CS311: Data Communication

Guided Transmission Media

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Outline of the Lecture

- Transmission Media Classification
- Introduction to Guided Transmission
- Characteristics and Applications of
  - Twisted-Pair Cable
  - Coaxial Cable
  - Optical Fibre Cable

Introduction

- The Shannon-Hartley theorem provides a channel capacity limit based on bandwidth.

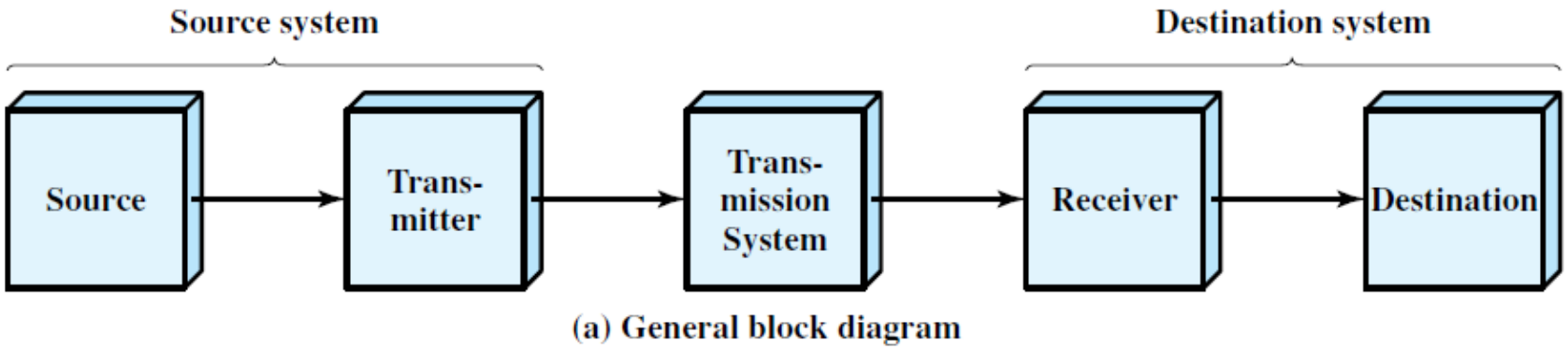
$$C = 2B \log_2 M$$

- The Shannon limit provides a channel capacity based on the signal to noise ratio.

$$C = B \log_2(1 + S/N)$$

- It is very important to study the characteristics of the popular transmission media.

Transmission Medium



(a) General block diagram

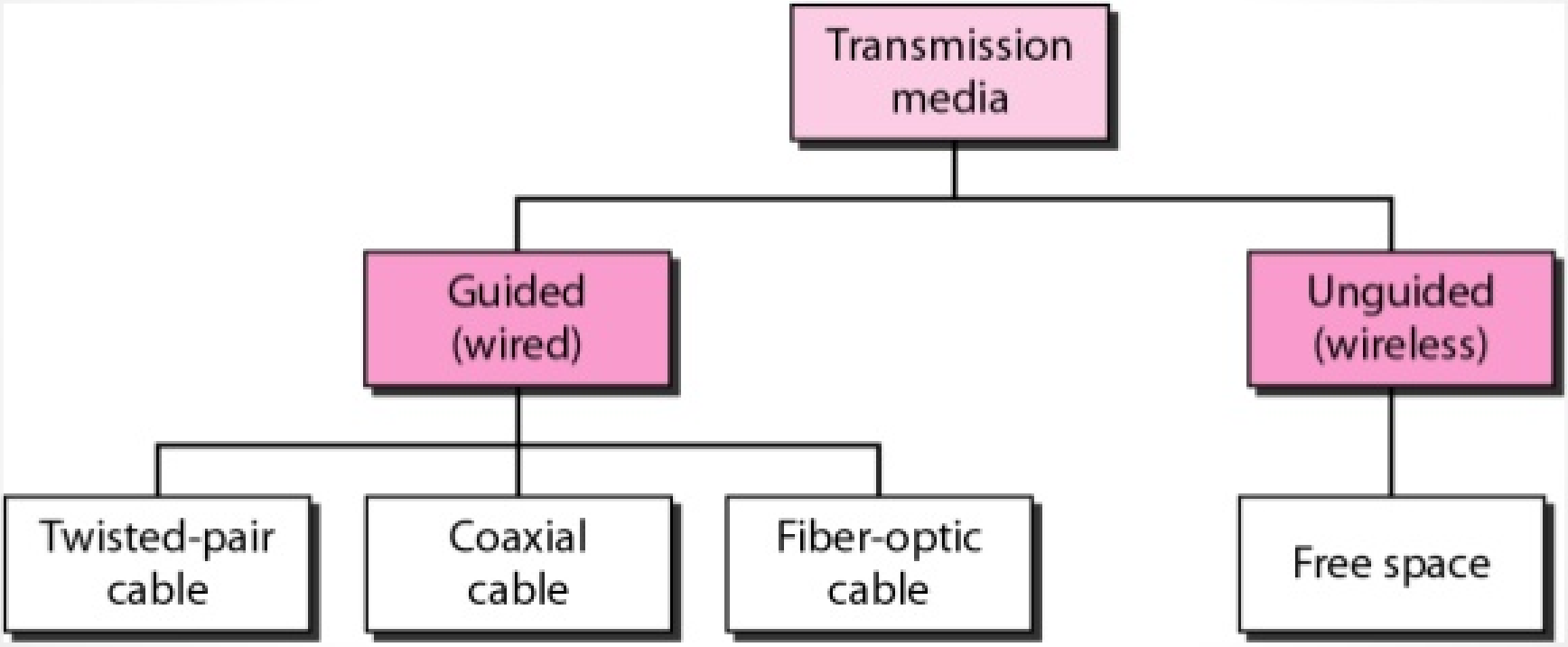
- Physical path between transmitter and the receiver in a data communication system is called the Transmission medium.

