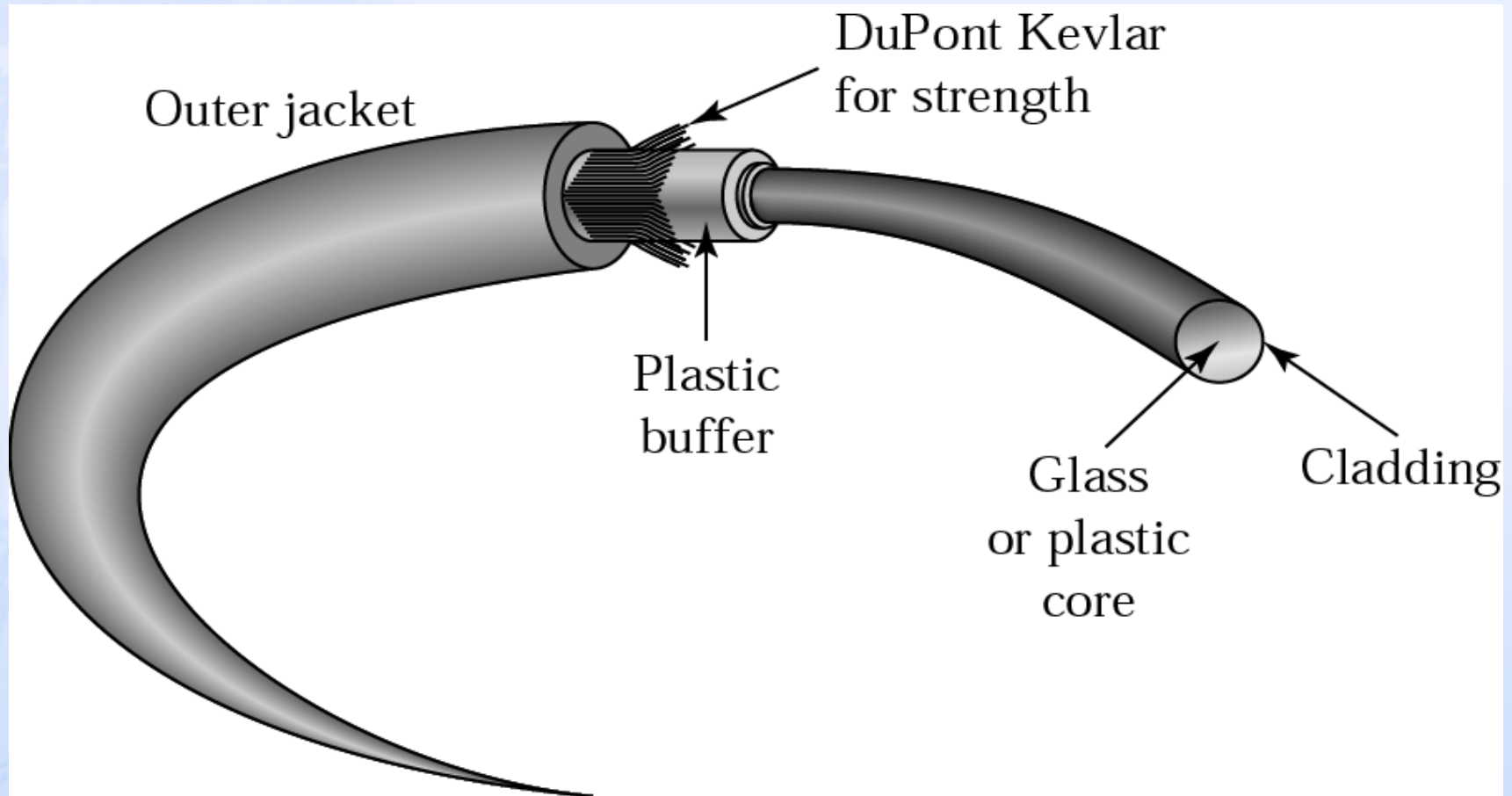
$I = \text{critical angle,}$
refraction



$I > \text{critical angle,}$
reflection

* **Bending of light ray**

Fiber construction

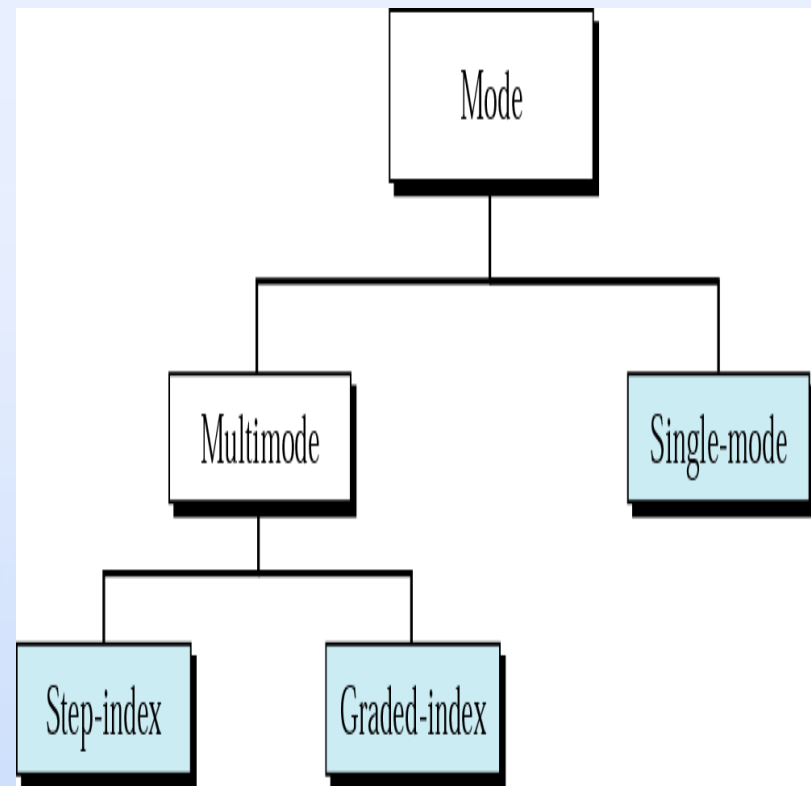


Types of Optical Fiber

- ✿ **There are two basic types of fiber: multimode fiber and single-mode fiber.**
- ✿ **Multimode fiber is best designed for short transmission distances, and is suited for use in LAN systems and video surveillance.**
- ✿ **Single-mode fiber is best designed for longer transmission distances, making it suitable for long-distance telephony and multichannel television broadcast systems.**

