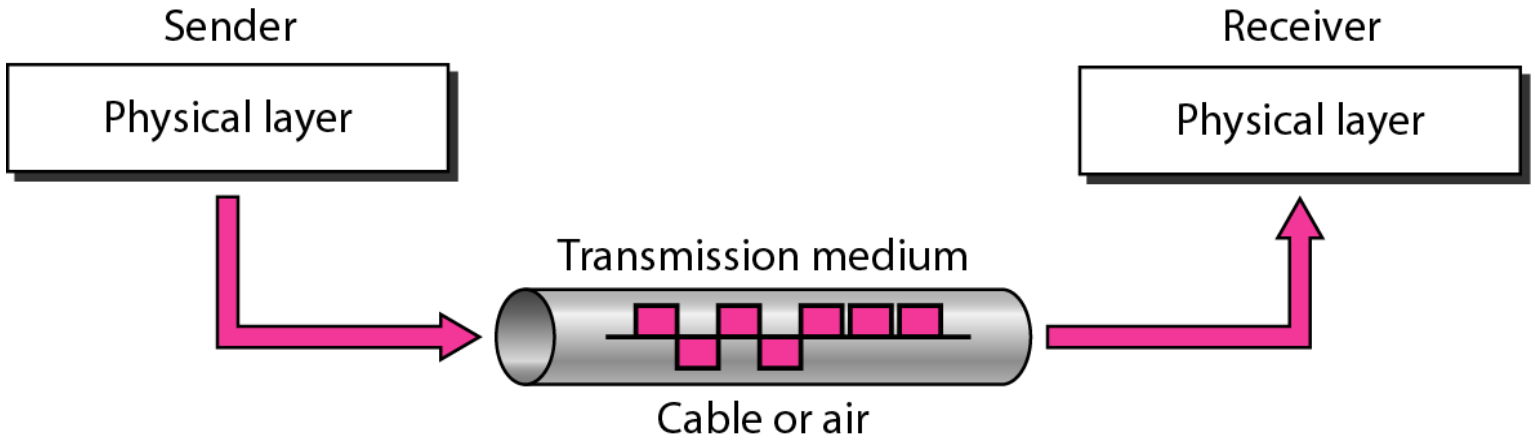
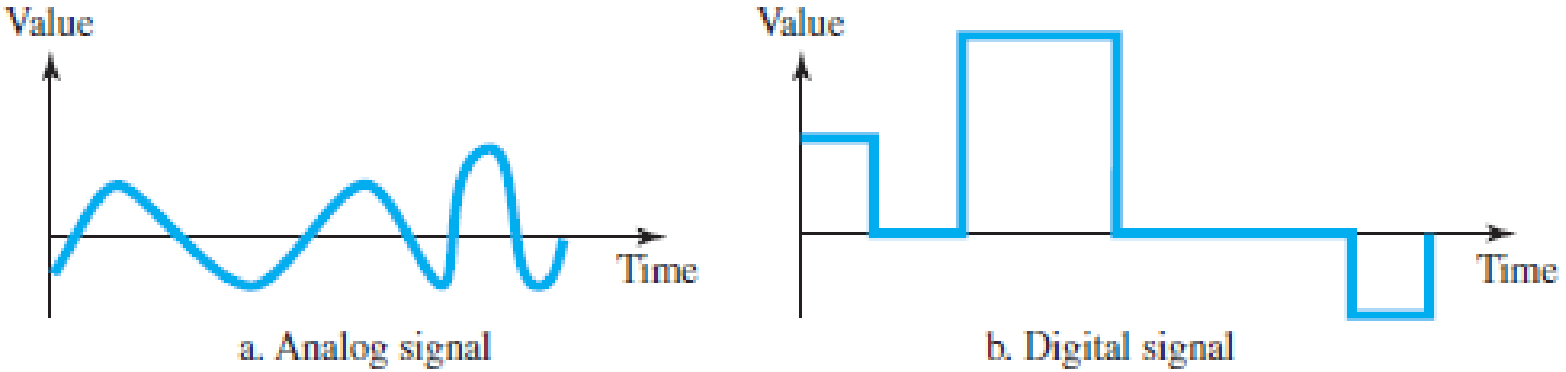
Physical Layer

Transmission Media

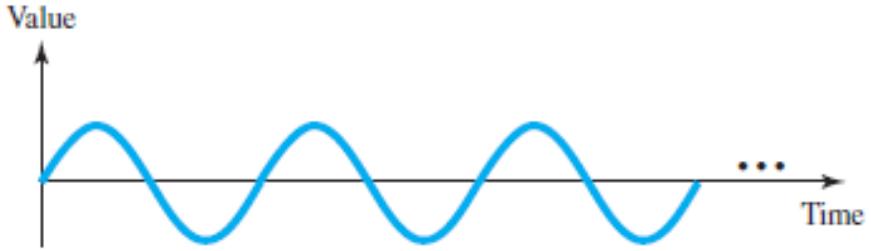
- Transmission media are actually located below the physical layer and are directly controlled by the physical layer.
- A **transmission medium** can be broadly defined as anything that can carry information from a source to a destination.
- The transmission medium is usually free space, metallic cable, or fiber-optic cable.
- The information is usually a signal that is the result of a conversion of data from another form.



- Data can be analog or digital.
  - **Analog data** refers to information that is continuous; For example, Analog data, such as the sounds made by a human voice, take on continuous values.
  - **Digital data** refers to information that has discrete states. For example, data are stored in computer memory in the form of 0s and 1s.
- Signals can be either analog or digital.
  - An analog signal has infinitely many levels of intensity over a period of time. As the wave moves from value A to value B, it passes through and includes an infinite number of values along its path.
  - A digital signal, on the other hand, can have only a limited number of defined values. Although each value can be any number, it is often as simple as 1 and 0.



- Both analog and digital signals can take one of two forms: *periodic* or *nonperiodic*
  - A **periodic signal** completes a pattern within a measurable time frame, called a **period,** and repeats that pattern over subsequent identical periods.
  - A **nonperiodic signal** changes without exhibiting a pattern or cycle that repeats over time.
- In data communications, we commonly use periodic analog signals and nonperiodic digital signals