Classification of Transmission Media

Transmission Media can be classified into two types, Guided and Un-Guided Media.

- Guided Media: Waves are guided along a solid medium such as copper Twisted Pair, copper Coaxial cable or an Optical Fiber.
- Un-Guided Media: Provides a means for transmitting electro-magnetic signals through air but do not guide them. Can also be termed as Wireless Communication.

Classification of Transmission media

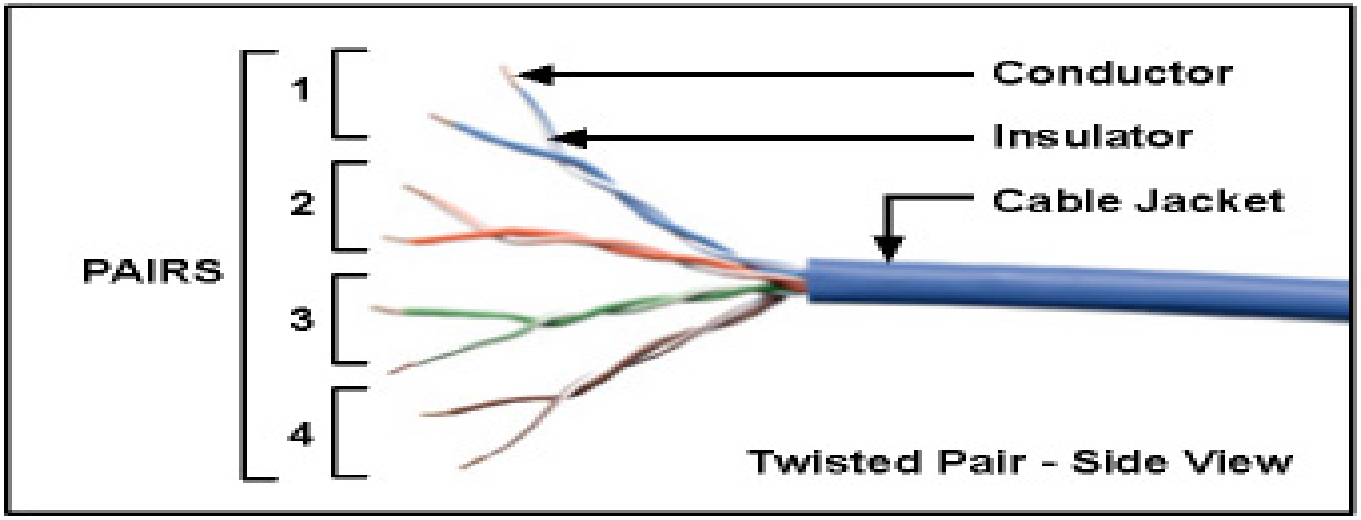


Quality of Transmission

- Characteristics and quality of data transmission are determined by medium and signal characteristics.
- For guided media, the medium is more important in determining the limitations of transmission.
- For un-guided media, the bandwidth of the signal produced by the transmitting antenna is more important than the medium.

