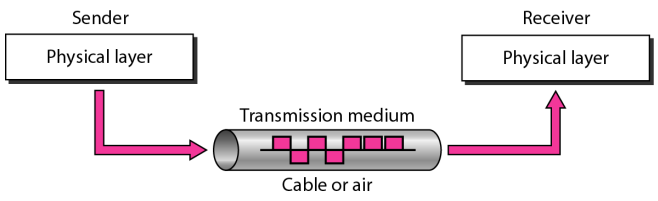
Data Communication & Computer Networks

2. Transmission Media

Transmission media

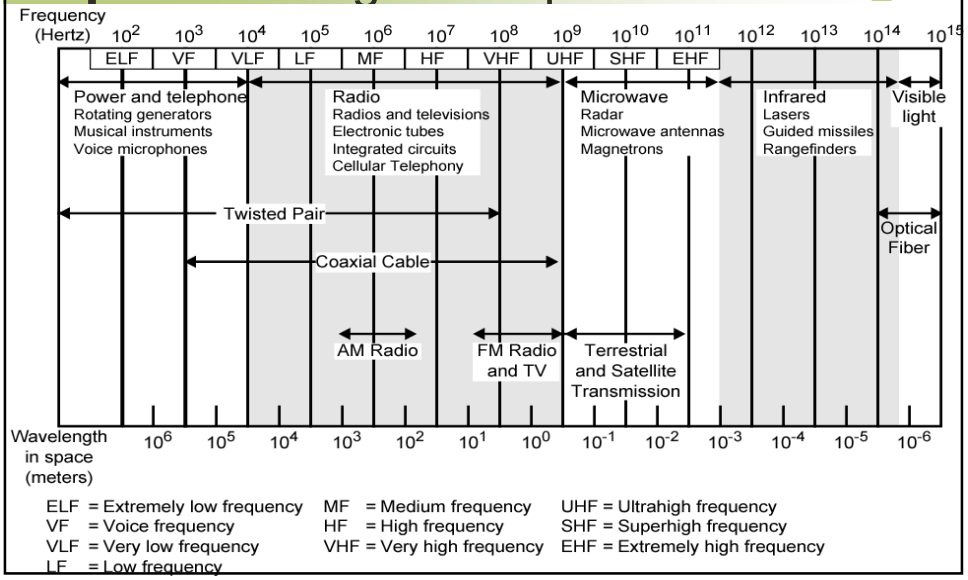
- A transmission medium can be broadly defined as anything that can carry information from a source to a destination.
- Transmission media are located below the physical layer
- Computers use signals to represent data.
- Signals are transmitted in form of electromagnetic energy.



Basic concepts

- Spectrum
  - range of frequencies contained in signal
- Absolute bandwidth
  - width of spectrum
- Effective bandwidth
  - Often just *bandwidth*
  - Narrow band of frequencies containing most of the energy

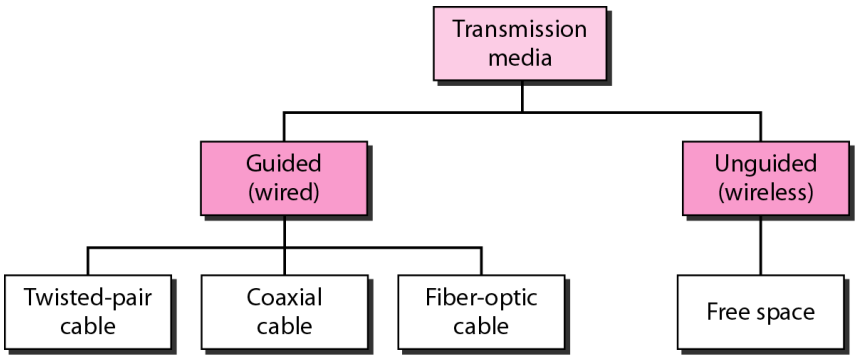
Electromagnetic Spectrum



Data Rate and Bandwidth

- Any transmission system has a limited band of frequencies
- This limits the data rate that can be carried