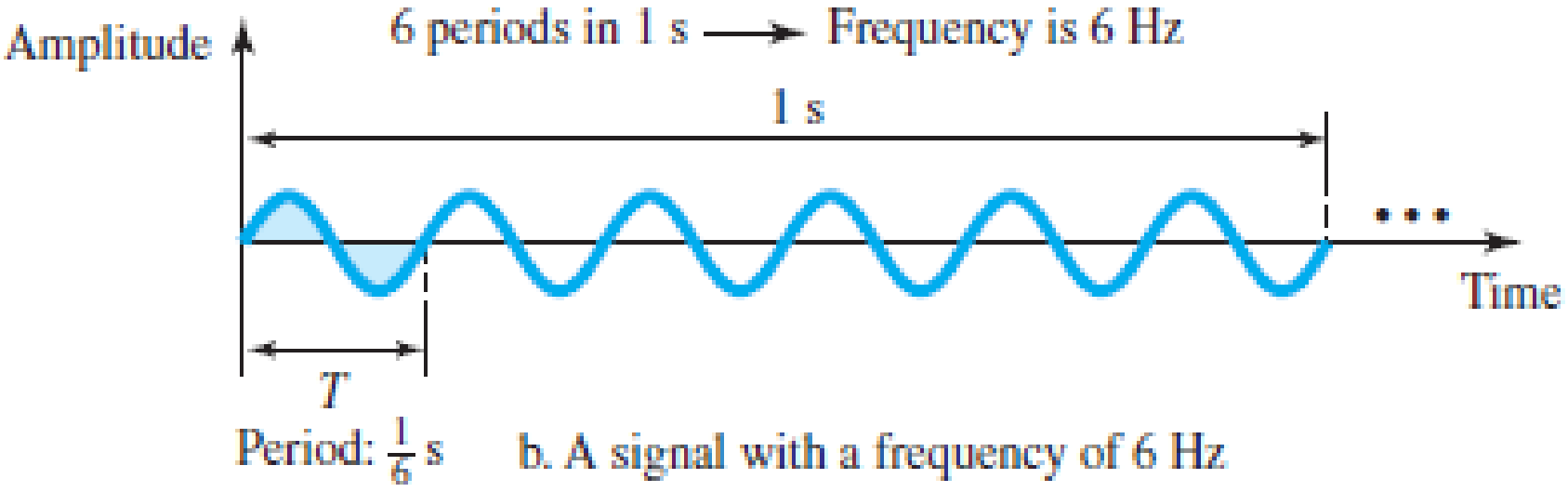


Analog Signal

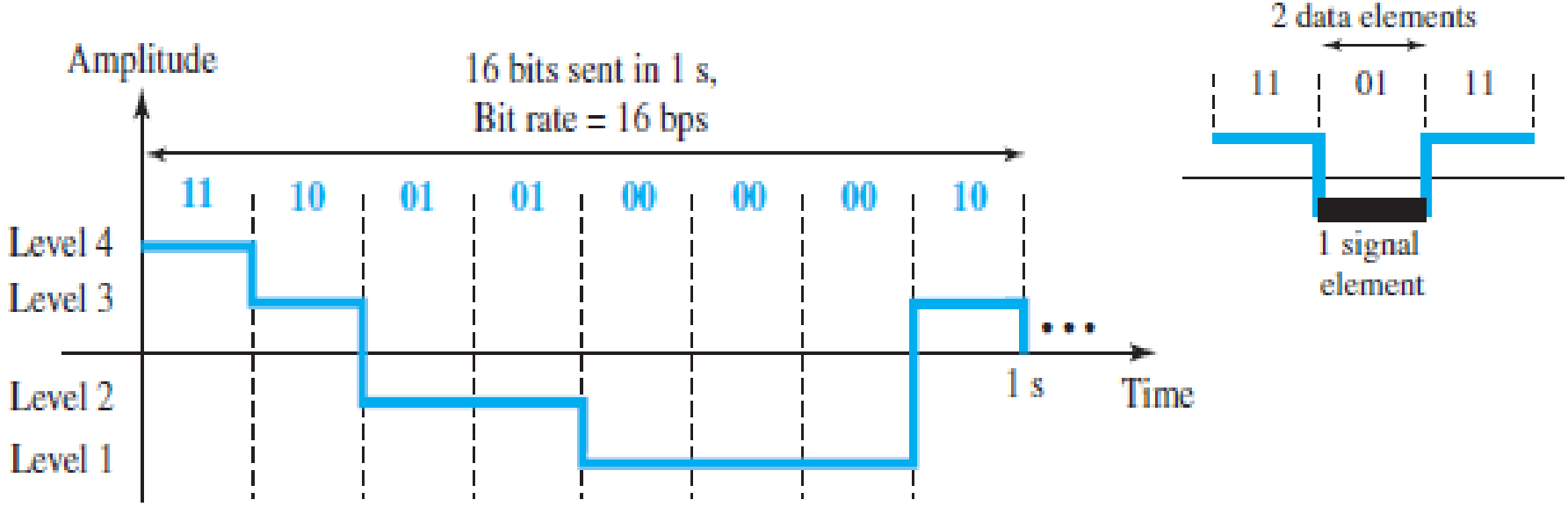
- Sine Wave
- Cycle
- Period
- *Peak Amplitude*
- *Frequency*
- *Phase*
- Wavelength
- Composite Signals
- Bandwidth

Digital Signal

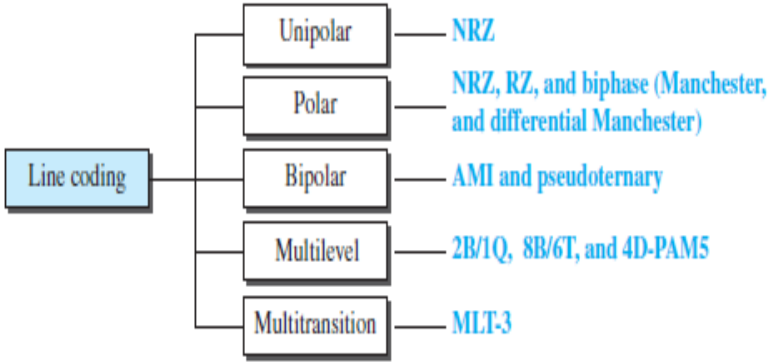
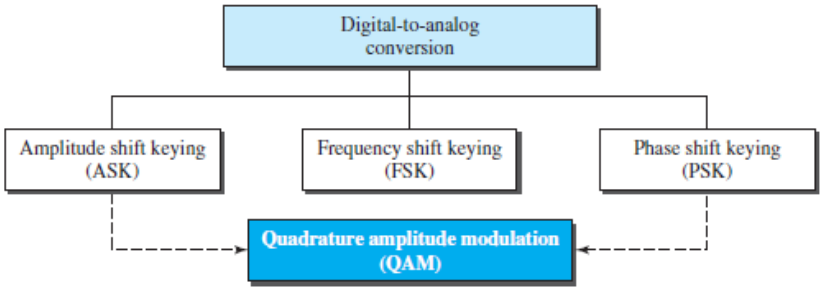
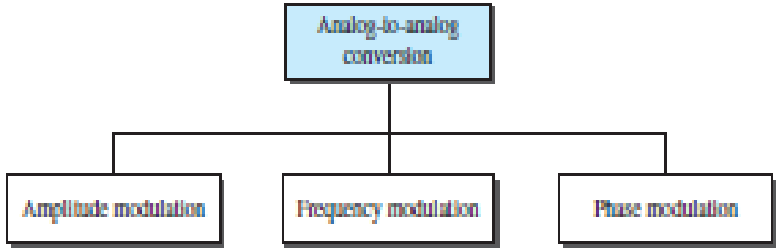
- Discrete Period
- Level
- Signal Element
- Signal Rate
- Data Element
- Bit duration
- *Bit rate*
- Bit length
- Bandwidth(Data Rate)



