Transmission Media

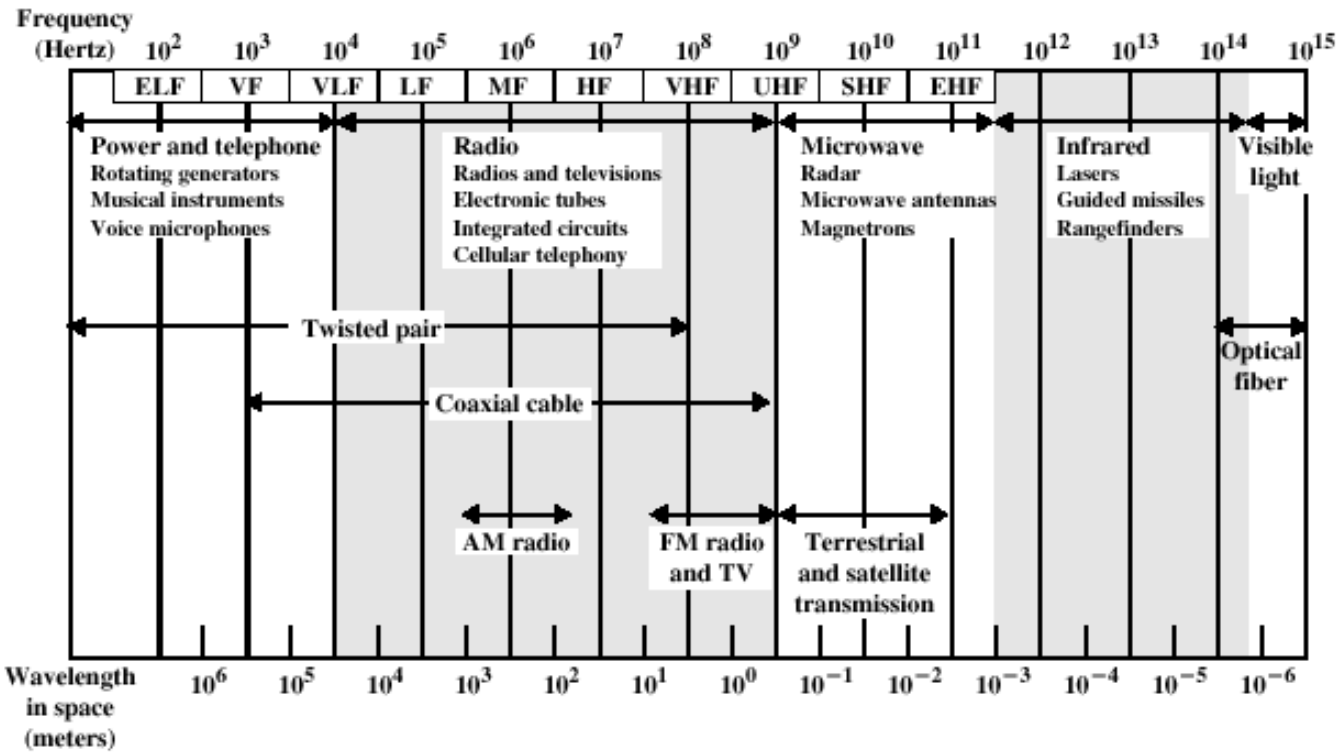
Classes of Transmission Media

- Conducted or guided media
  - use a conductor such as a wire or a fiber optic cable to move the signal from sender to receiver
- Wireless or unguided media
  - use radio waves of different frequencies and do not need a wire or cable conductor to transmit signals