Classes of transmission media

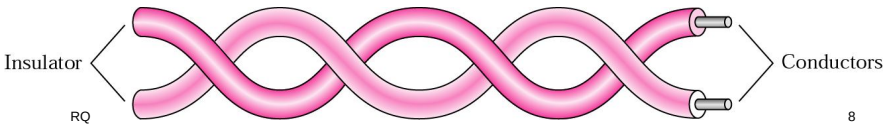


Guided Media

- Guided media are those that provide a conduit from one device to another, e.g.
  - Twisted-Pair Cable
  - Coaxial Cable
  - Fiber-Optic Cable

Twisted pair

- Consists of two conductors (normally copper), each with its own plastic insulation, twisted together
- One of the wires carries signal, the other is used only as a ground reference.
- The receiver uses the difference b/w the two levels.
- Twisting increases the probability that both wires are effected by the noise in the same manner, thus the difference at the receiver remains same.
- Therefore, number of twists per unit length determines the quality of the cable.



Twisted Pair - Applications

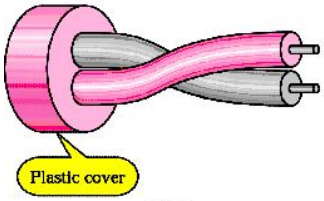
- Most common medium
- Telephone network
- Within buildings
- For local area networks (LAN)

Twisted Pair - Pros and Cons

- Cheap
- Easy to work with
- Low data rate
- Short range

Unshielded Twisted Pair (UTP)

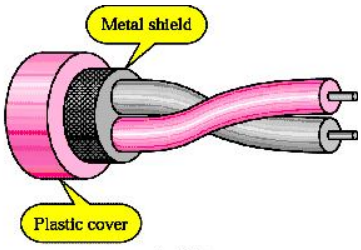
- Ordinary telephone wire
- Cheapest
- Easiest to install
- Suffers from external EM interference



a. UTP

Shielded Twisted Pair (STP)

- Metal braid or sheathing that reduces interference
- More expensive
- Harder to handle (thick, heavy)
- Seldom used outside of IBM



b. STP

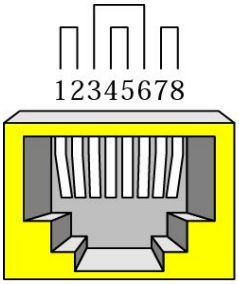
UTP Categories

- The Electronic Industries Association (EIA) has developed standards to classify unshielded twisted-pair cable into seven categories.
- Categories are determined by cable quality, with 1 as the lowest and 7 as the highest.

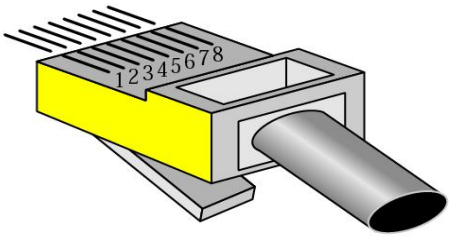
UTP Categories

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

UTP connector



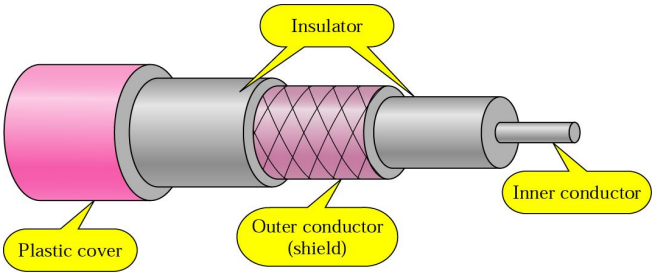
RJ-45 Female



RJ-45 Male

Coaxial cable

- Carries signals of higher frequency ranges than those in twisted pair cable
- Inner conductor is a solid wire
- Outer conductor serves both as a shield against noise and a second conductor



Coaxial Cable Applications

- Most versatile medium
- Television distribution
- Long distance telephone transmission
  - Can carry 10,000 voice calls simultaneously
- Short distance computer systems links
- Local area networks