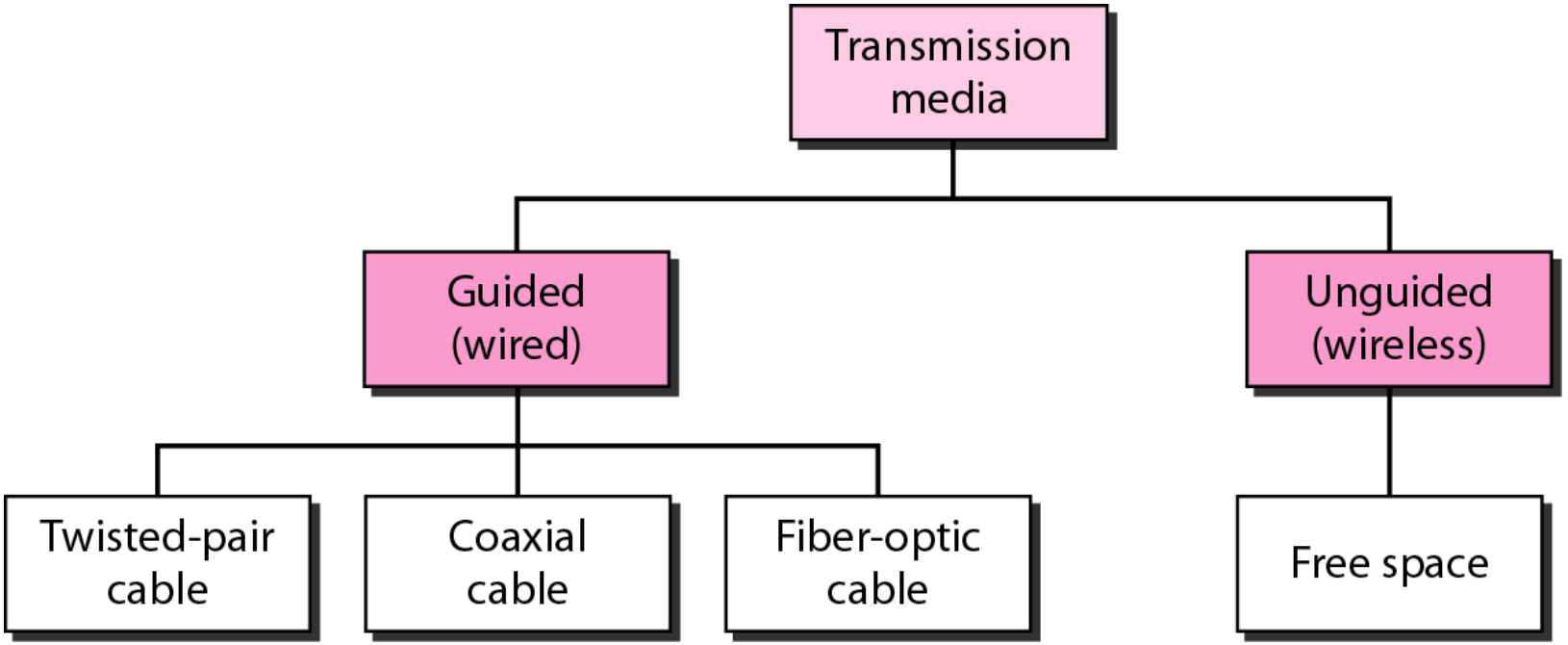
b. A signal with a frequency of 6 Hz



b. A digital signal with four levels

	Digital Signal	Analog Signal
Digital Data		
Analog Data	**Pulse Code Modulation (PCM)** **Delta Modulation (DM)**	

Classes of Transmission Media



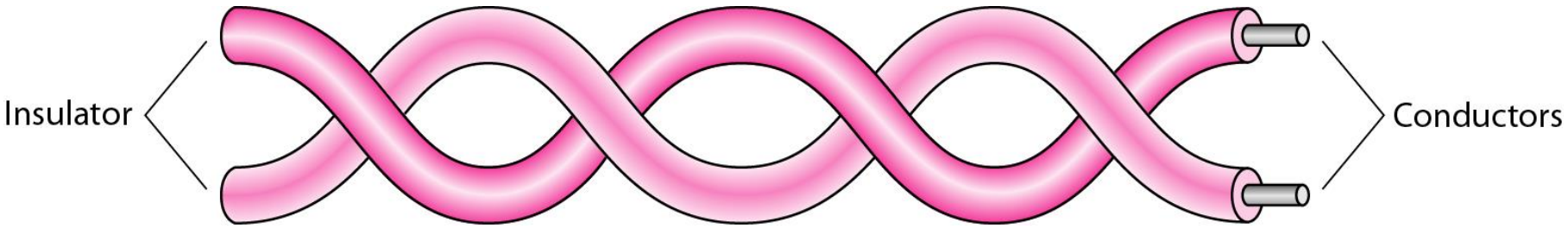
GUIDED MEDIA

Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable.

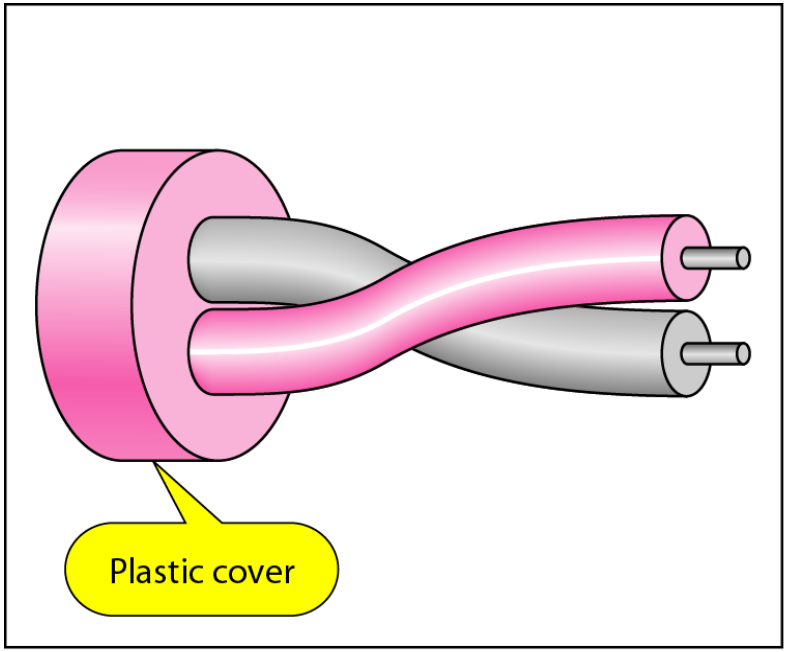
Twisted-Pair Cable
Coaxial Cable
Fiber-Optic Cable

Twisted-pair cable

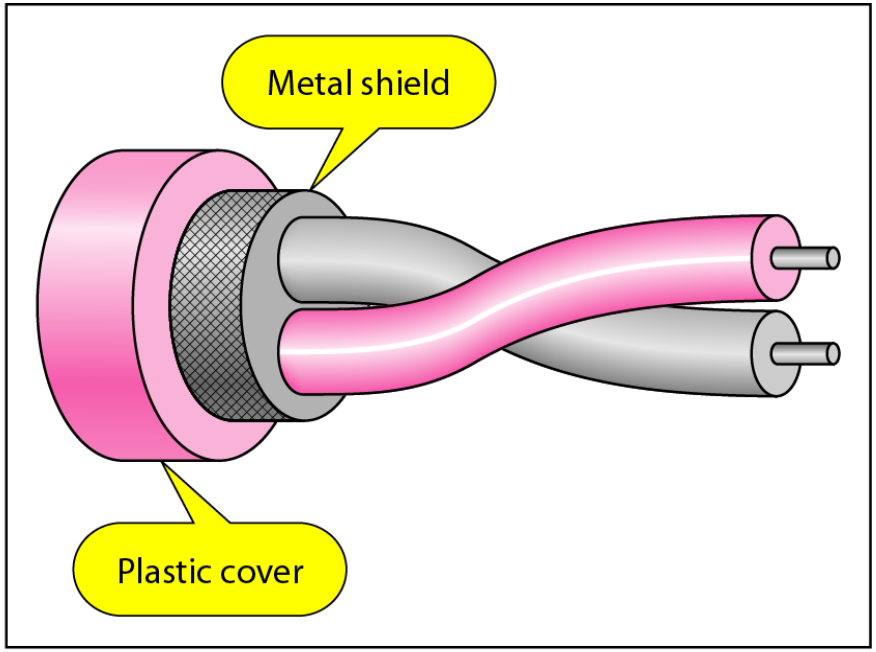
A twisted pair consists of two conductors (normally copper), each with its own plastic Insulation. One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference