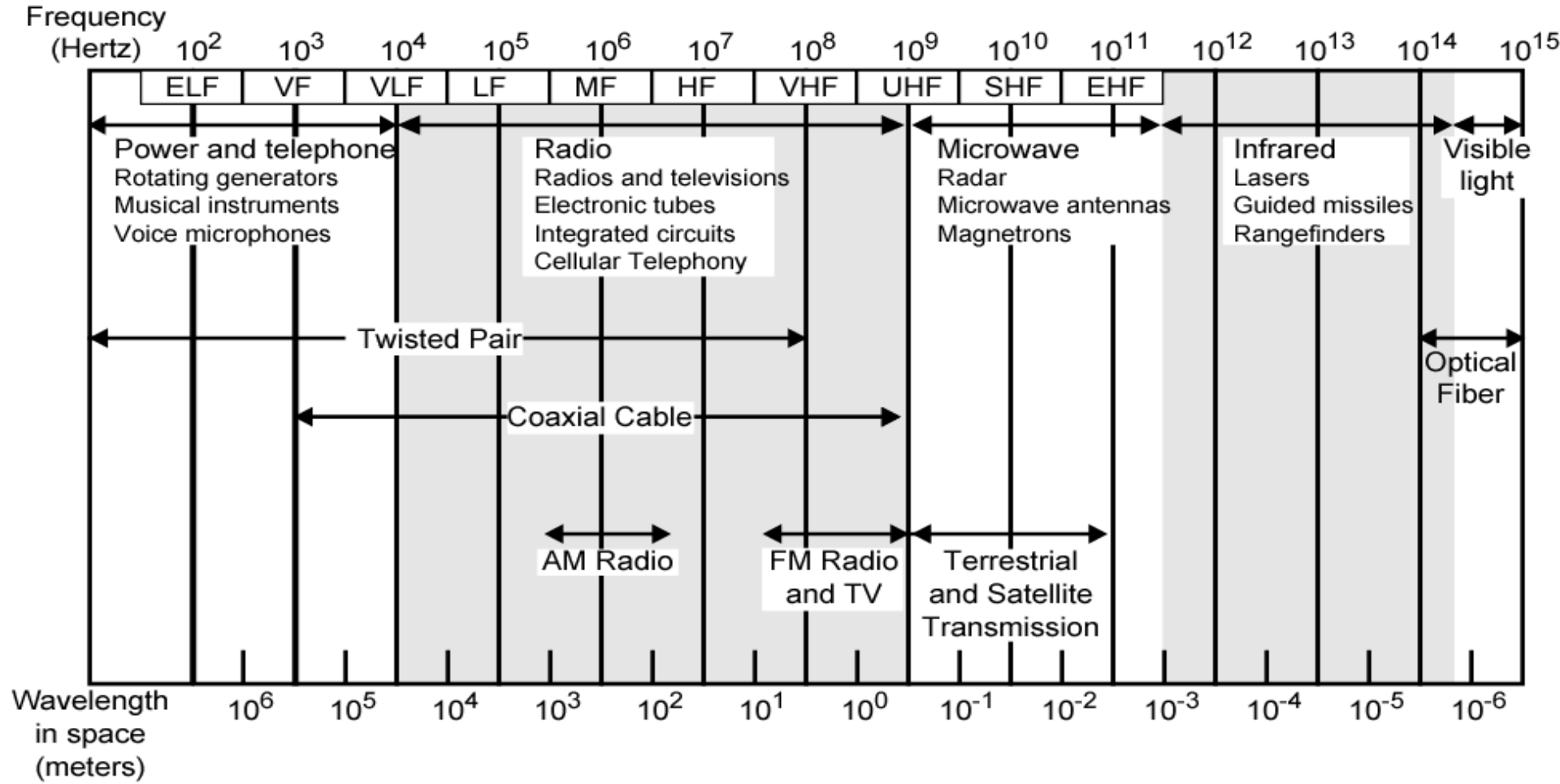
Design Factors for Transmission Media

- Bandwidth: All other factors remaining constant, the greater the band-width of a signal, the higher the data rate that can be achieved.
- Transmission impairments. Limit the distance a signal can travel.
- Interference: Competing signals in overlapping frequency bands can distort or wipe out a signal.
- Number of receivers: Each attachment introduces some attenuation and distortion, limiting distance and/or data rate.

Electromagnetic Spectrum for Transmission Media



Electromagnetic Spectrum



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

- Transmission capacity depends on the distance and on whether the medium is point-to-point or multipoint
- Examples
  - twisted pair wires
  - coaxial cables
  - optical fiber

Twisted Pair Wires

- Consists of two insulated copper wires arranged in a regular spiral pattern to minimize the electromagnetic interference between adjacent pairs
- Often used at customer facilities and also over distances to carry voice as well as data communications
- Low frequency transmission medium

Types of Twisted Pair

- STP (shielded twisted pair)
  - the pair is wrapped with metallic foil or braid to insulate the pair from electromagnetic interference
- UTP (unshielded twisted pair)
  - each wire is insulated with plastic wrap, but the pair is encased in an outer covering

Ratings of Twisted Pair

- Category 3 UTP
  - data rates of up to 16mbps are achievable
- Category 5 UTP
  - data rates of up to 100mbps are achievable
  - more tightly twisted than Category 3 cables
  - more expensive, but better performance
- STP
  - More expensive, harder to work with