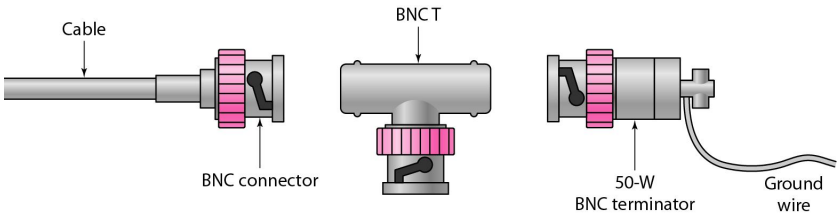
Coaxial cable categories

- Coaxial are categorized by their Radio Government (RG) ratings

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

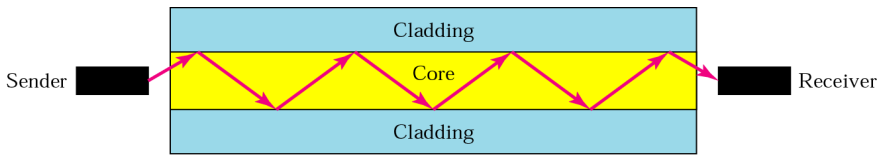
Coaxial cable connectors

- BNC = Bayone-Neill-Concelman
- BNC Connector is used to connect the end of the cable to a device
- BNC T is used in networks to branch out a cable for connection to a computer or other device
- BNC Terminator is used at the end of the cable to prevent the reflection of signal.



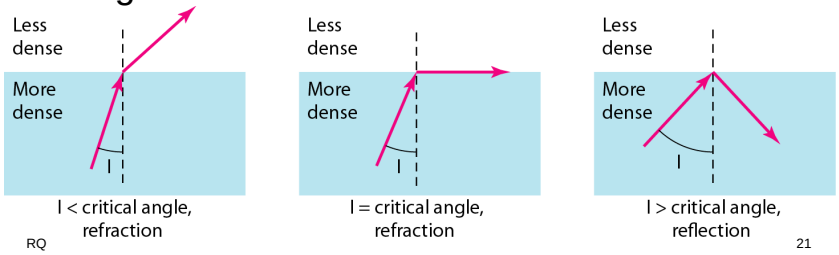
Fibre-Optic Cable

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



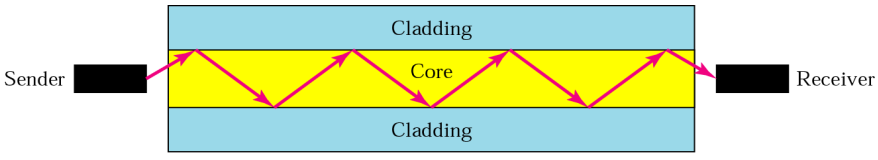
Bending of light ray

- Angle of Incidence (I): the angle the ray makes with the line perpendicular to the interface between the two substances
- Critical Angle: the angle of incidence which provides an angle of refraction of 90-degrees



Optical fiber

- Uses reflection to guide light through a channel
- Core is of glass or plastic surrounded by Cladding
- Cladding is of less dense glass or plastic



Optical Fiber - Benefits

- Greater capacity
  - Data rates of hundreds of Gbps
- Smaller size & weight
- Lower attenuation
- Electromagnetic isolation
- Greater repeater spacing
  - 10s of km at least

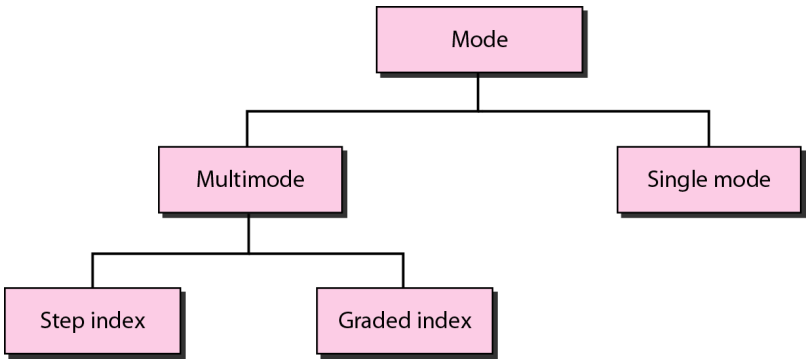
Optical Fiber - Applications

- Long-haul trunks
- Metropolitan trunks
- Rural exchange trunks
- Subscriber loops
- LANs

