Transmission Media

Unit 3

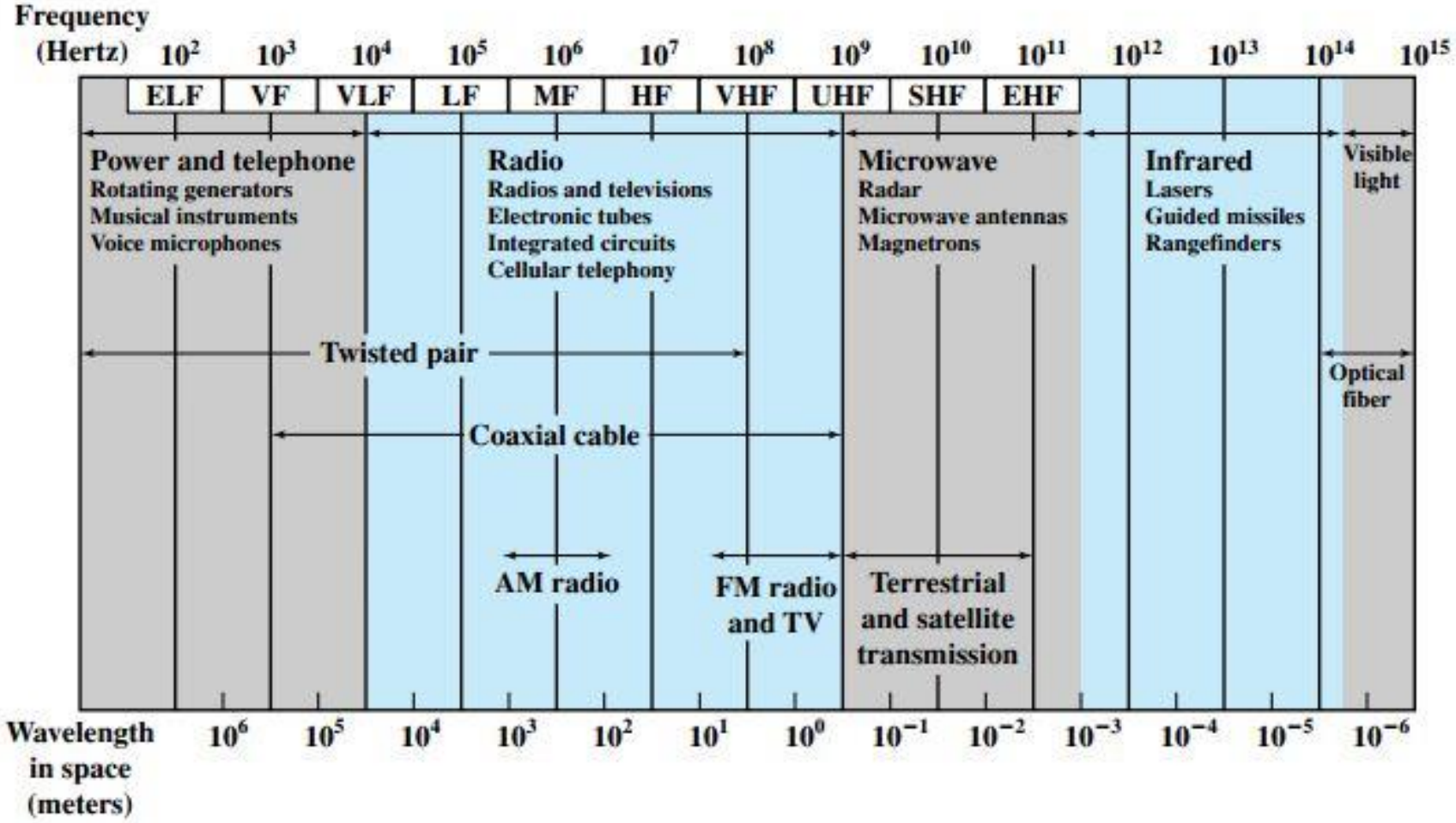
Transmission Media

- Transmission media is a means by which a communication signal is carried from one system to another.
- A transmission medium can be 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.

Design Factor

- In considering the design of data transmission system, key concerns are **data rate** and **distance**: *the greater the data rate and distance, the better.*
- A number of **design factor** that determine the data rate and distance of the transmission media are:

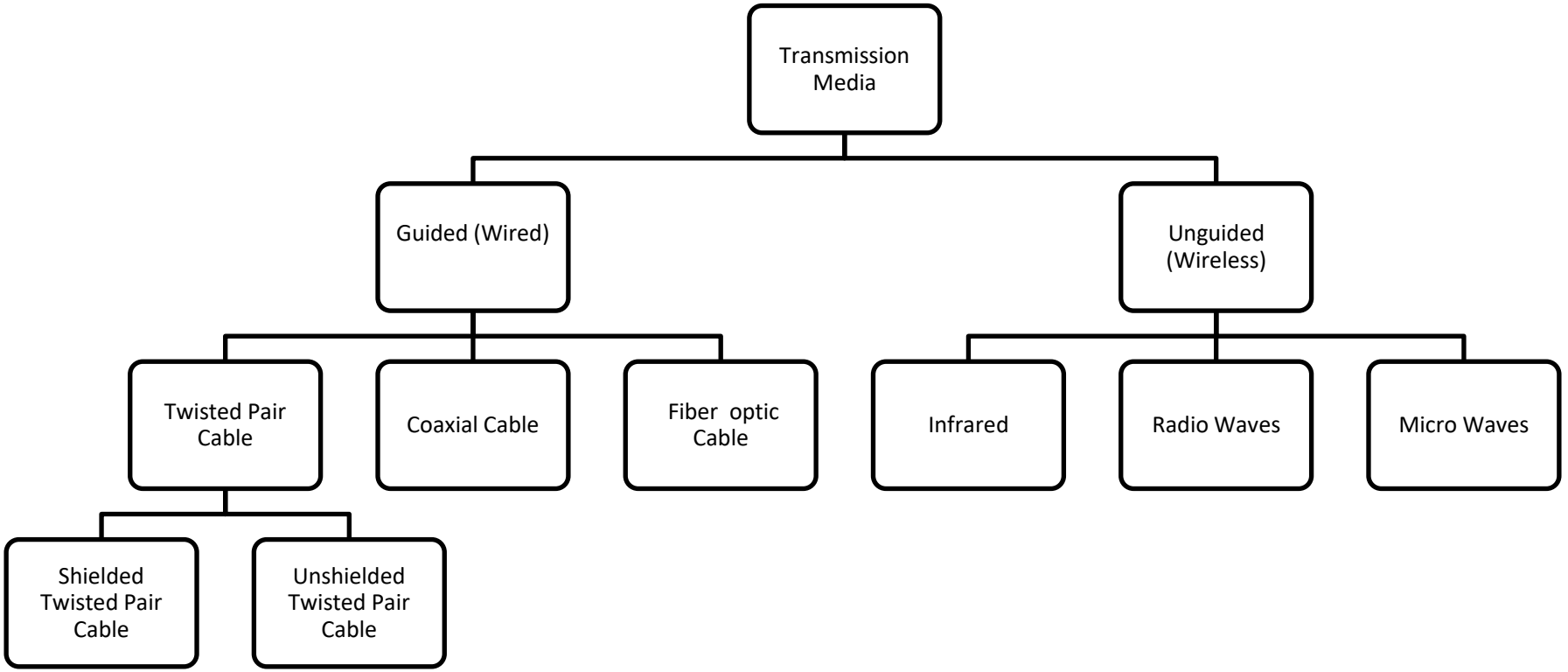
1. Bandwidth
2. Transmission Impairments
3. Interference
4. Number of receivers



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 = Ultra high frequency
SHF = Super high frequency
EHF = Extremely high frequency

Figure: Electromagnetic Spectrum for Telecommunication

Classification of Media



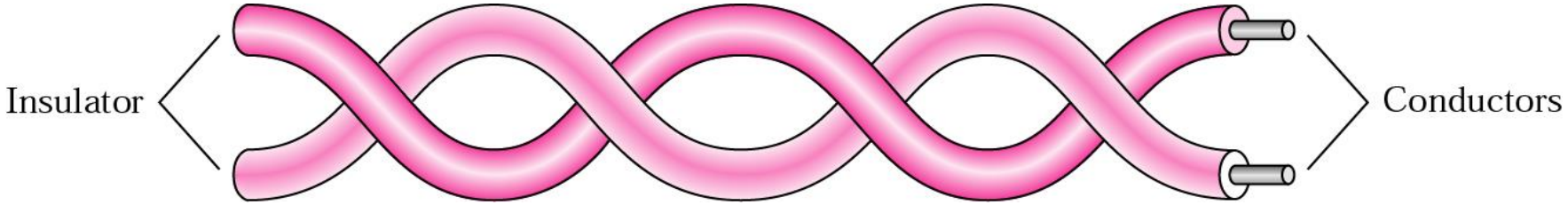
Guided Media

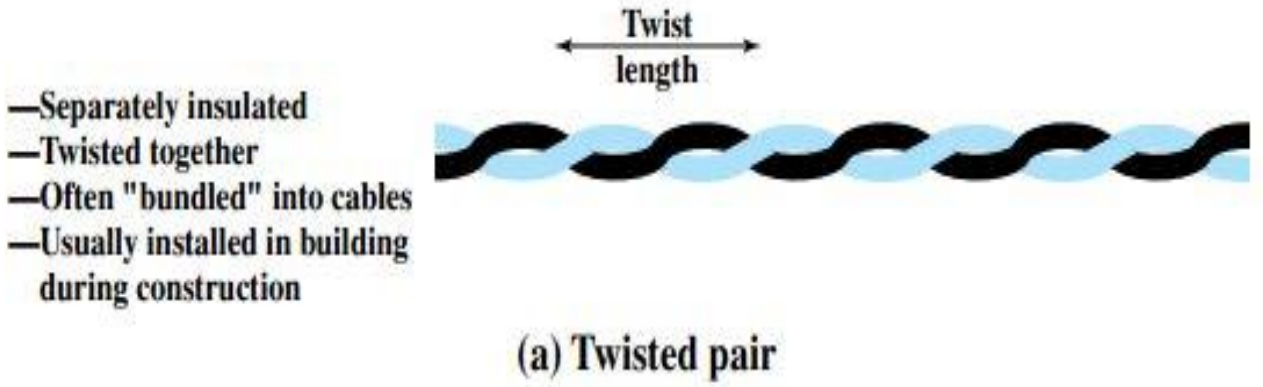
- Guided Transmission media uses a cabling system that guides the data signals along a specific path.
- Guided media also known as Bounded media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable.
- Out of these twisted-pair cable, coaxial cable transport signals in the form of electric signals and fiber-optic cable transport signals in the form of light.
- **Types**:

1. Twisted-Pair Cable
2. Coaxial Cable
3. Fiber-Optic Cable

Twisted Pair Cable

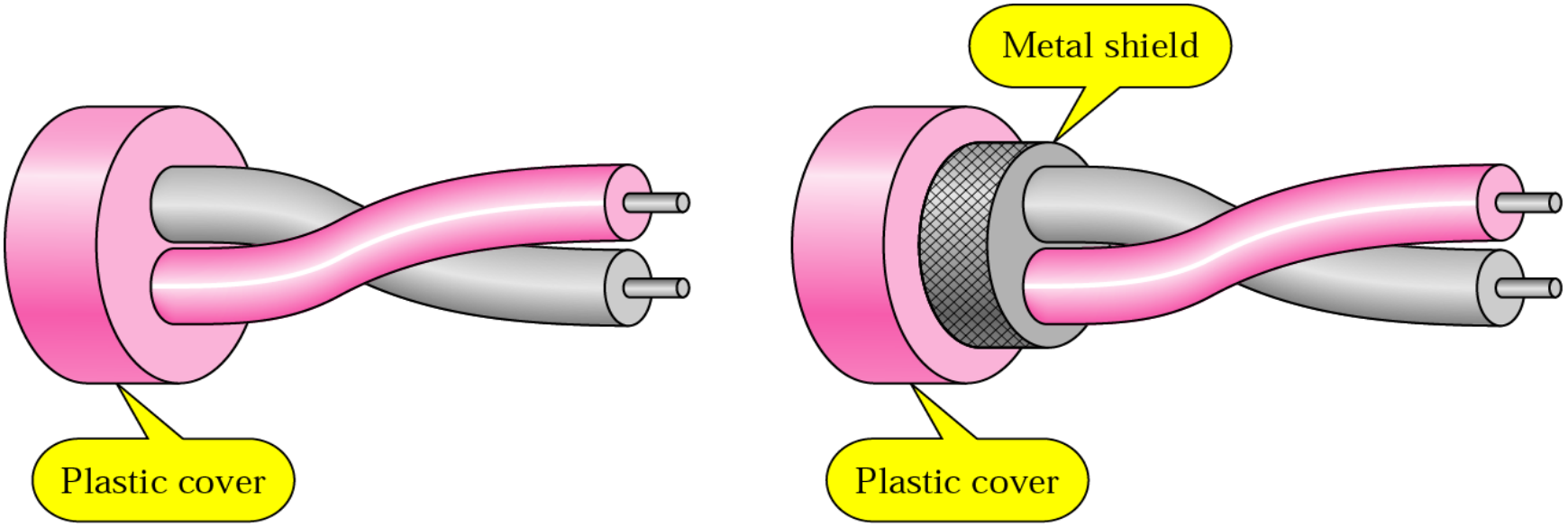
- A twisted pair cable consists of two insulated copper wires arranged in a regular spiral pattern.
- One of the wire is used to carry signal and other is used as ground reference. The receiver uses the difference between the two.
- Subjected to noise, crosstalk and interference.
- Used to transmit both analog and digital data.
- For analog signals, amplifiers are required about every 5 to 6 km.
- For digital transmission, repeaters are required every 2 or 3 km.


Insulator
Conductors


Twist
length
—Separately insulated
—Twisted together
—Often "bundled" into cables
—Usually installed in building
during construction
(a) Twisted pair

Types of Twisted Pair Cable

1. Unshielded Twisted Pair Cable
2. Shielded Twisted Pair Cable

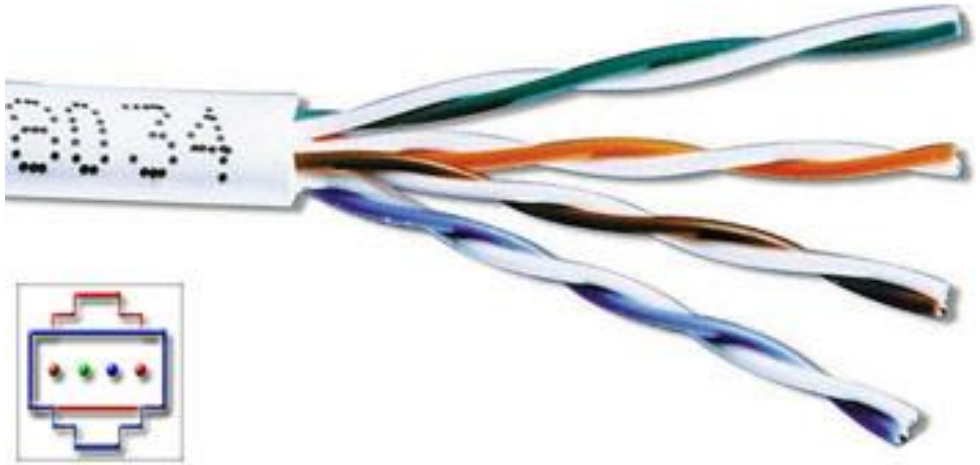


a. UTP

b. STP

Shielded twisted pair (STP)

Unshielded twisted pair (UTP)



Unshielded Twisted Pair Cable

- UTP is commonly used in telephone system.
- EIA (Electronics Industries Association) has categorized the UTP into seven categories i.e. category 1 to category 7.
- Subjected to external noises and interferences

Shielded Twisted Pair Cable

- Commonly used in LAN for digital data communication.
- Has metal foil or braided mesh covering each pair of insulated conductor → prevents from noise or cross talk
- Bulkier and expensive

Application

- Most Common Medium.
- For Local Area Networks (LAN).
- Telephone Networks
  - Between House and Local Exchange (Subscriber Loop).
- Within Buildings
  - To Private Branch Exchange (PBX).
- Cable Connectors => RJ45 and RJ11.

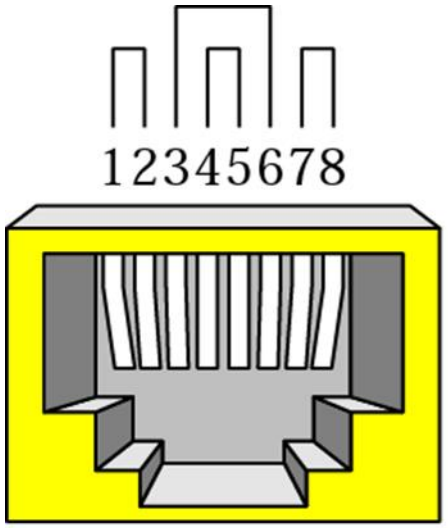
UTP Categories

Category	Bandwidth	Data Rate	Digital/Analog	Use
1	Very Low	<100 Kbps	Analog	Telephone
2	< 2MHz	2Mbps	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	200 MHz	200 Mbps	Digital	LANs

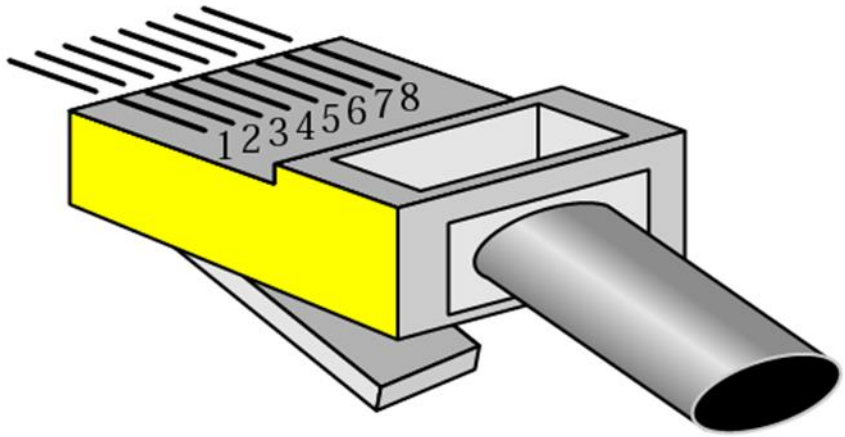
Categories of unshielded twisted-pair cables