Guided Media: Twisted Pair Cable

- A twisted pair cable consists of two insulated copper wires arranged in a regular spiral pattern.
- Typically, a number of pairs are bundled together into a cable by wrapping them in a tough protective sheath.



Guided Media: Twisted Pair Cable

Why Twisting?

- Twisting decreases the crosstalk interference between adjacent pairs in a cable.
- Tighter twisting provides much better performance but also increases the cost.

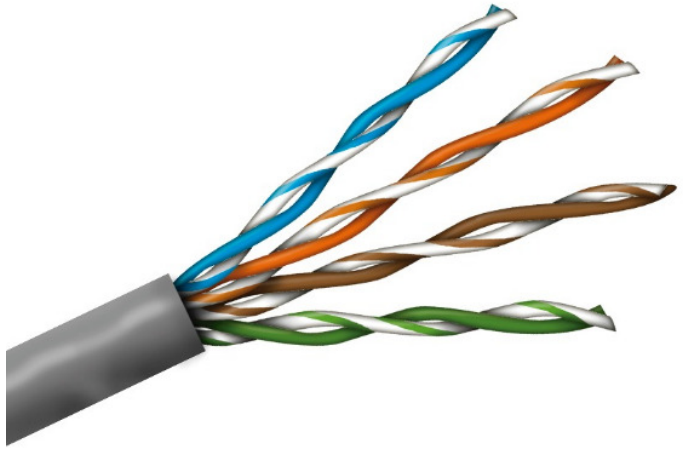


Table 7.1 Categories of unshielded twisted-pair cables

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
6 (draft)	200 MHz	200 Mbps	Digital	LANs
7 (draft)	600 MHz	600 Mbps	Digital	LANs

Guided Media: Twisted Pair Cable

- Two commonly used categories (vide Electronics Industries Association Standard EIA-568) are

  Category 3: up to 16 MHz

  Category 5: up to 100 MHz

- A key difference is the number of twists in the cable per unit distance.

  Category 3 ➔ 3-4 twists per ft.

  Category 5 ➔ 3-4 twists per inch.

Guided Media: Twisted Pair Cable

- Two common types of twisted pair cables are Unshielded Twisted pair (UTP) and Shielded Twisted pair (STP).

Guided Media: Twisted Pair Cable

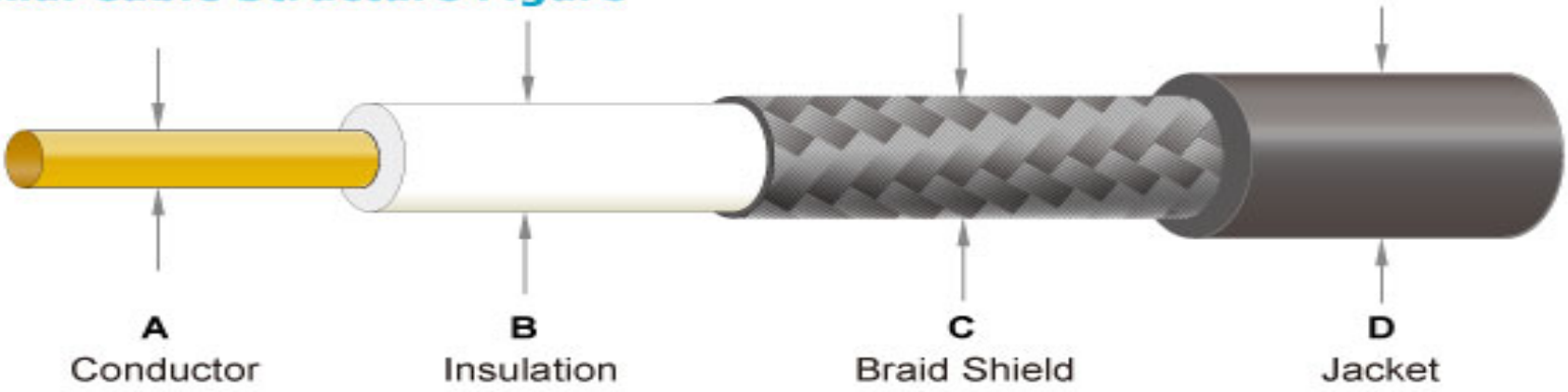
Some common applications of Twisted Pair Cables are listed as below;