UTP and STP cables

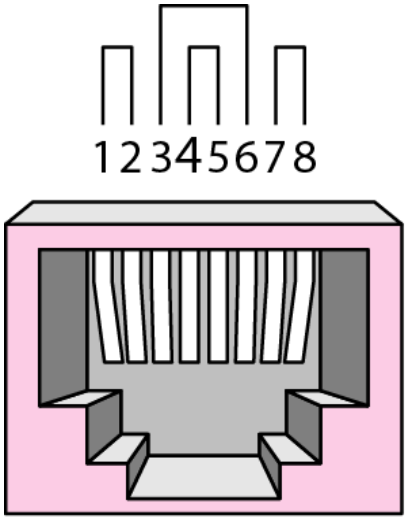


a. UTP

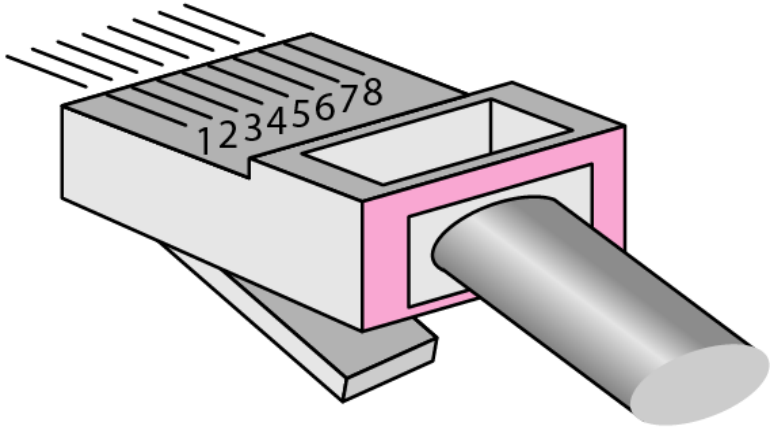


b. STP

UTP connector



RJ-45 Female



RJ-45 Male

Categories of unshielded twisted-pair 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. The 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 decreases the effect of crosstalk and increases the data rate.	600	LANs

Twisted Pair performance

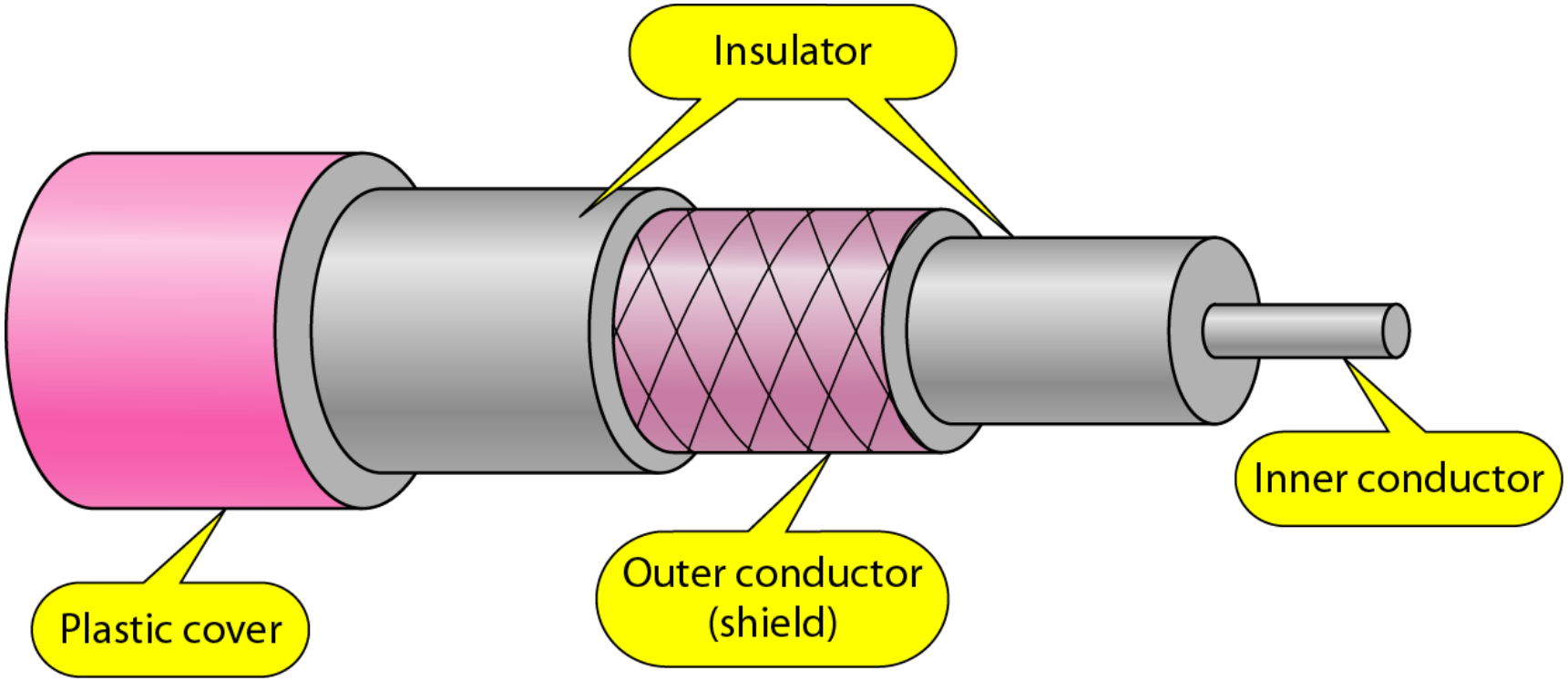
One way to measure the performance of twisted-pair cable is to compare attenuation versus frequency and distance.

Twisted Pair Applications

- Twisted-pair cables are used in telephone lines to provide voice and data channels.
- Local-area networks, such as 10Base-T and 100Base-T, also use twisted-pair cables.

Coaxial cable

Coaxial cable (or *coax*) carries signals of higher frequency ranges than those in twistedpair cable



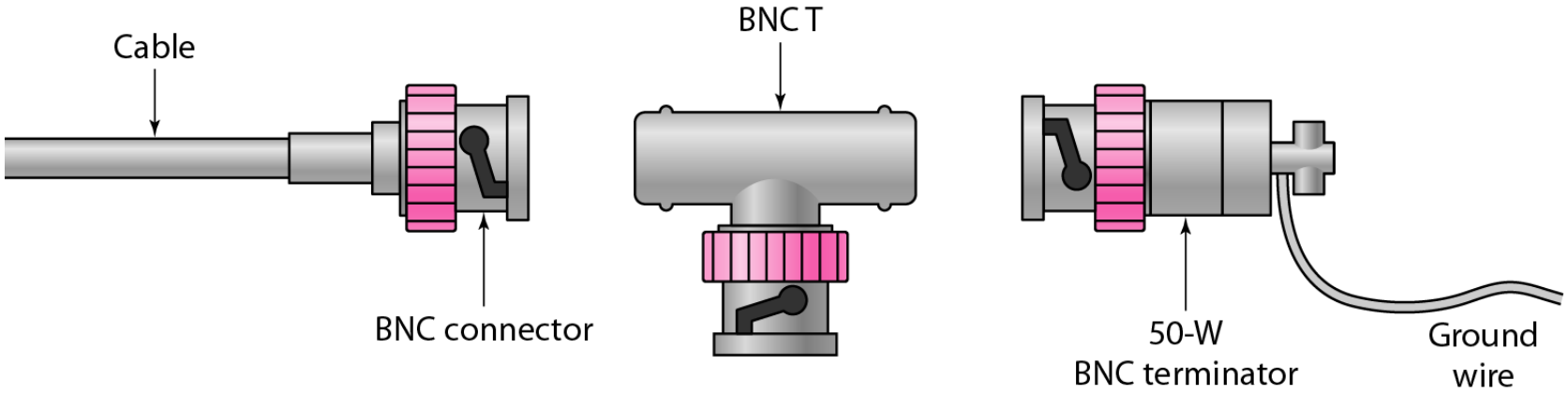
Categories of coaxial cables

- 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 conductor, the thickness and type of the inner insulator, the construction of the shield, and the size and type of the outer casing.

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

BNC connectors

The most common type of connector used today is the **Bayonet Neill-Concelman (BNC)** connector.