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

UTP Connector



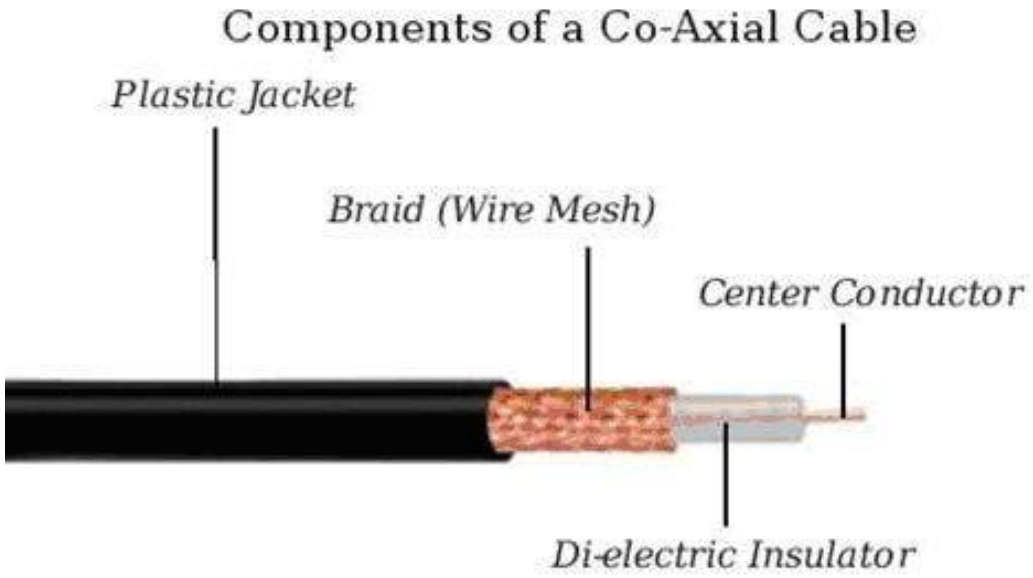
RJ-45 Female



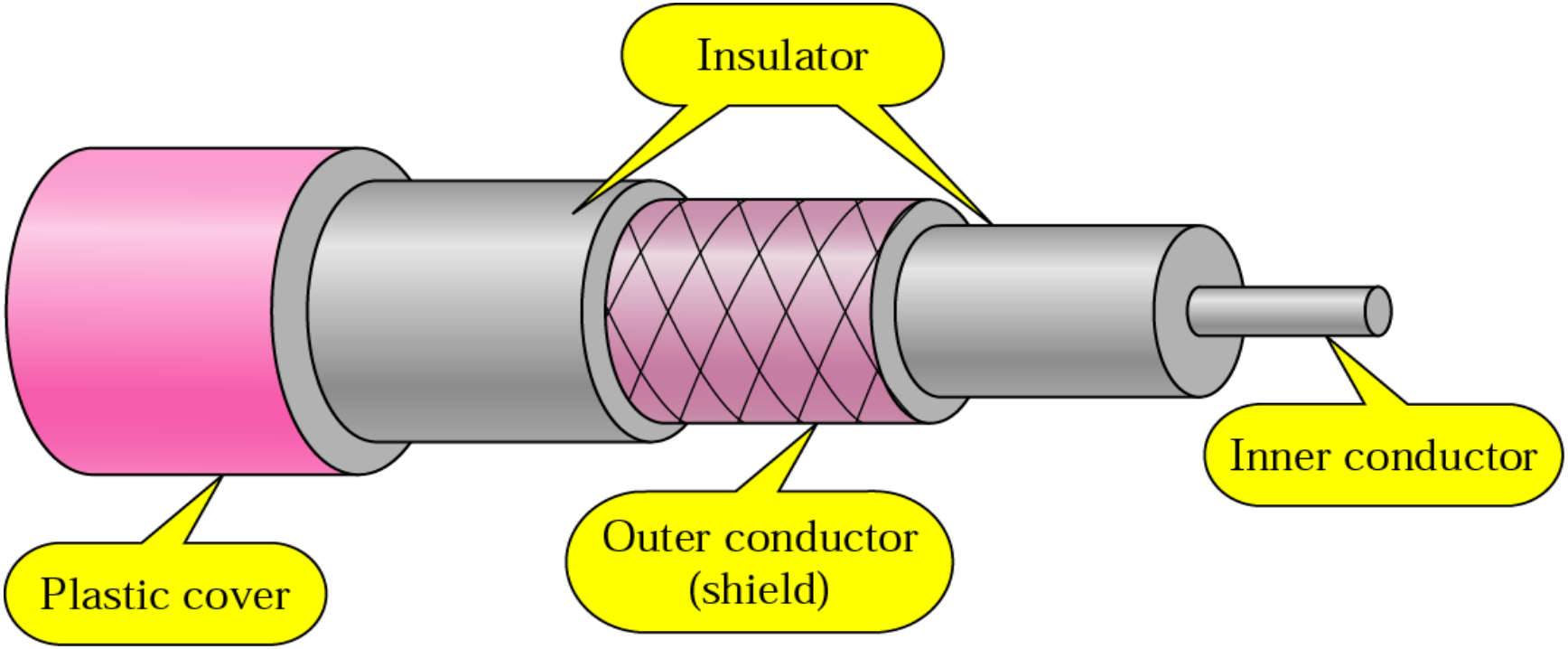
RJ-45 Male

Coaxial Cable

- Coaxial cable (Coax) has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two. The whole cable is protected by a plastic cover.