- As local loop in telephone lines
- Digital Subscriber Lie (DSL)
- Local Area Networks (10BaseT, 100BaseT)
- Connector Used – RJ45 (8-Lines)

Guided Media: Coaxial Cable

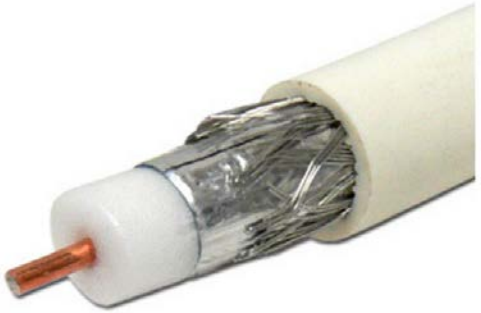
- Consists of a hollow outer cylindrical conductor that surrounds a single inner wire conductor.
- The inner conductor is held in place by either regularly spaced insulating rings or a solid dielectric material.
- The outer conductor is covered with a jacket or a shield.

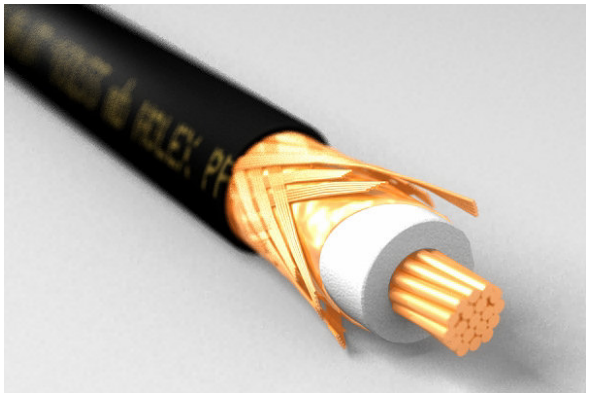
Coaxial Cable Structure Figure



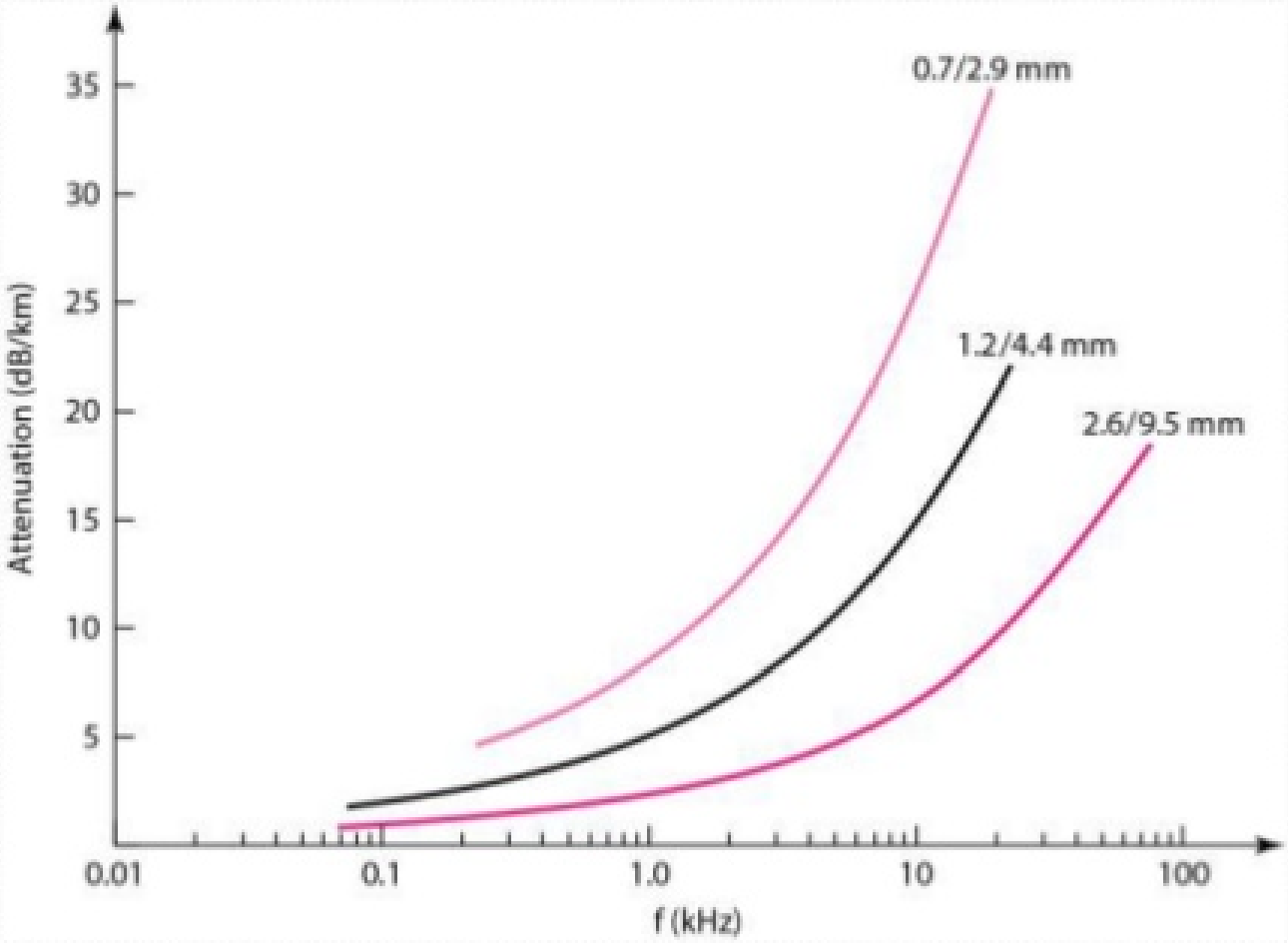
Guided Media: Coaxial Cable

- Due to its shielding, coaxial cables are much less susceptible to interference or crosstalk than twisted pair.