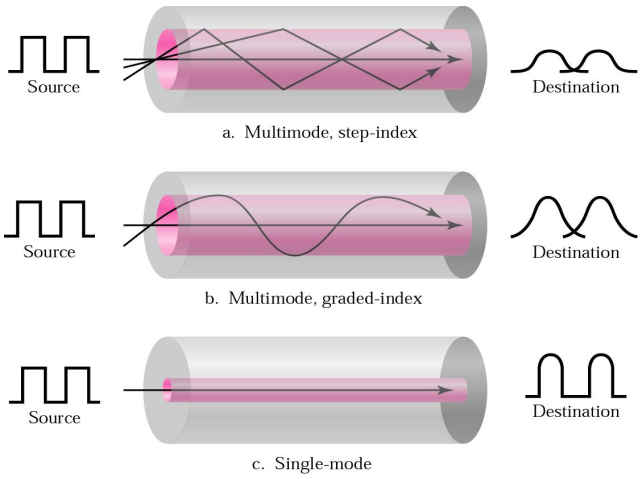
Optical Fiber - Transmission Characteristics

- Act as wave guide for 10^{14} to 10^{15} Hz
  - Portions of infrared and visible spectrum
- Light Emitting Diode (LED)
  - Cheaper
  - Wider operating temp range
  - Last longer
- Injection Laser Diode (ILD)
  - More efficient
  - Greater data rate

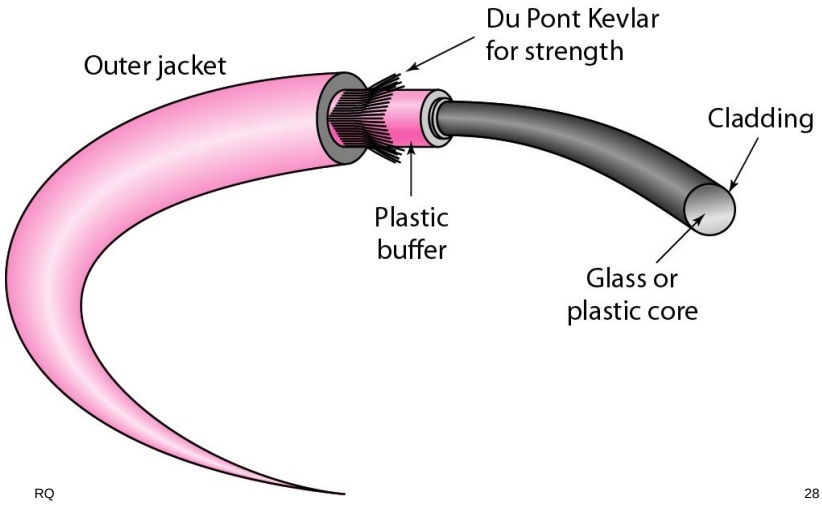
Fiber-optic propagation modes



Fiber-optic propagation modes

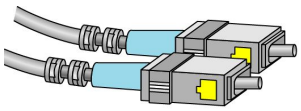


Fiber construction

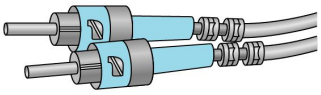


Fiber-optic cable connectors

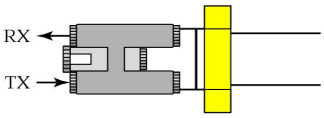
- Subscriber Channel (SC) is used in cable TV
- Straight-Tip (ST) is used for connecting cable to networking devices
- MT-RJ is a new connector with the same size of RJ45