Twisted Pair UTP Categories

Category	Bandwidth	Data Rate	Digital/ Analog	Use
1	Very Low	<100 Kbps	Analog	Telephone
2	< 2MHz	2Mbps	Analog	T-1 lines
3	16MHz	10Mbps	Digital	LAN
4	20MHz	20Mbps	Digital	LAN
5	100MHz	100Mbps	Digital	LAN
6	200MHz	200Mbps	Digital	LAN
7	600MHz	1000Mbps	Digital	LAN

Twisted Pair Advantages

- Inexpensive and readily available
- Flexible and light weight
- Easy to work with and install

—Separately insulated
—Twisted together
—Often "bundled" into cables
—Usually installed in building during construction

(a) Twisted pair

Twisted Pair Disadvantages

- Susceptibility to interference and noise
- Attenuation problem
  - For analog, repeaters needed every 5-6km
  - For digital, repeaters needed every 2-3km
- Relatively low bandwidth (3000Hz)

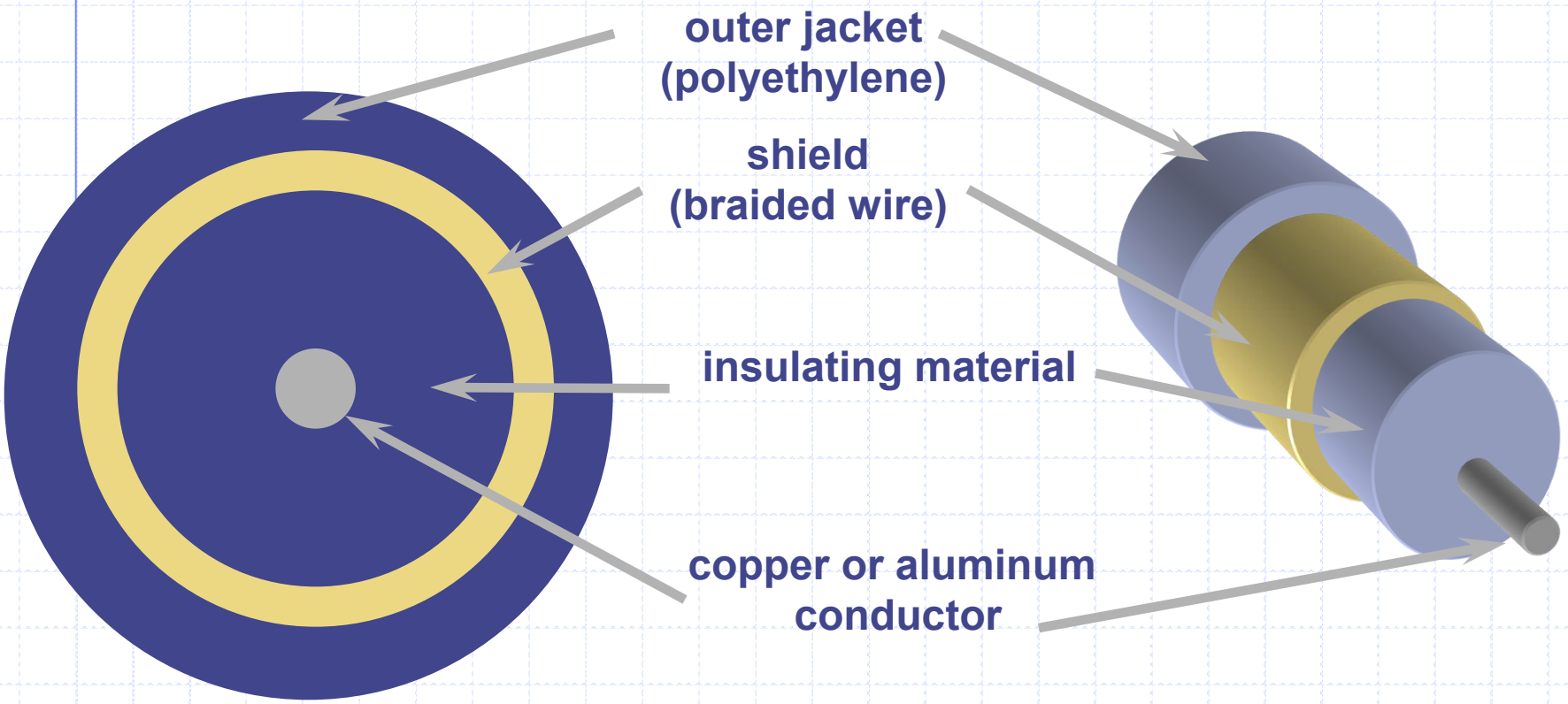
Twisted Pair Applications

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

Coaxial Cable (or Coax)