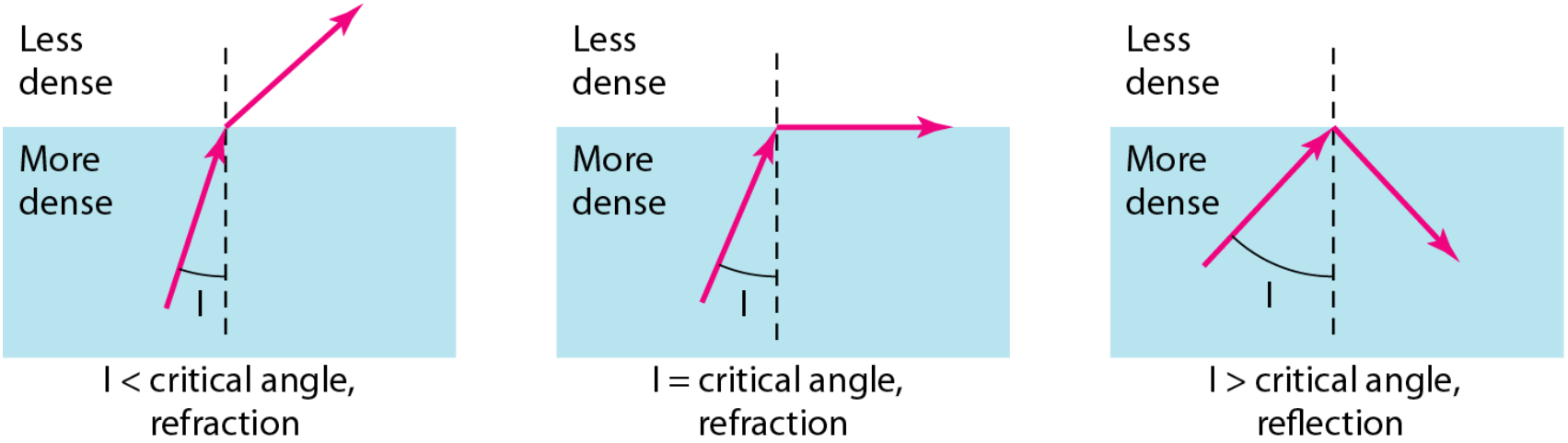


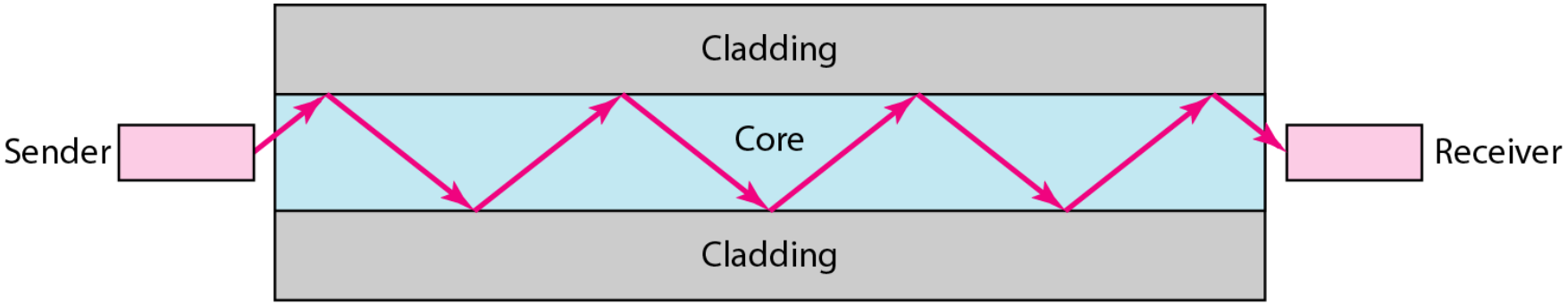
Applications

- Coaxial cable was widely used in analog telephone networks where a single coaxial network could carry 10,000 voice signals.
- Later it was used in digital telephone networks where a single coaxial cable could carry digital data up to 600 Mbps.

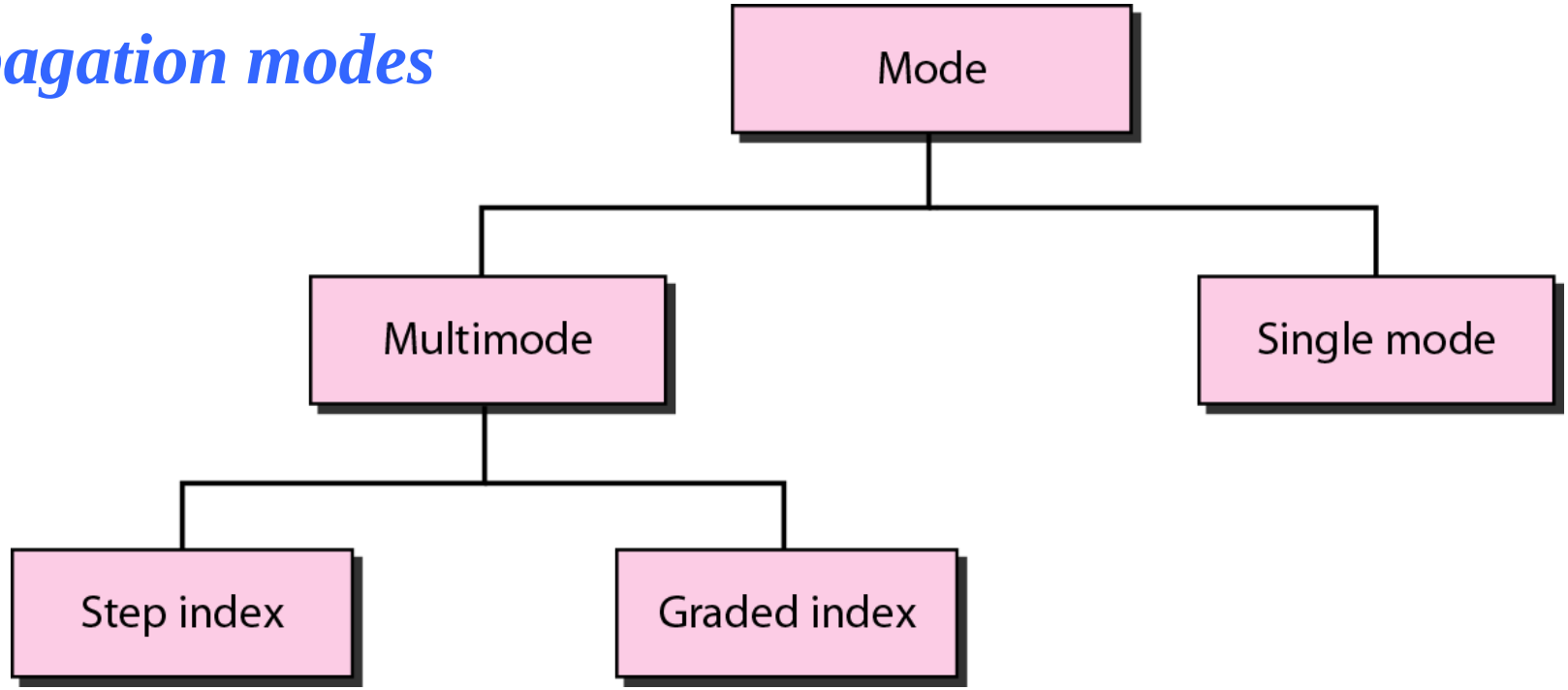
Fiber optics

A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.