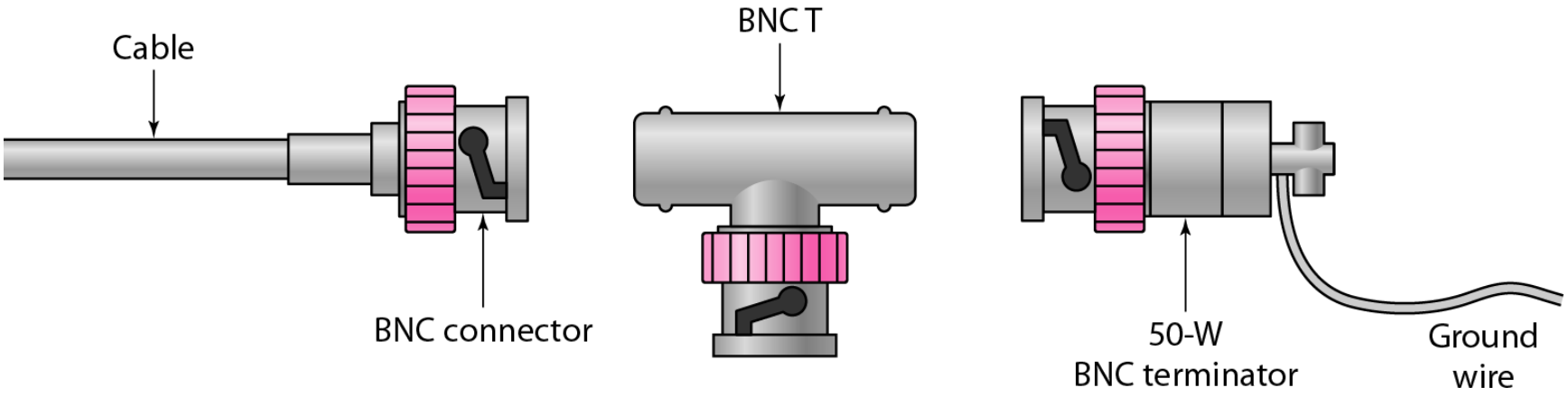
Structure

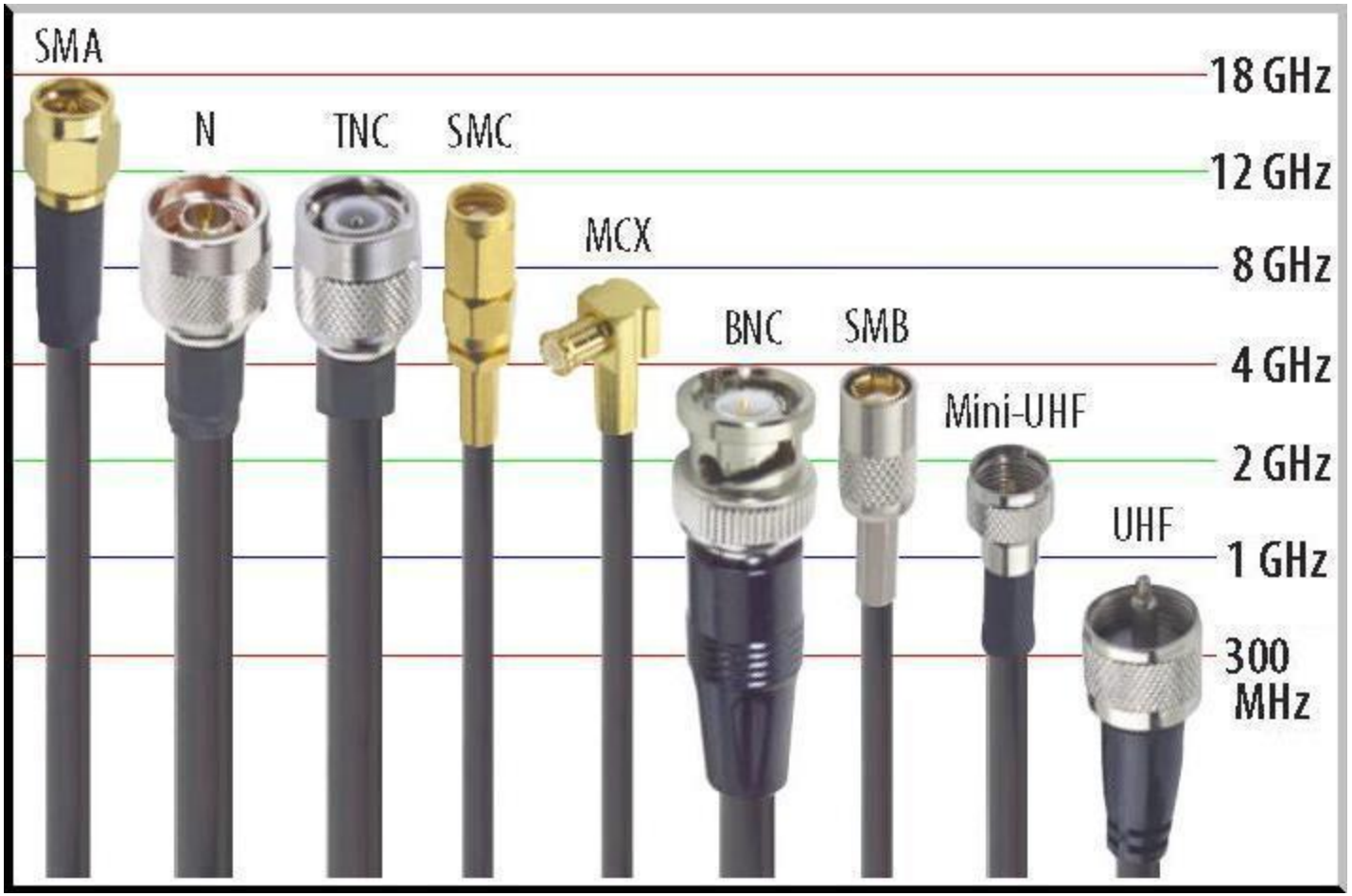

Insulator
Inner conductor
Outer conductor
(shield)
Plastic cover

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

BNC Connectors

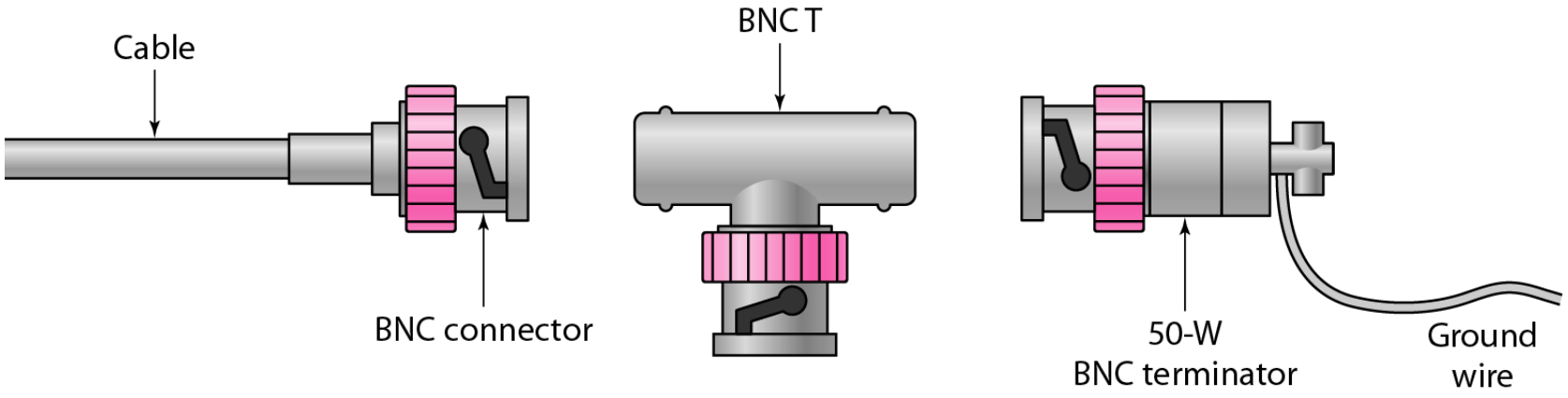



SMA
N
TNC
SMC
MCX
BNC
SMB
Mini-UHF
UHF
18 GHz
12 GHz
8 GHz
4 GHz
2 GHz
1 GHz
300 MHz

- The distance between the outer conductor (Shield) and inner conductor plus the type of material used for insulating the inner conductor determine the cable properties or impedance.
- Coax can operate in wide range of frequencies.
- It is less susceptible to noise, cross talk and interference.
- Coaxial (coax) cables are used in video equipment, computer networks, cable TV, and feed lines connecting radio transmitters and receivers with their antennas.

Coaxial Cable Connector

- Coaxial cable connector has 50 ohm or 75 ohm impedance.
- Most common type of connector used today is Bayone-Neill-Concelman(Bne)
  - The BNC Connector
  - The BNC T connector
  - The BNC terminator



Applications

- Cable Television Distribution.
- Long Distance Telephone Transmission.
  - Can Carry 10,000 Voice Calls Simultaneously.
- Traditional LAN => Diskless Workstation in Novell Netware.
- Being Replaced by Optical Fibers.
- Baseband Cable and Broadband Cable

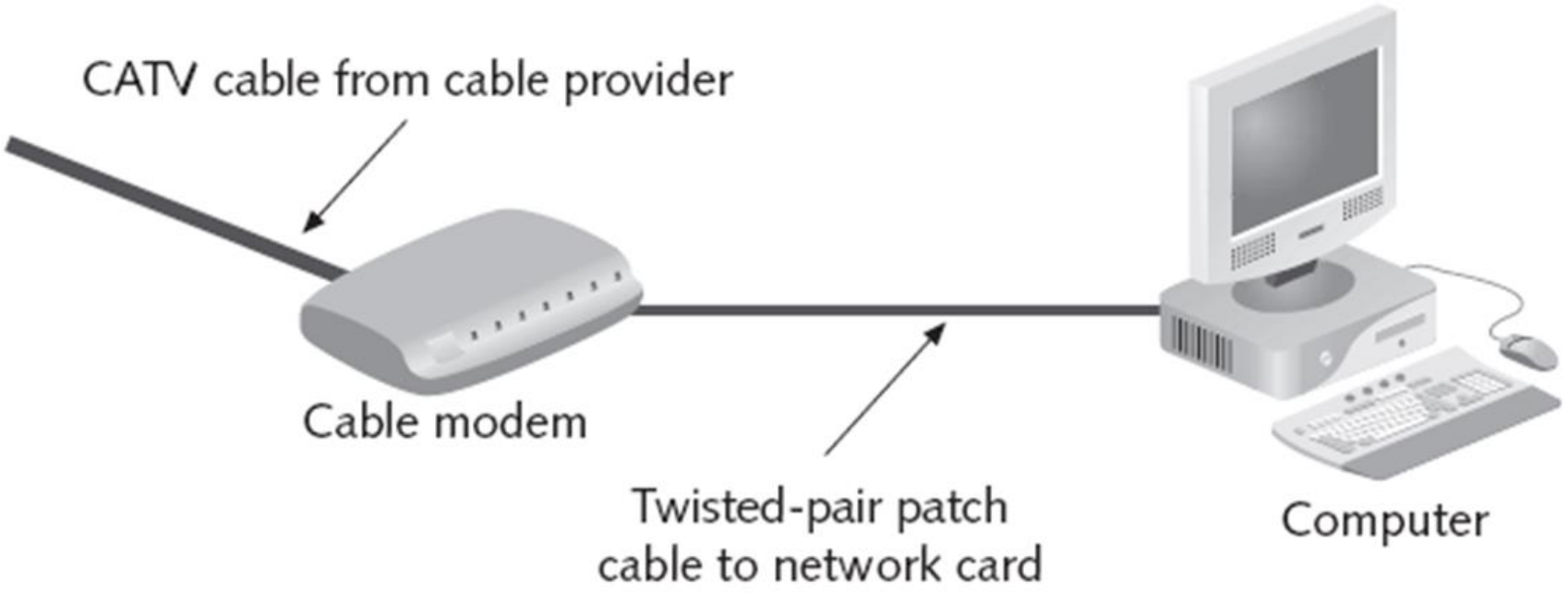
Baseband Cable

- Carries Single Signal at a Fixed Frequency.
- It is used for Digital Transmission.
- Uses Digital Signaling Technique.
- It is used for Small Area.
- 10 Base 5 Cable => Distance up to 500m.
- Repeaters Can be used to deal with attenuation.

Broadband Cable

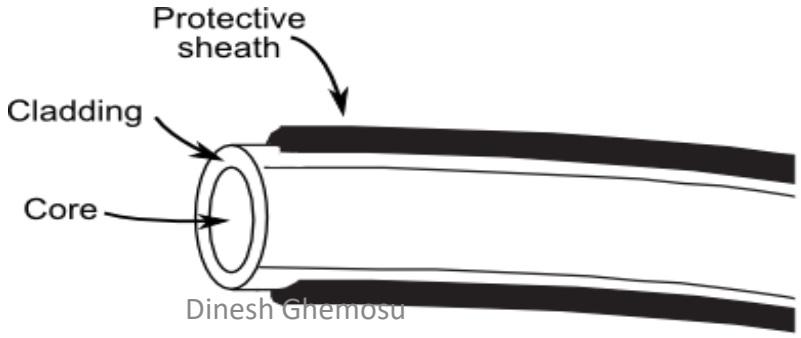
- Carries Multiple Signals => Multiplexing.
- It is used for Analog Transmission.
- Uses Analog Signaling Technique.
- It is used for Large Area => Cable Television
- Amplifiers Can be used to deal with attenuation.