- Used for cable television, LANs, telephony
- Has an inner conductor surrounded by a braided mesh
- Both conductors share a common center axial, hence the term “co-axial”

Coax Layers


outer jacket
(polyethylene)
shield
(braided wire)
insulating material
copper or aluminum
conductor

Coax Advantages

- Higher bandwidth
  - 400 to 600Mhz
  - up to 10,800 voice conversations
- Can be tapped easily (pros and cons)
- Much less susceptible to interference than twisted pair

Coax Disadvantages

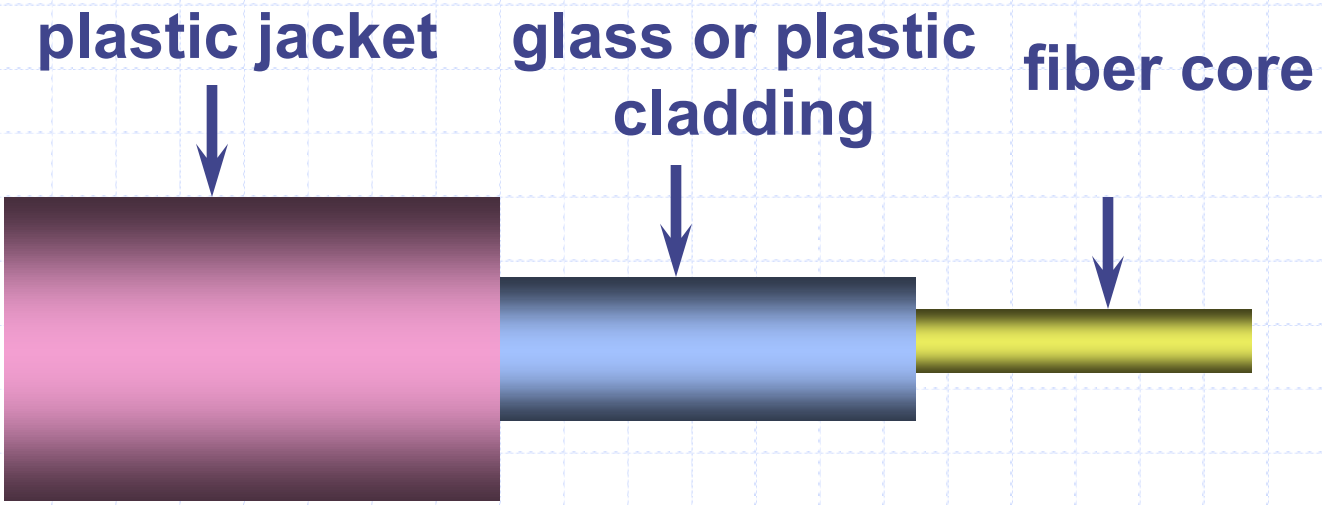
- High attenuation rate makes it expensive over long distance
- Bulky

Fiber Optic Cable

- Relatively new transmission medium used by telephone companies in place of long-distance trunk lines
- Also used by private companies in implementing local data communications networks
- Require a light source with injection laser diode (ILD) or light-emitting diodes (LED)