Coaxial cable performance



Guided Media: Coaxial Cable

Some common applications of Coaxial cables are:

- Television distribution (Cable TV)
- Long distance telephone transmission (10,000 voice channels per cable)
- Local Area Networks

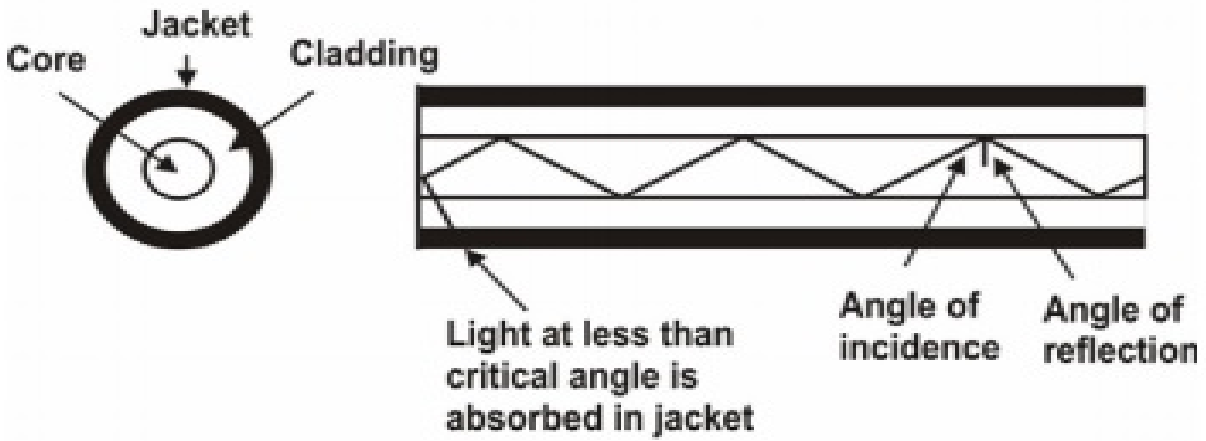
Category	Impedance	Use
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

Guided Media: Optical Fiber

- An Optical Fiber is a thin (2-125 µm), flexible medium capable of conducting an optical ray.
- Made of ultra pure fused silica, glass fiber or even plastic.
- It has a cylindrical shape and consists of three concentric sections: the ***Core***, the ***Cladding*** and the ***Jacket***.