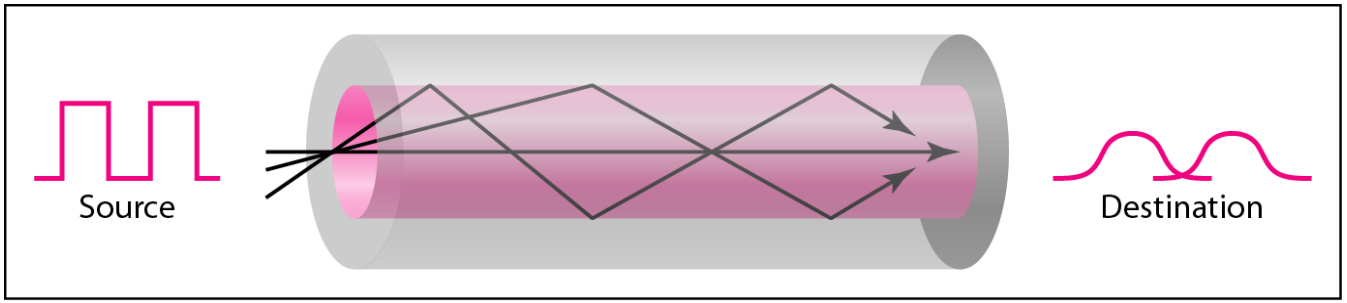


Propagation modes

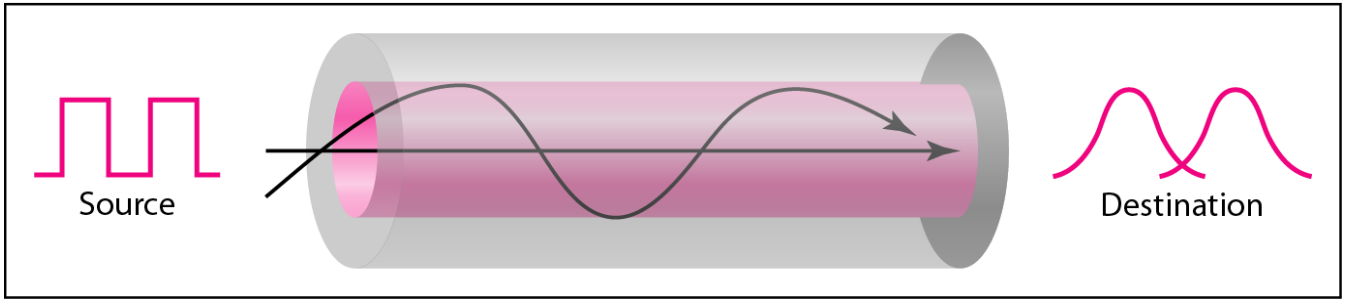


Multimode is so named because multiple beams from a light source move through the core in different paths.

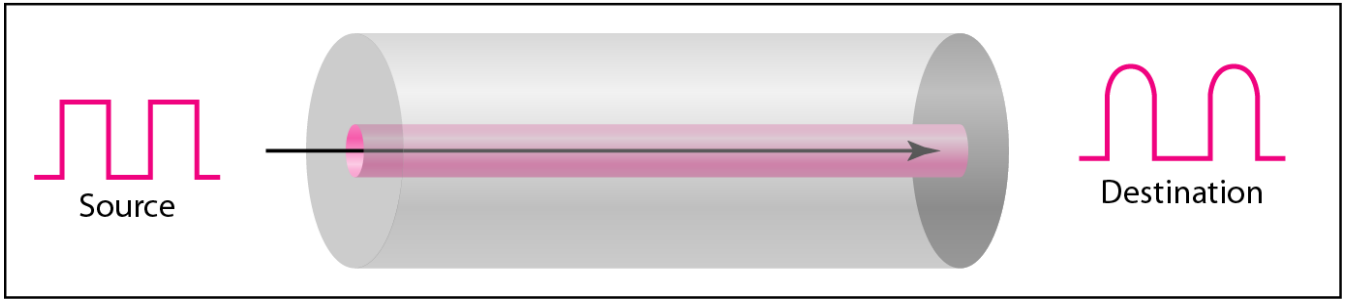
Modes



a. Multimode, step index



b. Multimode, graded index



c. Single mode

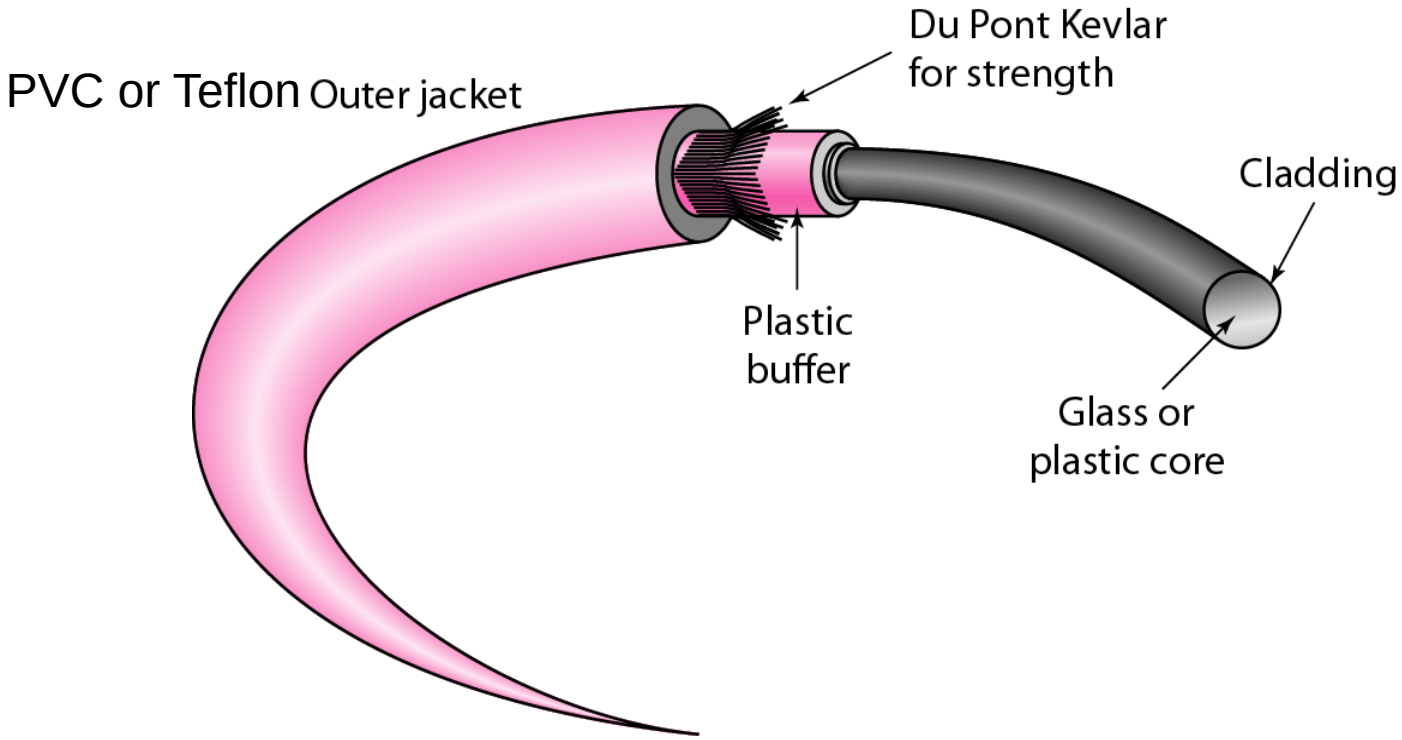
Density of the core remains constant from the center to the edges.

Density is highest at the center of the core and decreases gradually to its lowest at the edge.