Fiber Optic Layers

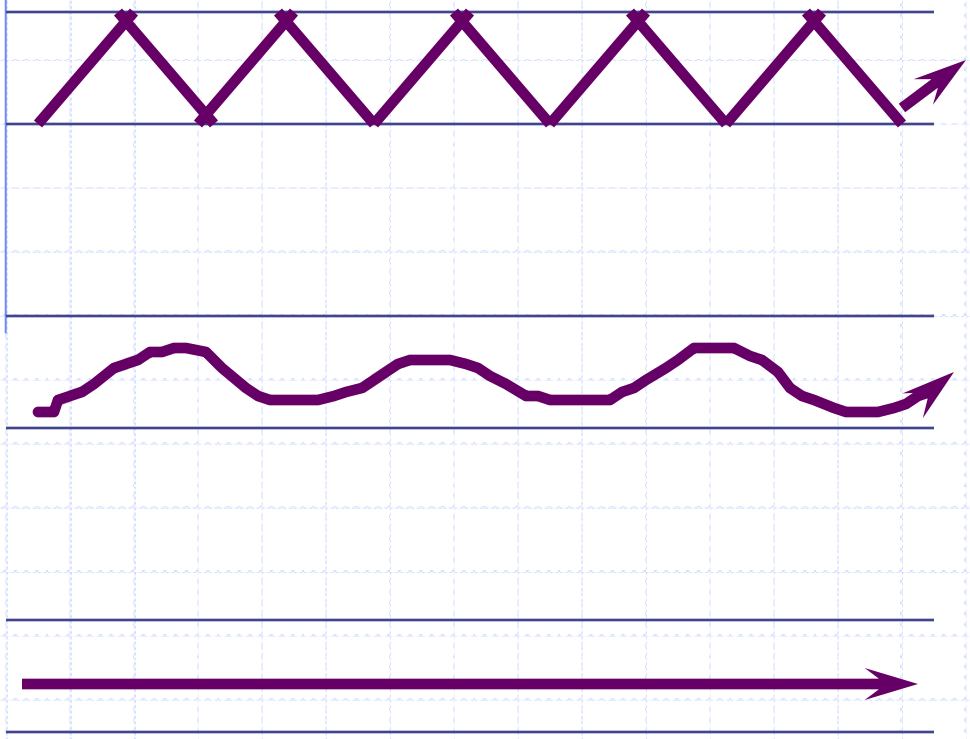
- consists of three concentric sections



Fiber Optic Types

- multimode step-index fiber
  - the reflective walls of the fiber move the light pulses to the receiver
- multimode graded-index fiber
  - acts to refract the light toward the center of the fiber by variations in the density
- single mode fiber
  - the light is guided down the center of an extremely narrow core

Fiber Optic Signals



fiber optic multimode step-index

fiber optic multimode graded-index

fiber optic single mode

Fiber Optic Advantages

- greater capacity (bandwidth of up to 2 Gbps)
- smaller size and lighter weight
- lower attenuation
- immunity to environmental interference
- highly secure due to tap difficulty and lack of signal radiation

Fiber Optic Disadvantages

- expensive over short distance
- requires highly skilled installers
- adding additional nodes is difficult

Wireless (Unguided Media) Transmission

- transmission and reception are achieved by means of an antenna
- directional
  - transmitting antenna puts out focused beam
  - transmitter and receiver must be aligned
- omnidirectional
  - signal spreads out in all directions
  - can be received by many antennas

Wireless Examples

- terrestrial microwave
- satellite microwave
- broadcast radio
- infrared

Terrestrial Microwave

- used for long-distance telephone service
- uses radio frequency spectrum, from 2 to 40 Ghz
- parabolic dish transmitter, mounted high
- used by common carriers as well as private networks
- requires unobstructed line of sight between source and receiver
- curvature of the earth requires stations (repeaters) ~30 miles apart

Satellite Microwave Applications

- Television distribution
- Long-distance telephone transmission
- Private business networks

Microwave Transmission Disadvantages

- line of sight requirement
- expensive towers and repeaters
- subject to interference such as passing airplanes and rain