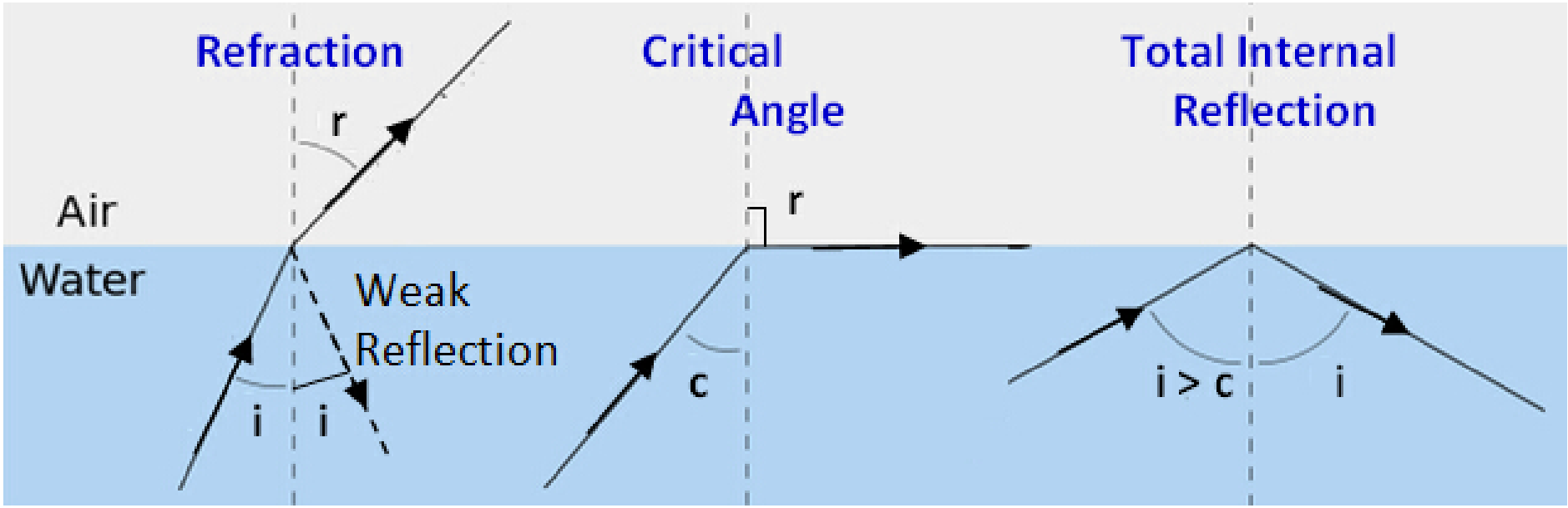
Guided Media: Optical Fiber

- The ***Core*** consists of one very thin strands of fibers made of glass or plastic.
- The ***Cladding*** is a glass or plastic coating that has optical properties different from that of ***Core***.
- The ***Jacket*** surrounds one or a bundle of cladded fibers.