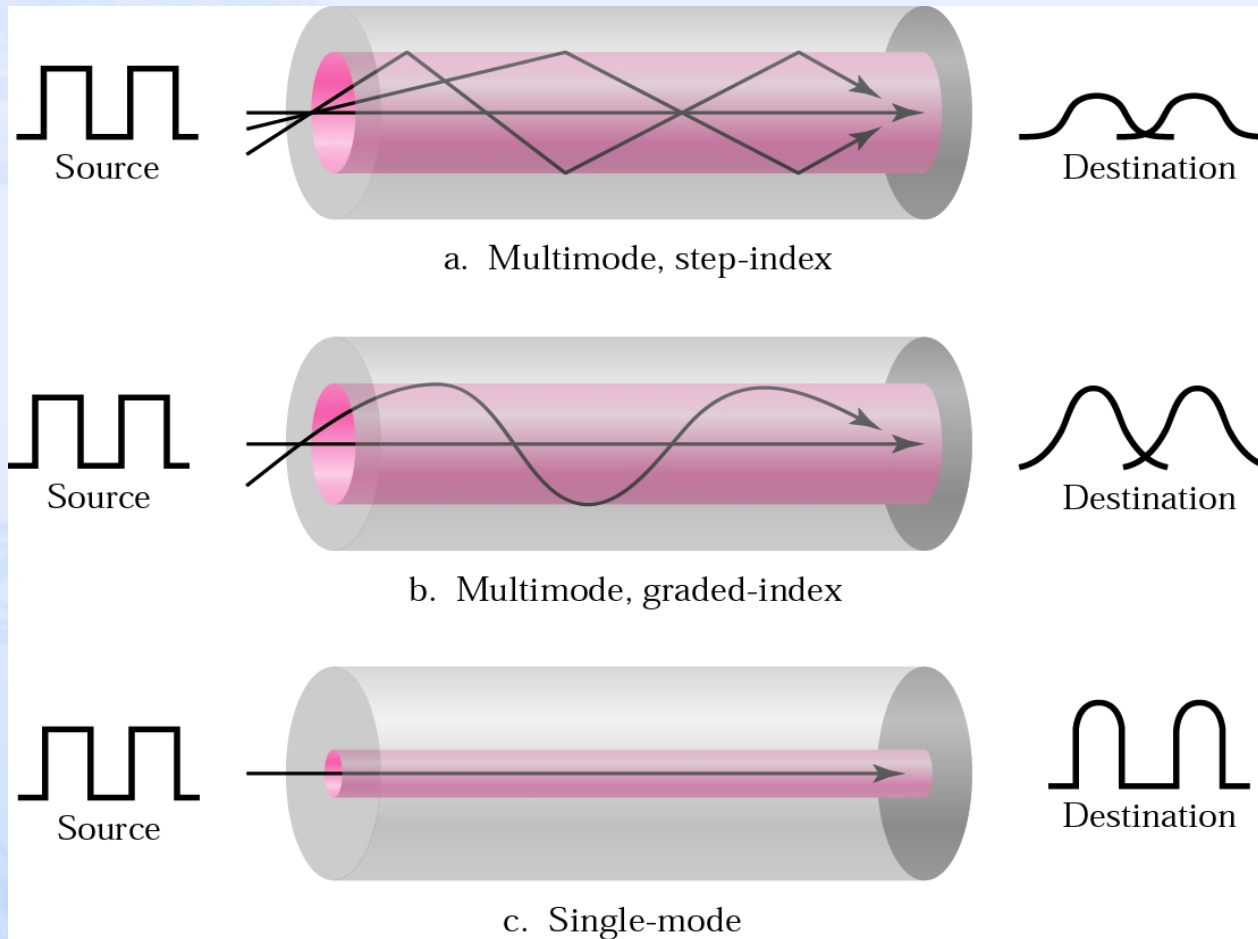
Propagation Modes (Types of Optical Fiber)

- Current technology supports two modes for propagating light along optical channels, each requiring fiber with different physical characteristics: **Multimode and Single Mode.**
- Multimode, in turn, can be implemented in two forms: step-index or graded index.



- ✿ **Multimode:** In this case multiple beams from a light source move through the core in different paths.
- ✿ 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 cladding. At the interface there is an abrupt change to a lower density that alters the angle of the beam's motion.
- ✿ In a **multimode graded-index fiber** the density is highest at the center of the core and decreases gradually to its lowest at the edge.

Propagation Modes



- * **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.

- * **Fiber Sizes**

Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding, both expressed in microns (micrometers)