Application

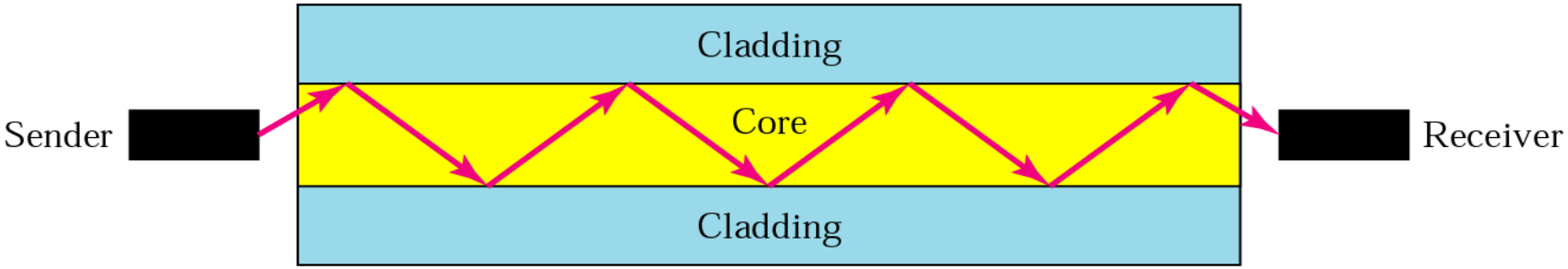


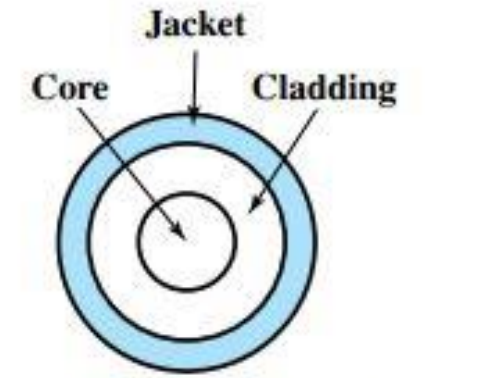
Fiber Optic Cable

- Optical fiber consists of thin glass fiber and transmits the signals in the form of light.
- It has a cylindrical shape and consists of three concentric sections: the core, the cladding, and the jacket.
- The core is the innermost section which consists fiber made of glass or plastic.
- A typical core diameter is 62.5 microns.
- Core is surrounded by a cladding, a glass or plastic coating.
- Typically cladding has a diameter of 125 micro meter.
- The optical properties (i.e. refractive index) of core and cladding are different and light propagate through the core by process called the total internal reflection.
- The outermost layer is the jacket, made of plastic or other material and used for protection.

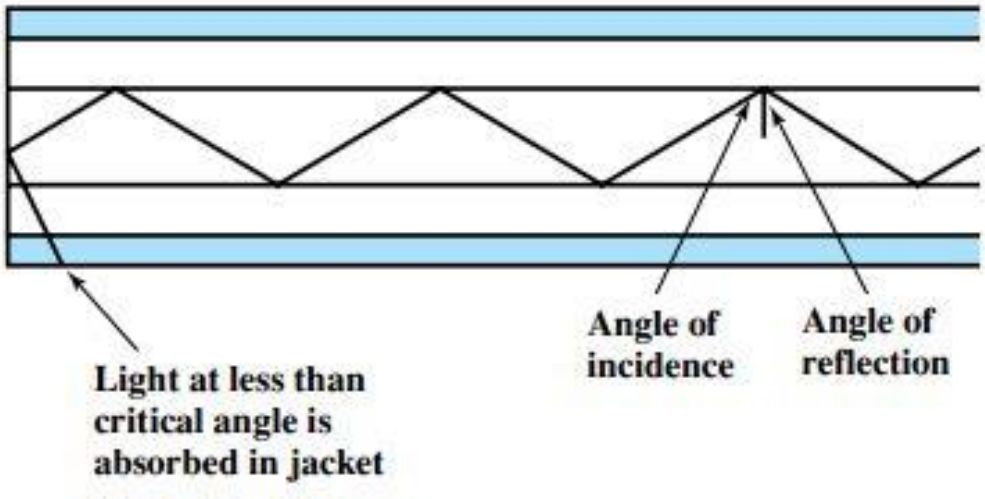


Structure

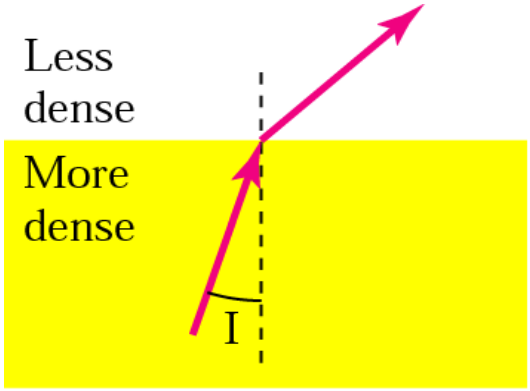




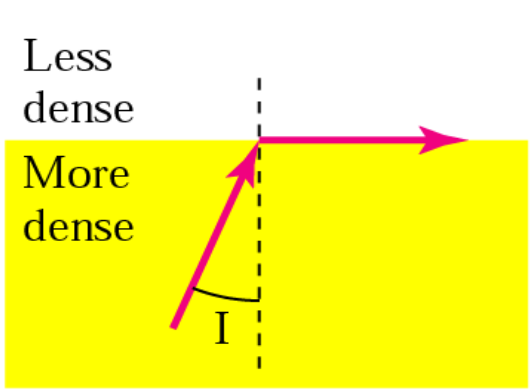
—Glass or plastic core
—Laser or light emitting diode
—Specially designed jacket
—Small size and weight