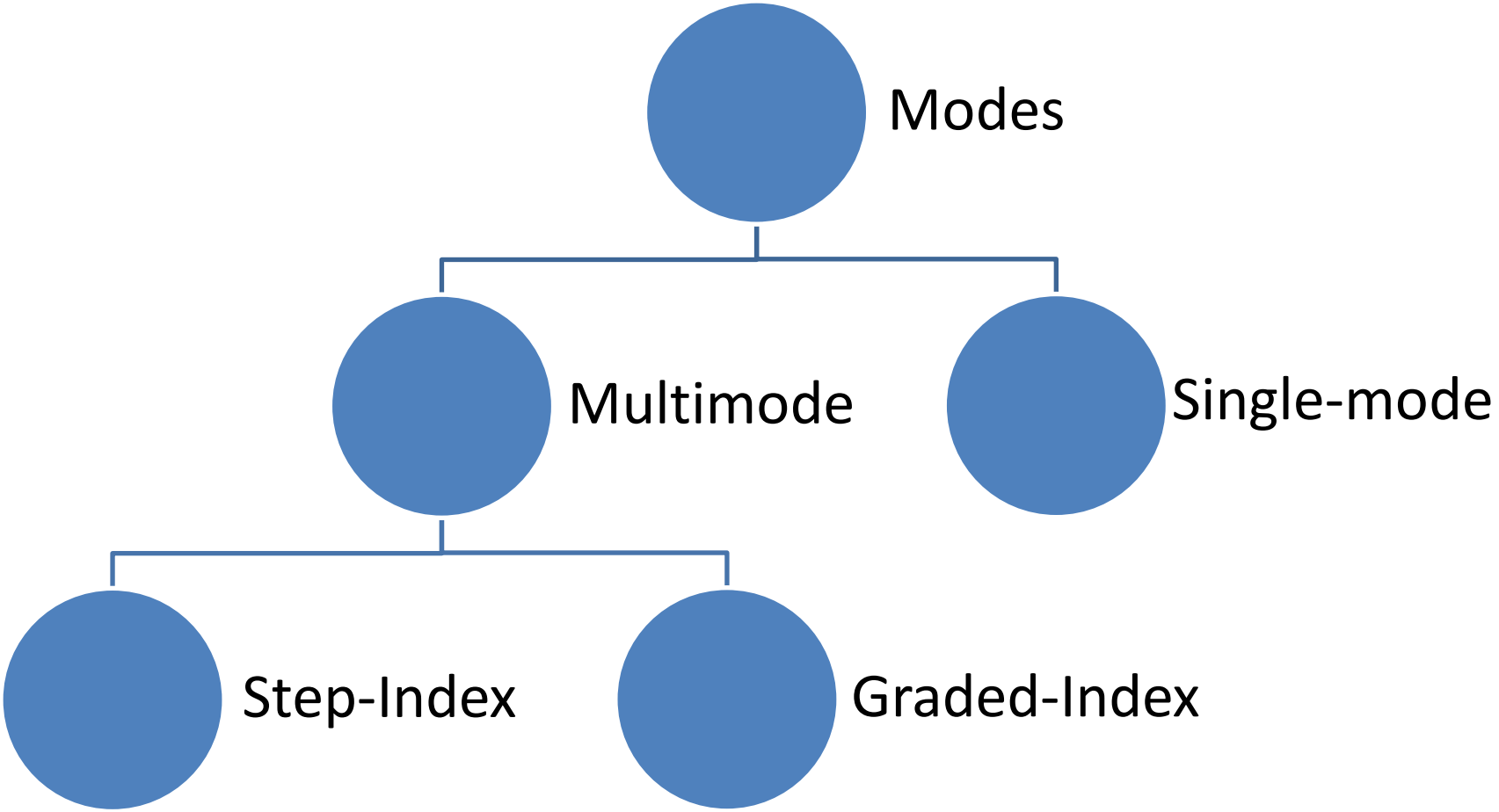


Guided Media: Optical Fiber

How Optical Fiber Works



Guided Media: Optical Fiber



Guided Media: Optical Fiber

- ***Multimode:*** Refers to the variety of angles that will reflect. Multiple propagation path exists, signal elements spread out in time and hence limits the data rate.
- ***Single-Mode:*** When the fiber core radius is reduced, fewer angles will reflect. By reducing the radius of the core to the order of a wavelength, only a single angle or mode can pass (the axial ray).
- ***Multimode Graded Index:*** By varying the refractive index of the core, rays may be focused more efficiently than multimode.