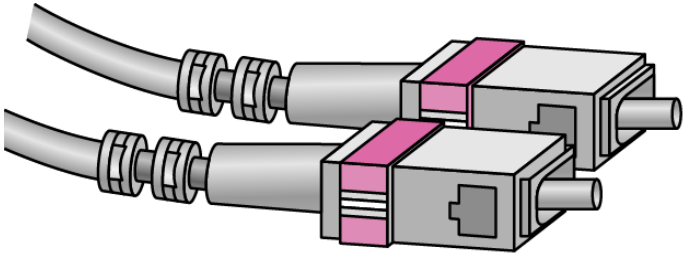
Smaller diameter and with substantially lower density

Fiber types

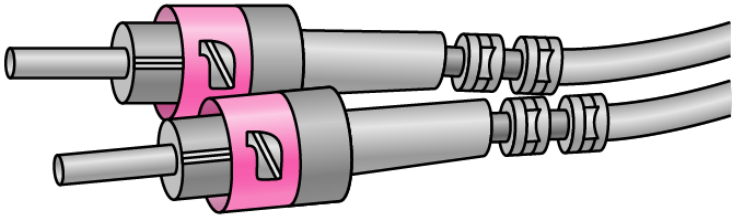
Type	*Core (μm)*	*Cladding (μm)*	*Mode*
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	Multimode, graded index
100/125	100.0	125	Multimode, graded index
7/125	7.0	125	Single mode



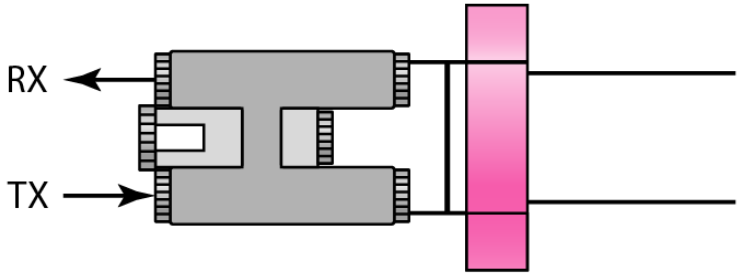
Fiber-optic cable connectors



SC connector



ST connector



MT-RJ connector

Applications

- Fiber-optic cable is often found in backbone networks because its wide bandwidth is cost-effective. Today, with wavelength-division multiplexing (WDM), we can transfer data at a rate of 1600 Gbps.
- Some cable TV companies use a combination of optical fiber and coaxial cable, thus creating a hybrid network.

Advantages

- Higher bandwidth.
- Less signal attenuation
- Immunity to electromagnetic interference
- Resistance to corrosive materials
- Light weight
- Greater immunity to tapping

Disadvantages

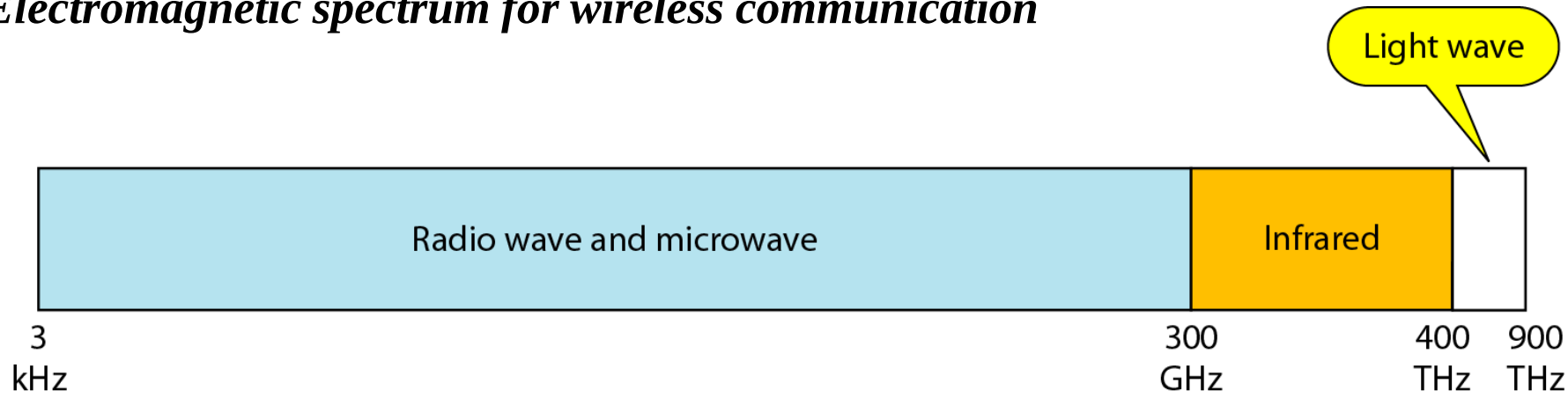
- Installation and maintenance
- Unidirectional light propagation
- Cost

UNGUIDED MEDIA: WIRELESS

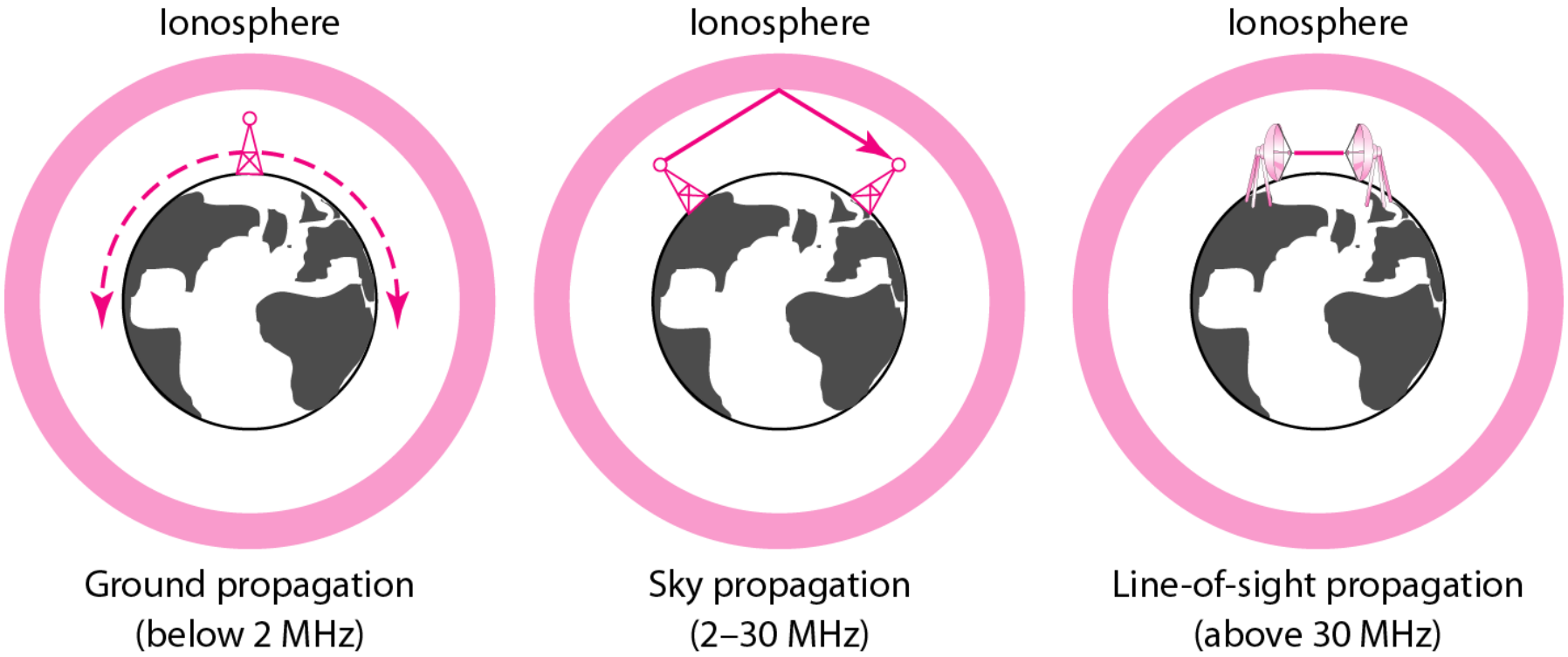
Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.