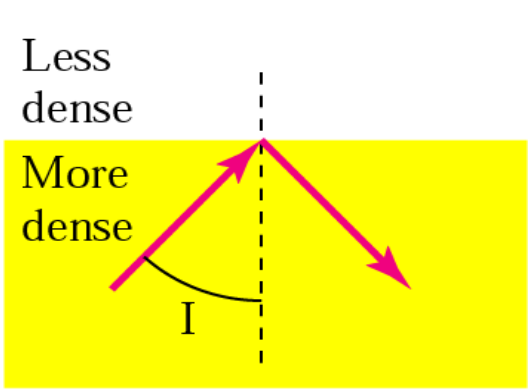
Bending of Light



I < critical angle,
refraction

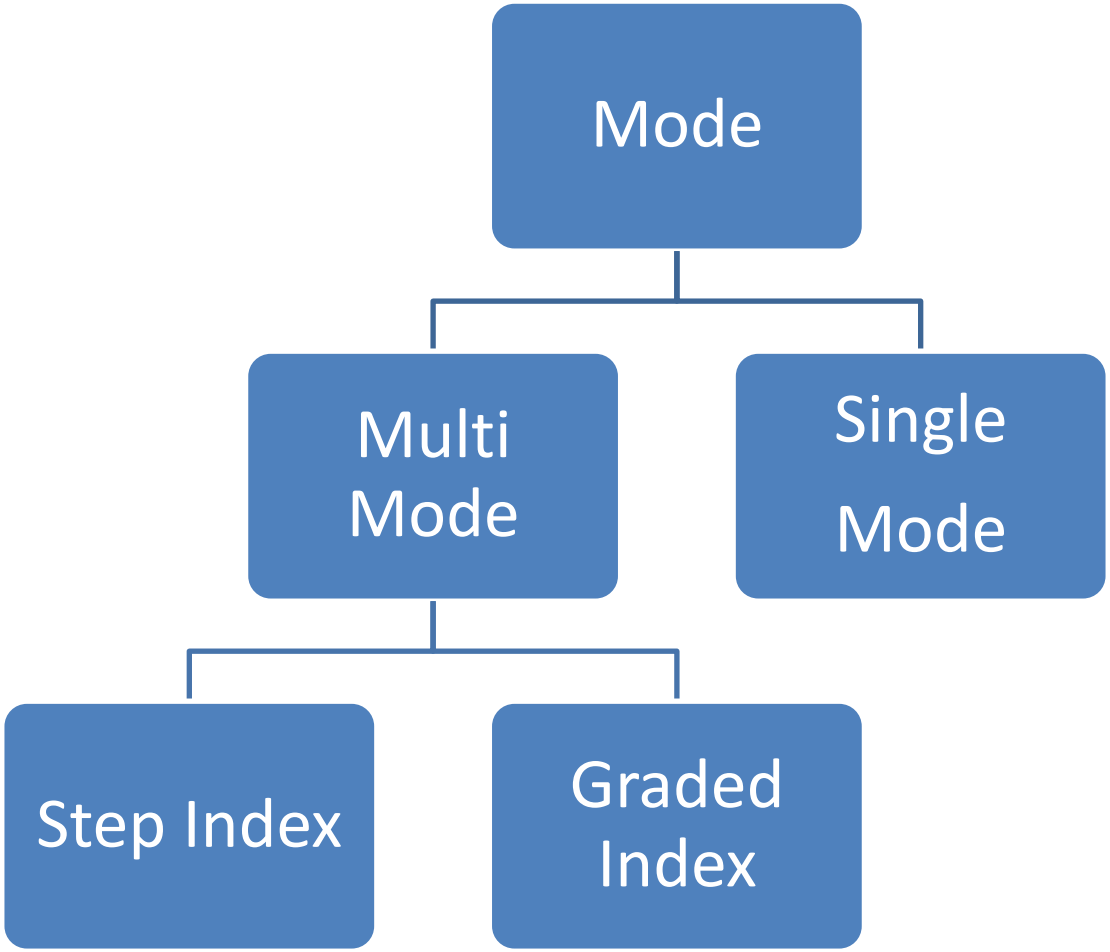


I = critical angle,
refraction



I > critical angle,
reflection

Propagation Mode

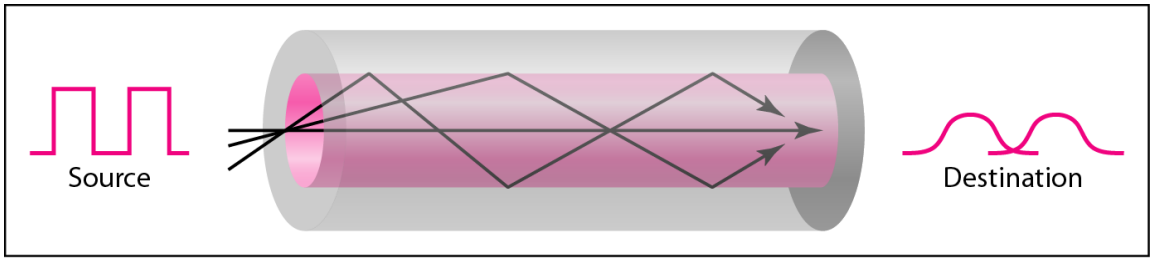


Multimode

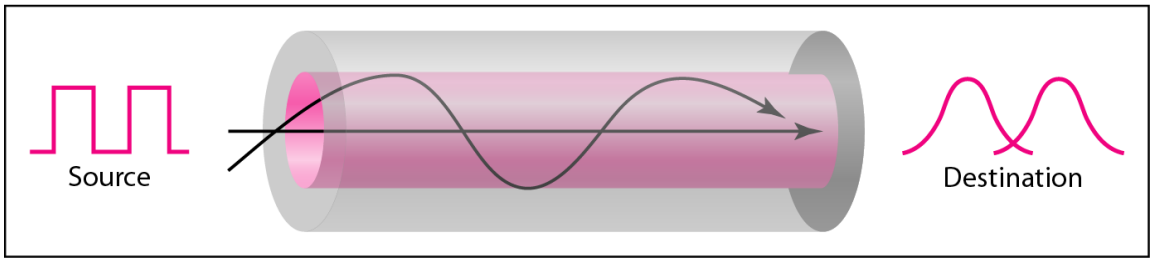
- In multimode propagation, multiple beams from a light source move through the core in different paths. How these beams move within the cable depends on the structure of the core.

Multimode step index

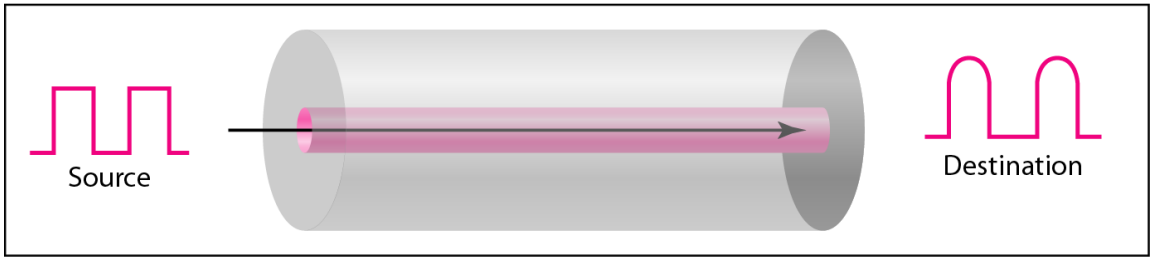
- In multimode step index, the density(i.e. refractive index) of the core remains constant form the center to the edge.
- Core diameter ranges from 100 to 970 micro meter.
- A beam of light moves through this constant density in a straight line until it reached the interface of the core and the cladding. At the cladding, there is an abrupt change due to a lower density; this alters the angle of the beam's motion.
- There are many paths though which light can travels and lights exits in different time duration, the phenomena called **model dispersion**



a. Multimode, step index



b. Multimode, graded index



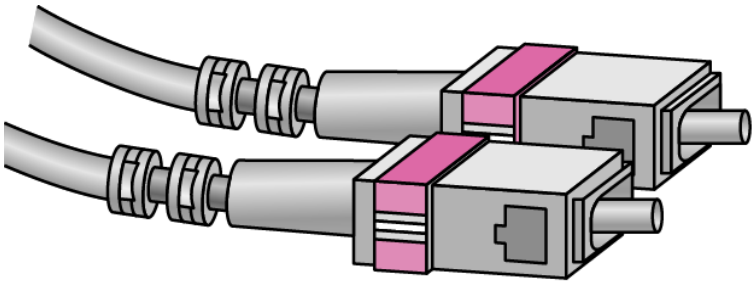
c. Single mode

Figure: Optical Fiber Transmission Mode

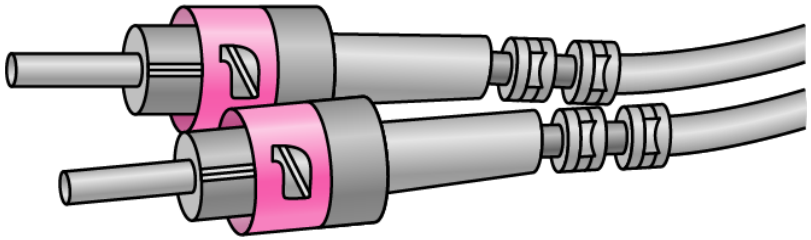
Fiber Types

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

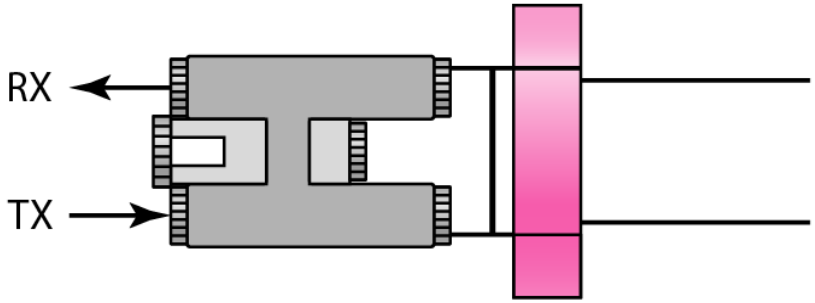
Fiber-optic Cable connectors



SC connector



ST connector



MT-RJ connector

Multimode graded index

- In the multimode graded index, the refractive index of core gradually decreases from the center to edge.
- Core diameter: 50 to 85 micro meter.
- Cladding diameter: 125 micro meter.
- Improved version of multimode step index fiber.
- Because the light travels faster through the lower refractive index of refraction, the light at the fiber core travels more slowly than the light nearer the surface.
- Therefore, the light rays arrive at the exit point at almost the same time, thus reducing the ***modal dispersion.***

Single mode step index

- In this mode, a light ray travel on only one path i.e. light propagates in the horizontal direction, thus model dispersion is zero.
- Core diameter: 5 to 10 micro meter.
- Cladding diameter: 125micro meter.

Advantages and Disadvantages of fiber optic cable

Advantages

- Higher bandwidth
- Less signal attenuation
- Immunity to electromagnetic interferences
- Resistance to corrosive materials
- Light weight
- Greater repeater spacing

Disadvantages

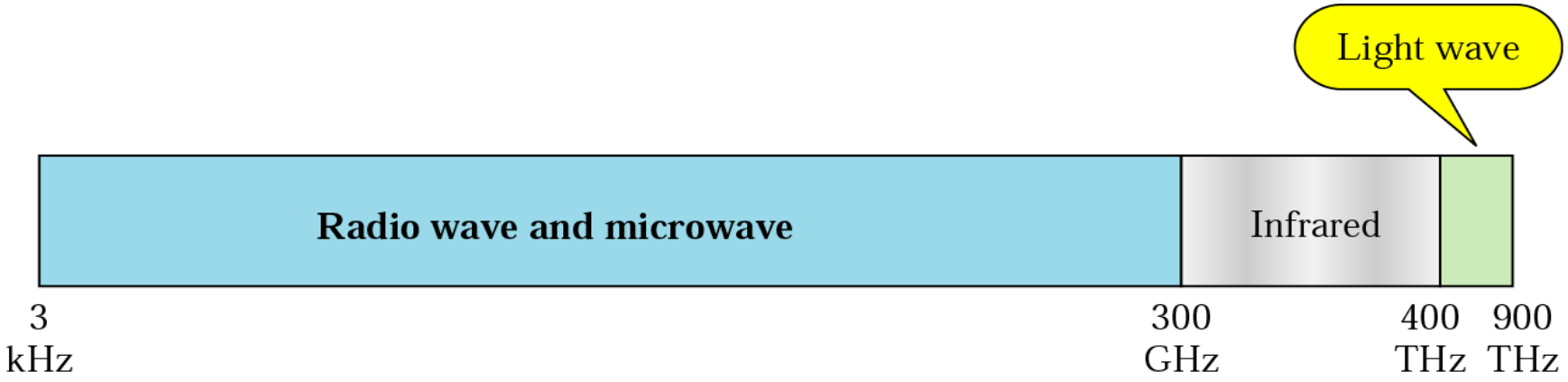
- Difficulty in installation and maintenance
- Unidirectional light propagation
- Very expensive