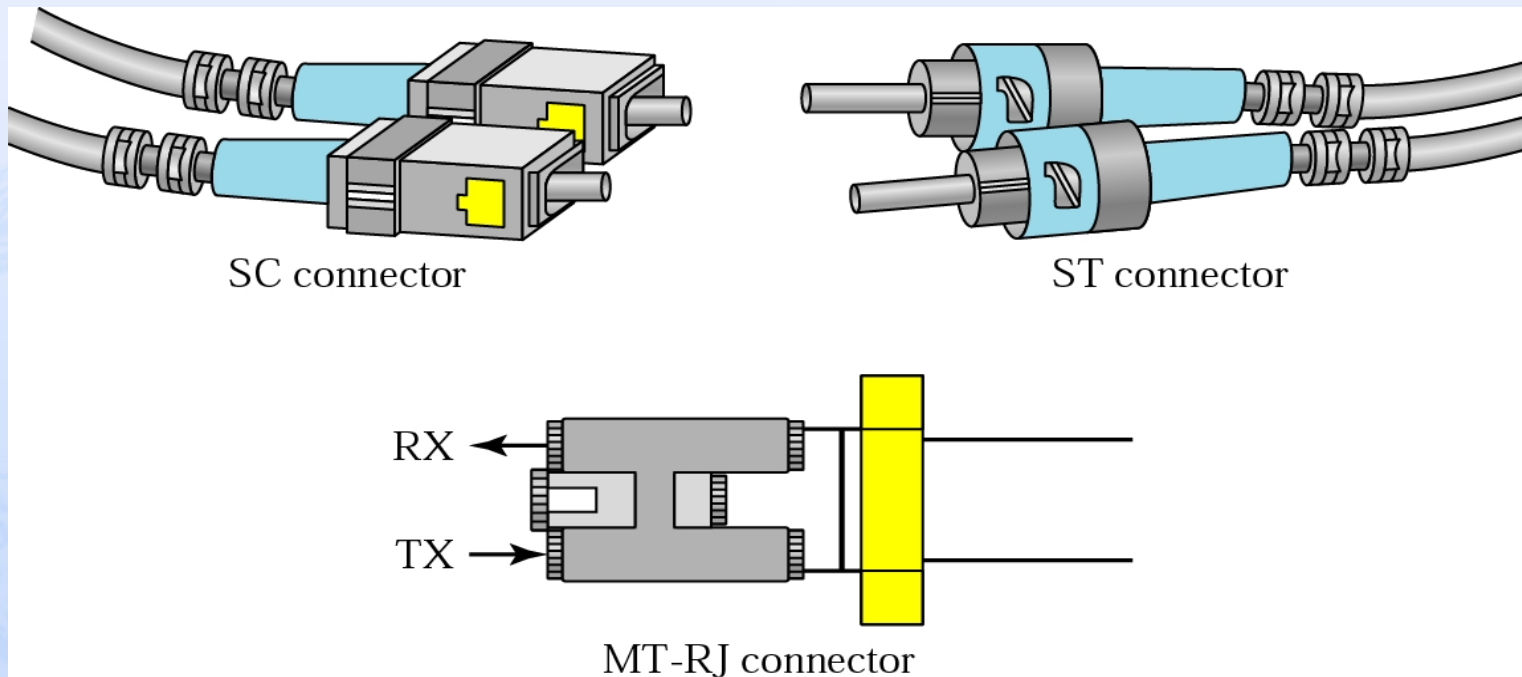
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62.5/125	62.5	125	Multimode, graded-index
100/125	100	125	Multimode, graded-index
7/125	7	125	Single-mode

Light sources for optical fibers

- * The purpose of fiber-optic cable is to contain and direct a beam of light from source to target.
- * The sending device must be equipped with a light source and the receiving device with photosensitive cell (called a photodiode) capable of translating the received light into an electrical signal.
- * The light source can be either a light-emitting diode (LED) or an injection laser diode.

Fiber-optic cable connectors

The subscriber channel (SC) connector is used in cable TV. It uses a push/pull locking system. The straight-tip (ST) connector is used for connecting cable to networking devices. MT-RJ is a new connector with the same size as RJ45.



Advantages of Optical Fiber

- * The major advantages offered by fiber-optic cable over twisted-pair and coaxial cable are **noise resistance, less signal attenuation, and higher bandwidth.**
- * **Noise Resistance:** Because fiber-optic transmission uses light rather than electricity, noise is not a factor. External light, the only possible interference, is blocked from the channel by the outer jacket.

Advantages of Optical Fiber

- ✿ **Less signal attenuation**

Fiber-optic transmission distance is significantly greater than that of other guided media. A signal can run for miles without requiring regeneration.

- ✿ **Higher bandwidth**

Currently, data rates and bandwidth utilization over fiber-optic cable are limited not by the medium but by the signal generation and reception technology available.

Disadvantages of Optical Fiber

- ✿ The main disadvantages of fiber optics are **cost, installation/maintenance, and fragility.**
- ✿ Cost. Fiber-optic cable is expensive. Also, a laser light source can cost thousands of dollars, compared to hundreds of dollars for electrical signal generators.
- ✿ Installation/maintenance
- ✿ Fragility. Glass fiber is more easily broken than wire, making it less useful for applications where hardware portability is required.

Advantages & Disadvantages of fiber-optic Cables

* Advantages

- * Very fast
- * Low Attenuation
- * No EMI

* Disadvantages

- * Hard to install
- * Expensive