SC connector



ST connector



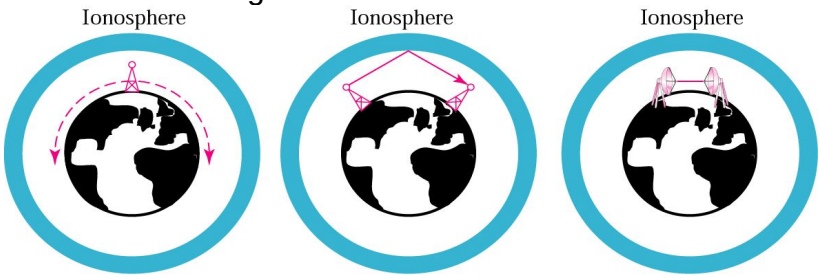
MT-RJ connector

Unguided Media

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

Wireless Propagation

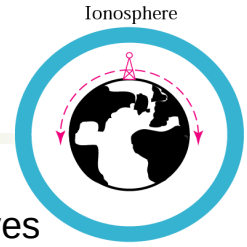
- Signal travels along three routes
  - Ground wave
  - Sky wave
  - Line of sight



Ground propagation (below 2 MHz) | Sky propagation (2 - 30 MHz) | Line-of-sight propagation (above 30 MHz)

RQ 31

Ground Propagation

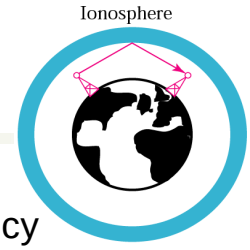


Ground propagation (below 2 MHz)

- In ground propagation, radio waves travel through the lowest portion of the atmosphere, hugging the earth.
- These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet.
- Distance depends on the amount of power in the signal: The greater the power, the greater the distance.

RQ 32

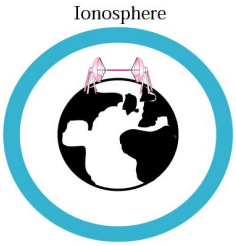
Sky Propagation



Sky propagation
(2 - 30 MHz)

- In sky propagation, higher-frequency radio waves radiate upward into the ionosphere where they are reflected back to earth.
  - Ionosphere is the layer of atmosphere where particles exist as ions
- This type of transmission allows for greater distances with lower output power.

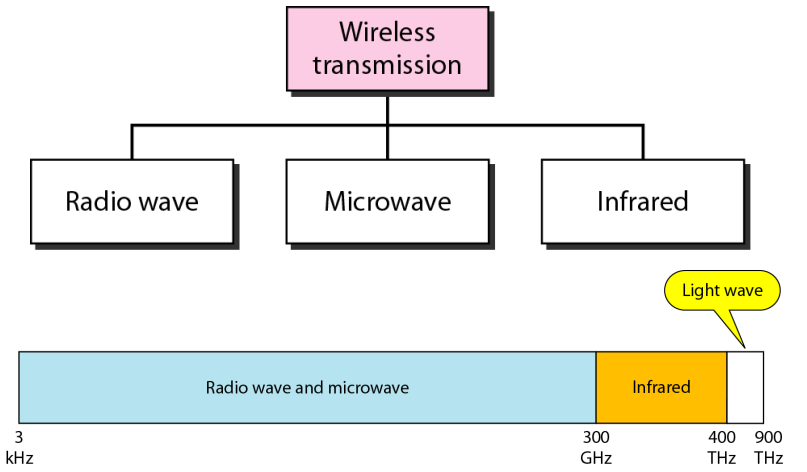
Line-of-sight Propagation



Line-of-sight propagation
(above 30 MHz)

- In LoS propagation, very high-frequency signals are transmitted in straight lines between antennas.
- Antennas must be directional, facing each other, and either tall enough or close enough together not to be affected by the curvature of the earth.
- Tricky because radio transmissions cannot be completely focused.

Wireless Transmission Waves



Wireless Transmission Waves

- Radio waves are used for multicast communications, such as radio and television, and paging systems.
- Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.
- Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

Wireless Band and Propagation

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