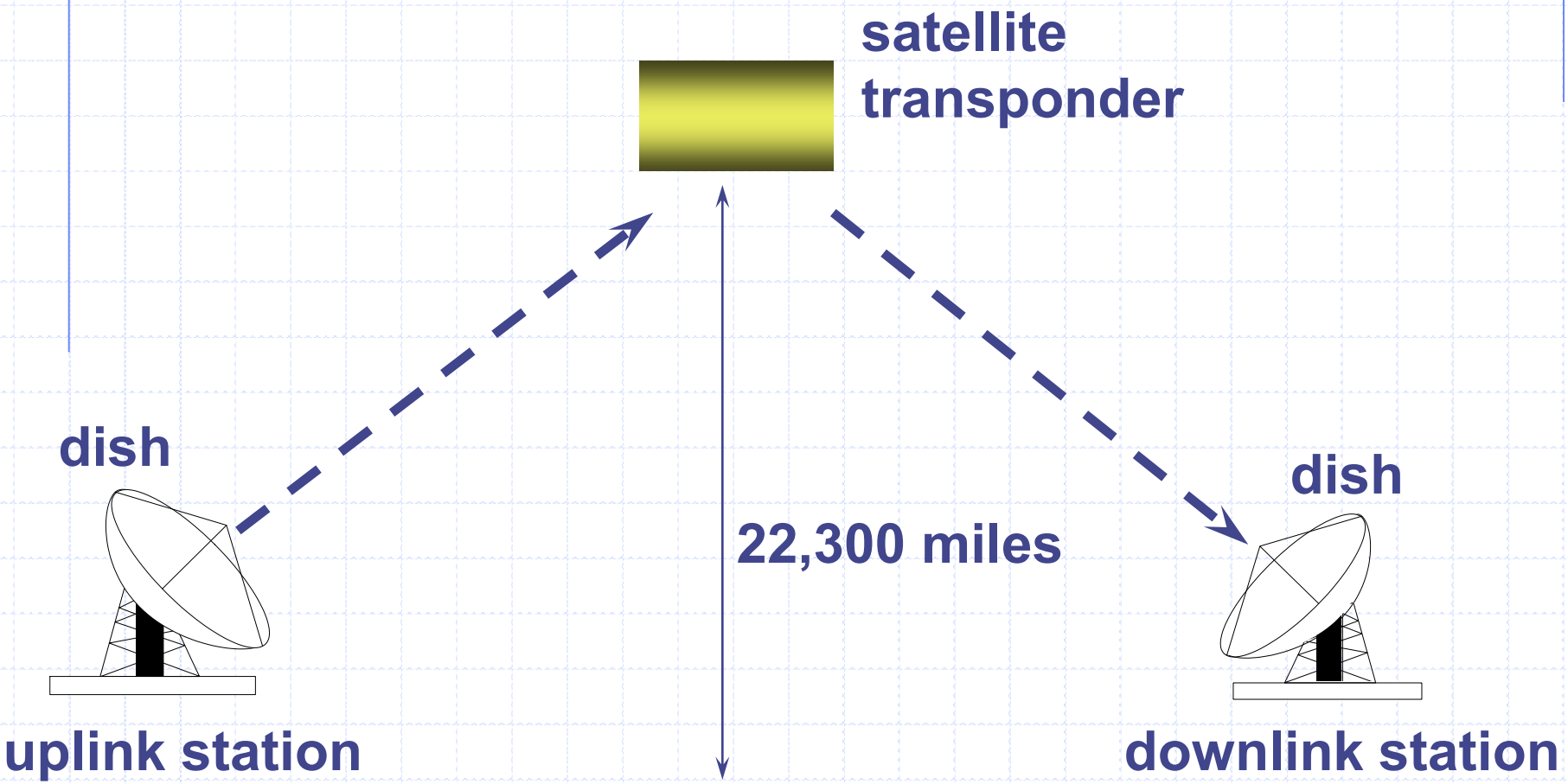
Satellite Microwave Transmission

- a microwave relay station in space
- can relay signals over long distances
- geostationary satellites
  - remain above the equator at a height of 22,300 miles (geosynchronous orbit)
  - travel around the earth in exactly the time the earth takes to rotate

Satellite Transmission Links

- earth stations communicate by sending signals to the satellite on an uplink
- the satellite then repeats those signals on a downlink
- the broadcast nature of the downlink makes it attractive for services such as the distribution of television programming

Satellite Transmission Process



Satellite Transmission Applications

- television distribution
  - a network provides programming from a central location
  - direct broadcast satellite (DBS)
- long-distance telephone transmission
  - high-usage international trunks
- private business networks

Principal Satellite Transmission Bands

- C band: 4(downlink) - 6(uplink) GHz
  - the first to be designated
- Ku band: 12(downlink) -14(uplink) GHz
  - rain interference is the major problem
- Ka band: 19(downlink) - 29(uplink) GHz
  - equipment needed to use the band is still very expensive

Fiber vs Satellite

Table 7.6 A Comparison of Optical Fiber and Satellite Transmission

Characteritic	Optical Fiber	Satellite
Bandwidth	Theoretical limit of 1 terahertz; currently 1–10 GHz	Typical transponder has a bandwidth of 36–72 MHz
Immunity to interference	Immune to electromagnetic interference	Subject to interference from various sources, including microwave
Security	Difficult to tap without detection	Signals must be encrypted for security
Multipoint capability	Primarily a point-to-point medium	Point-to-multipoint communications easily implemented
Flexibility	Difficult to reconfigure to meet changing demand	Easy to reconfigure
Connectivity to customer site	Local loop required	With antenna installed on customer premises, local loop not required

Radio

- radio is omnidirectional and microwave is directional
- Radio is a general term often used to encompass frequencies in the range 3 kHz to 300 GHz.
- Mobile telephony occupies several frequency bands just under 1 GHz.

Infrared

- Uses transmitters/receivers (transceivers) that modulate noncoherent infrared light.
- Transceivers must be within line of sight of each other (directly or via reflection).
- Unlike microwaves, infrared does not penetrate walls.