Guided Media: Optical Fiber

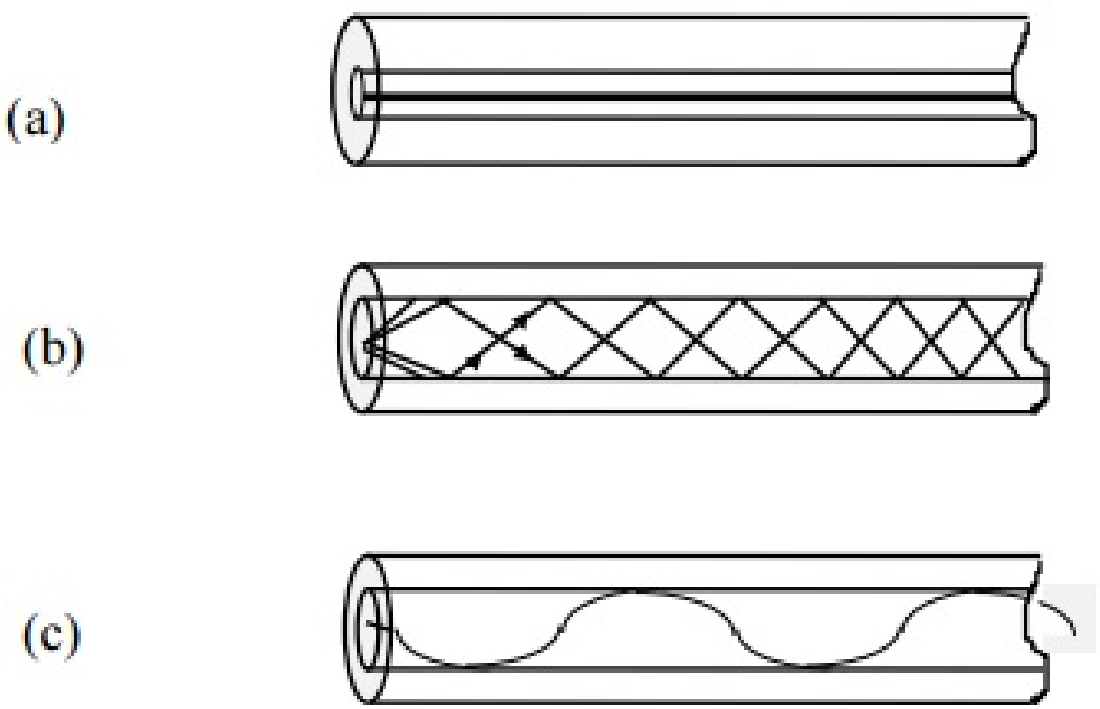


Figure 2.2.5 *Schematics of three optical fiber types, (a) Single-mode step-index, (b) Multi-mode step-index, and (c) Multi-mode graded-index*

Guided Media: Optical Fiber

Type	Core (µm)	Cladding (µm)	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

Numerical Aperture

- An important parameter is the **Numerical Aperture (NA)**
- **NA =** $(n_1^2 - n_2^2)^{1/2}$ **=** $n_1(2\Delta)^{1/2}$
- where Δ is the core-cladding index difference $n_2 = n_1(1-\Delta)$
- n_2 is chosen such that Δ is normally 0.01
- For fibers made of silica, n_1 = 1.48

Light Sources and Detectors

- Light Emitting Diode (LED)
  - Cheaper
  - Greater Temperature Range
  - Longer Life
  - Shorter distance
  - Power coupled: 25 µW (50 µW)
- Injection Laser Diode (ILD)
  - Costlier
  - More efficient
  - Allows longer distance
  - Power coupled: 1.0 mW (Monomode)
- Detectors:
  - PIN Photo Detector
  - Avalanche Photo Diode (APD)

Advantages of Optical Fiber

- Higher bandwidth leading to greater capacity (2Gbps over tens of kilometers)

  Long haul fiber transmission is becoming increasingly common in the telephone network.
- Smaller size and lighter weight
- Lower attenuation
- Resistance to corrosive material
- Immune to electromagnetic interference
- Greater repeater spacing

Comparison

Medium	Cost	Bandwidth, Data Rate	Attenuation	EMI	Security
UTP	Low	3 MHz, 4 Mbps	High, 2-10 Km	High	Low
Coaxial	Moderate	350 MHz, 500 Mbps	Moderate, 1-10 Km	Moderate	Low
Optical Fiber	High	2 GHz, 2 Gbps	Low, 10-100 Km	Low	High

Differences between:

Coaxial Cable

- transmission of signals happens in the electrical form over the inner conductor of the cable
- higher noise immunity than twisted-pair cable
- moderate cost
- moderately high bandwidth
- low attenuation
- easy to install
- get disturbed by external magnetic field

Twisted-Pair Cable

- transmission of signals happens in the electrical form over the metallic conducting wires
- low noise immunity
- cheapest
- low bandwidth
- very high attenuation
- easy to install
- get disturbed by external magnetic field

Fiber-Optic Cable

- signal transmission happens in optical forms over a glass fiber
- highest noise immunity
- expensive
- very high bandwidth
- very low attenuation
- difficult to install
- not affected by the external magnetic field
- most efficient
- glass fibler

Thanks!