Unguided Media : Wireless

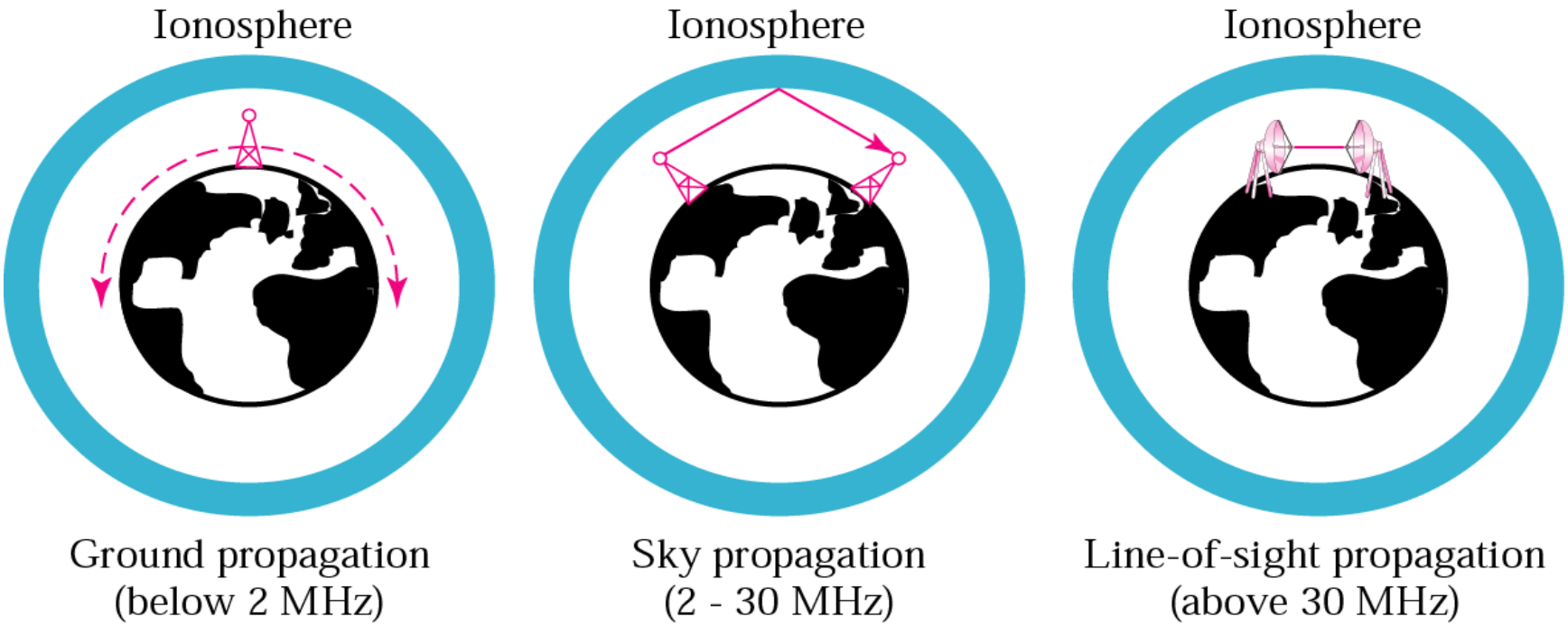
- Unguided media transport electromagnetic waves without using physical conductor.
- This type of communication is referred to as wireless communication.
- Unguided signals can propagate in the following three different ways:
  1. Ground-wave propagation
  2. Sky-wave propagation
  3. Line-of-sight propagation

- There are three types of unguided media:
  1. Radio waves
  2. Micro waves, and
  3. Infrared waves

Electromagnetic Spectrum

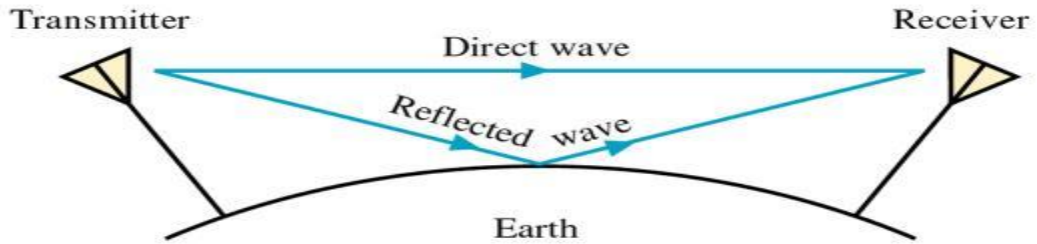


Propagation Methods?



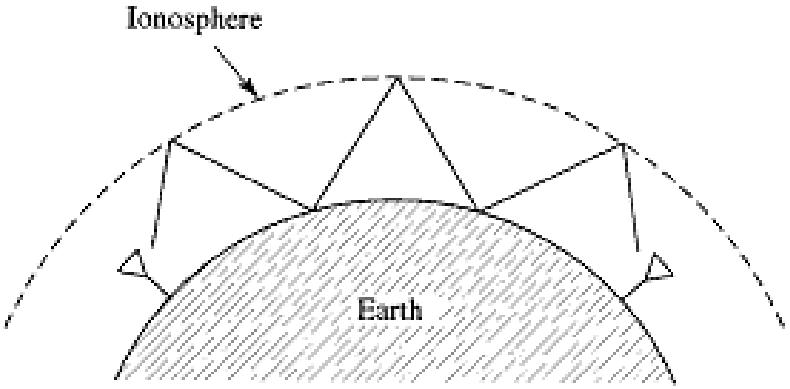
Ground Wave Propagation

- Uses radio waves up to 2MHz
- Propagates through the lower portion of atmosphere i.e. follow the curvature of the earth
- Distance covers depends upon the power of the signal, greater power greater distance
- Example: AM



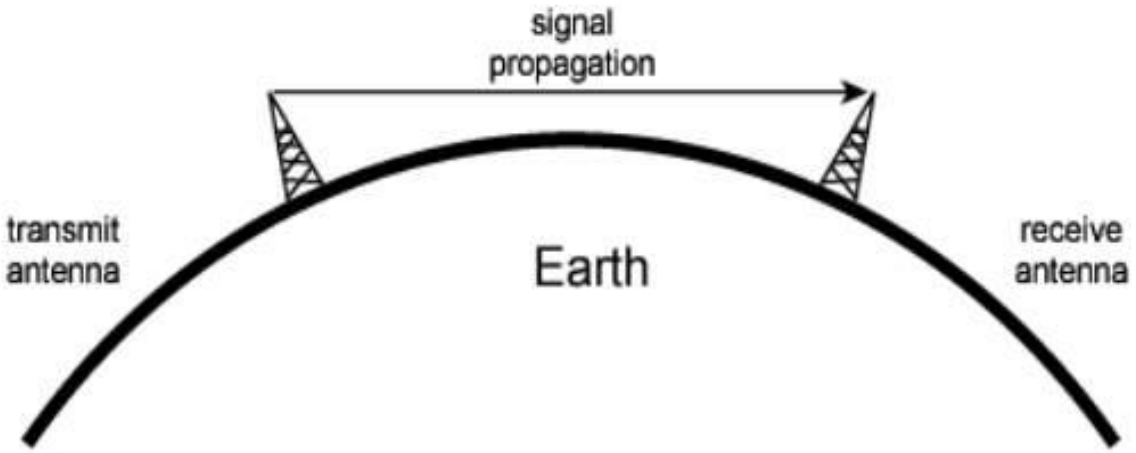
Sky wave propagation

- Higher frequencies radio waves are radiated upward towards the ionosphere and reflected back the earth.



Line-of-sight Propagation

- Very high frequencies signals are transmitted in straight lines directly from antenna to antenna.
- Example: Satellite communication

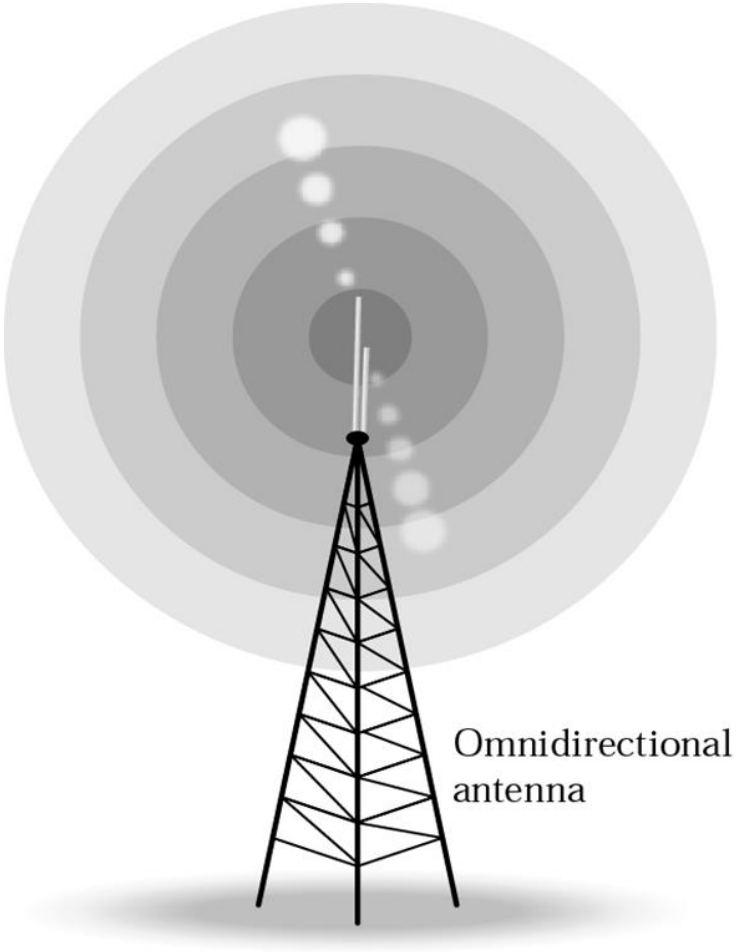


(c) Line-of-sight (LOS) propagation (above 30 MHz)

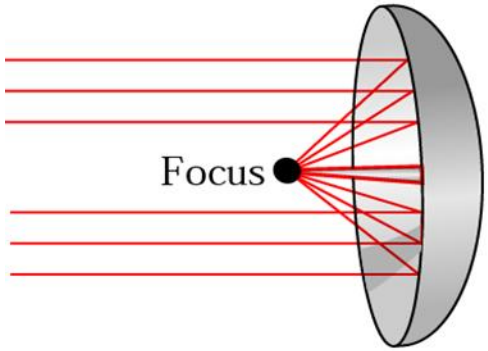
Bands

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), shipiaircraft 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