Radio Waves
Microwaves
Infrared

Electromagnetic spectrum for wireless communication



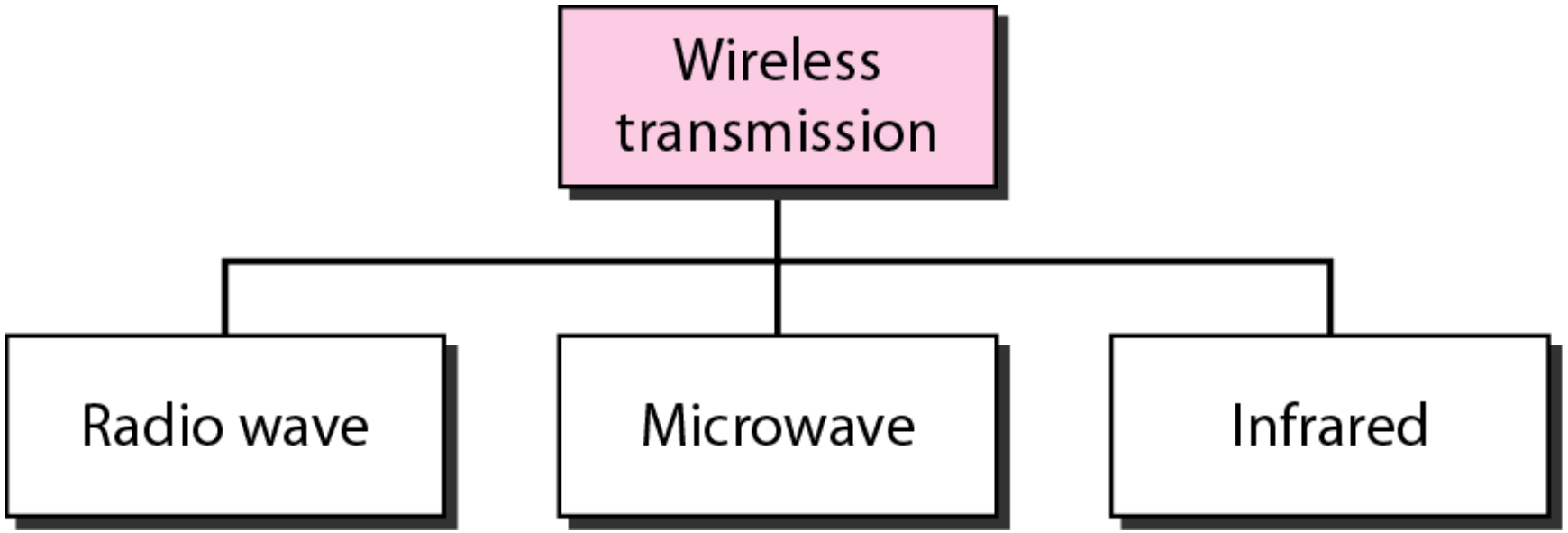
Propagation methods



Bands

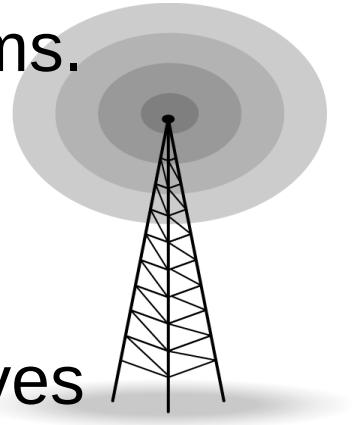
Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30–300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite

Wireless transmission waves



Radio Waves

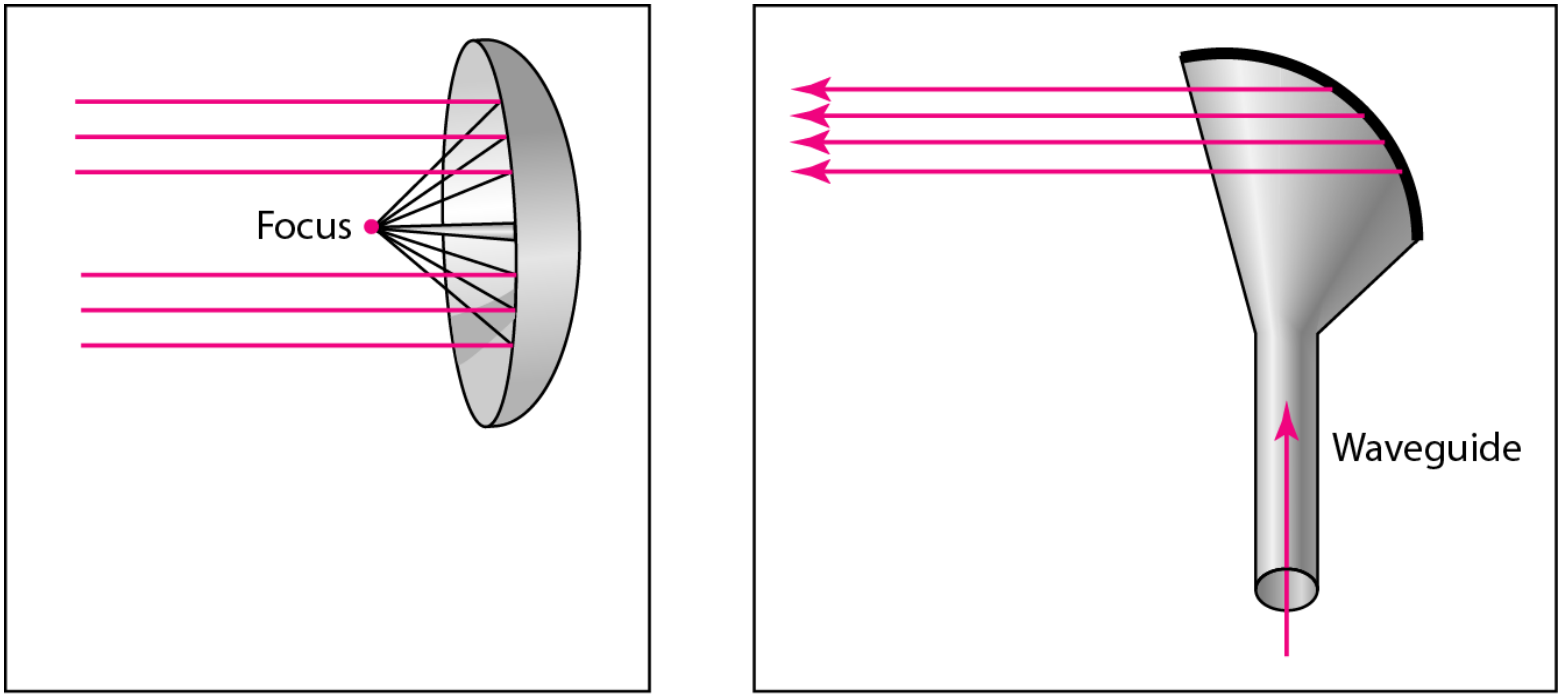
- Electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called
- **radio waves.**
- Radio waves are used for multicast communications, such as radio and television, and paging systems.
- They can penetrate through walls.
- Highly regulated.
- Use omni directional antennas
- The omnidirectional characteristics of radio waves make them useful for multicasting, in which there is one sender but many receivers. AM and FM radio, television, maritime radio, cordless phones, and paging are examples of multicasting.



Microwaves

- Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves.
- Microwaves are unidirectional. Use directional antennas - point to point line of sight communications.
- Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.
- Higher frequency ranges cannot penetrate walls.
- The microwave band is relatively wide, almost 299 GHz. Therefore wider sub-bands can be assigned, and a high data rate is possible. Use of certain portions of the band requires permission from authorities

Unidirectional antennas



a. Dish antenna

b. Horn antenna

Applications

Microwaves, due to their unidirectional properties, are very useful when unicast (one-to-one) communication is needed between the sender and the receiver. They are used in cellular phones ,satellite networks, and wireless LANs.

Infrared

- Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication.
- Infrared waves, having high frequencies, cannot penetrate walls.
- Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

Applications

For communication between devices such as TV Remotes, keyboards, mice, PCs, and printers

Wireless Channels

- Are subject to a lot more errors than guided media channels.
- Interference is one cause for errors, can be circumvented with high SNR.
- The higher the SNR the less capacity is available for transmission due to the broadcast nature of the channel.
- Channel also subject to fading and no coverage holes.