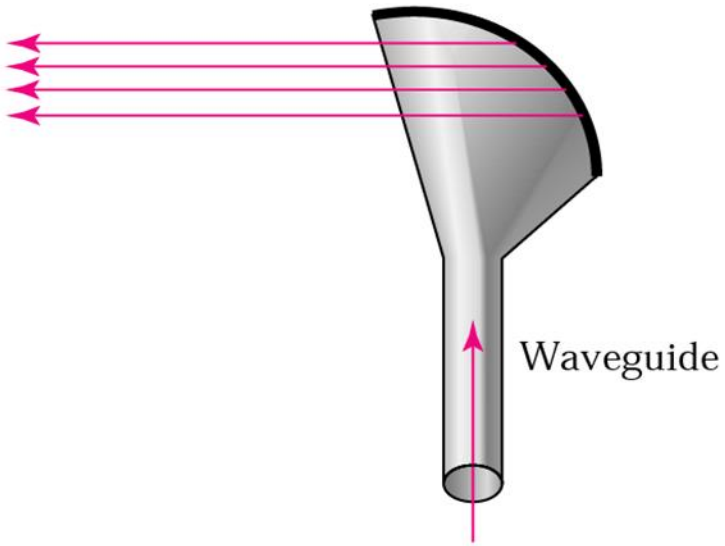
Antennas: Omnidirectional



Antenna: Unidirectional



a. Dish antenna



b. Horn antenna

Radio waves

- Electromagnetic wave ranging in frequencies between **3 KHz and 1GHz** are normally called radio waves.
- Radio waves are omni-directional when an antenna transmits radio waves they are propagated in all directions. This means that sending and receiving antenna do not have to he aligned. A sending antenna can send waves that can be received by any receiving antenna.
- Radio waves particularly those waves that propagate in sky mode, can travel long distances. This makes radio waves a good candidate for long-distance broadcasting such as AM radio.
- Radio waves particularly those of low and medium frequencies can penetrate walls. It is an advantage because; an AM radio can receive signals inside a building.

Micro waves

- Electromagnetic waves having frequencies between **1 and 300 GHz** are called microwaves.
- Microwaves are unidirectional; when an antenna transmits microwaves they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas.
- Microwaves propagation is line-of-sight. Since the towers with the mounted antennas needs to be in direct sight of each other, towers that are far apart need to be very tall, the curvature of the earth as well as other blocking obstacles do not allow two short towers to communicate using microwaves. Repeaters are often needed for long distance communication. Very high frequency microwaves cannot penetrate walls.
- Parabolic dish antenna and horn antenna are used for this means of transmission

Infrared

- Infrared signals with frequencies ranges from **300 GHz to 400 GHz** can be used for short range communication.
- Infrared signals, having high frequencies, cannot penetrate walls. This helps to prevent interference between one system and another. Infrared Transmission in one room cannot be affected by the infrared transmission in another room.
- Infrared band, has an excellent potential for data transmission. Transfer digital data is possible with a high speed with a very high frequency. There are number of computer devices which are used to send the data through infrared medium e.g. keyboard mice, PCs and printers. There are some manufacturers provide a special part called the IrDA (Infrared Data Assosication) port that allows a wireless keyboard to communicate with a PC.

Satellite

- A communication satellite is a microwave repeater. It amplifies the incoming signal and broadcast into another frequency back to earth.
- It is used to link two or more ground-based microwave transmitter/receivers. Known as **earth stations**, or **ground stations**.
- One **Earth Station** sends a transmission to the satellite. This is called a **Uplink**.
- The satellite **transponder** converts the signal and sends it down to the second earth station. This is called a **Downlink**.

- There are two common configurations for satellite communications:

1. Point-to-point link
   - Provides communication between two ground stations
2. Broadcast link
   - Provides communication between one ground based transmitter and a number of ground based receivers.

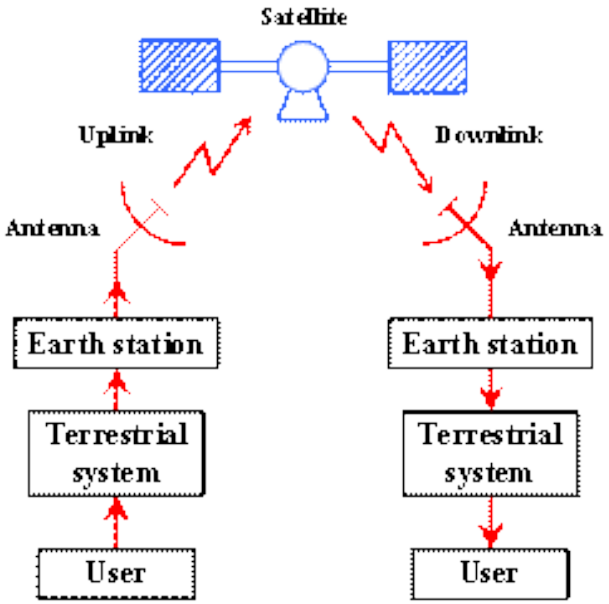


Figure: Point-to-point link

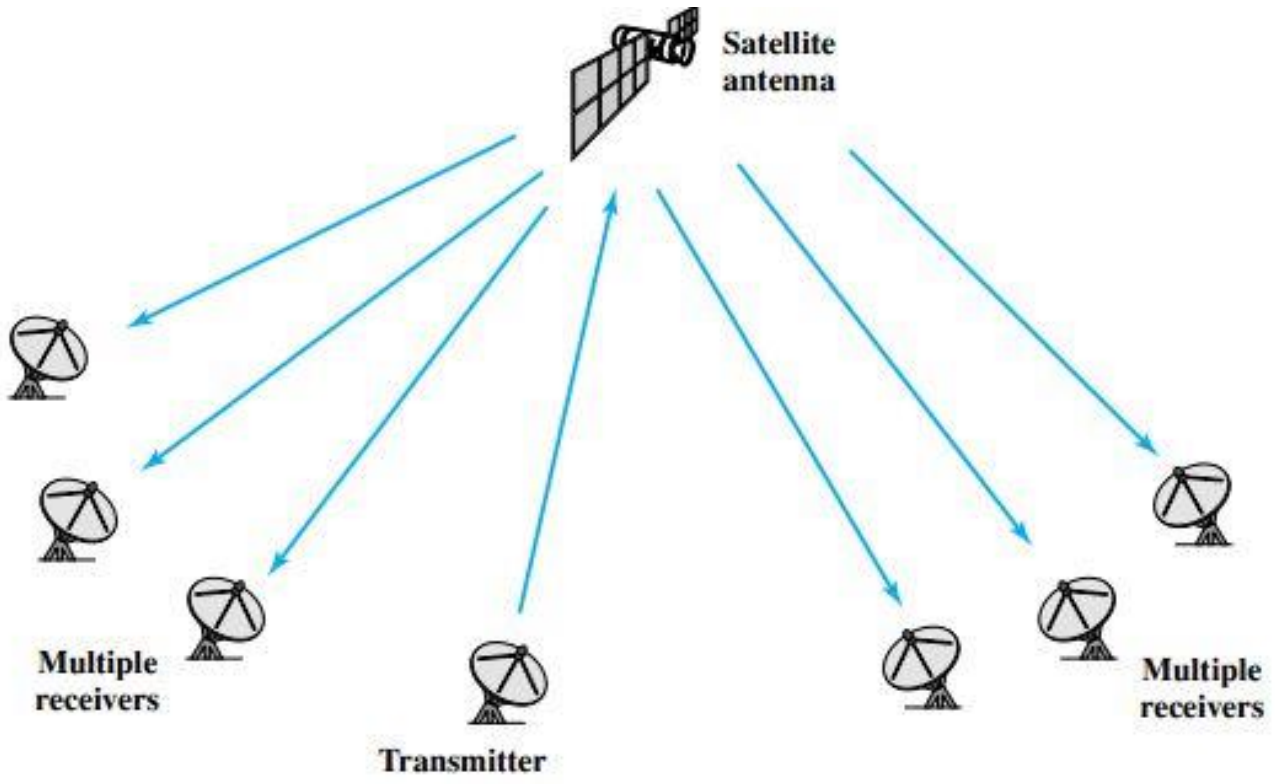


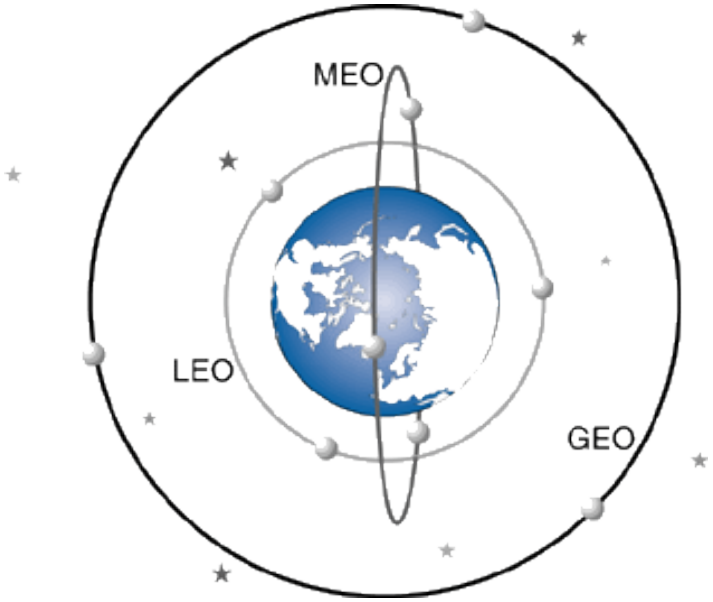
Figure: Broadcast Link

Frequency Band

Band (GHz)	Uplink (GHz)	Downlink(GHz)
4/6	5.9 to 6.4	3.7 to 4.2
12/14	14 to 14.5	11.7 to 12.2
20/30	27.5 to 30	17.7 to 20.2

Orbit

Orbit	Height From Earth Surface
LEO : LOW Earth Orbit	500 to 1500 Km
MEO: Medium Earth Orbit	8000 to 18000 Km
GEO: Geostationary Earth Orbit	36,000 Km



GEO

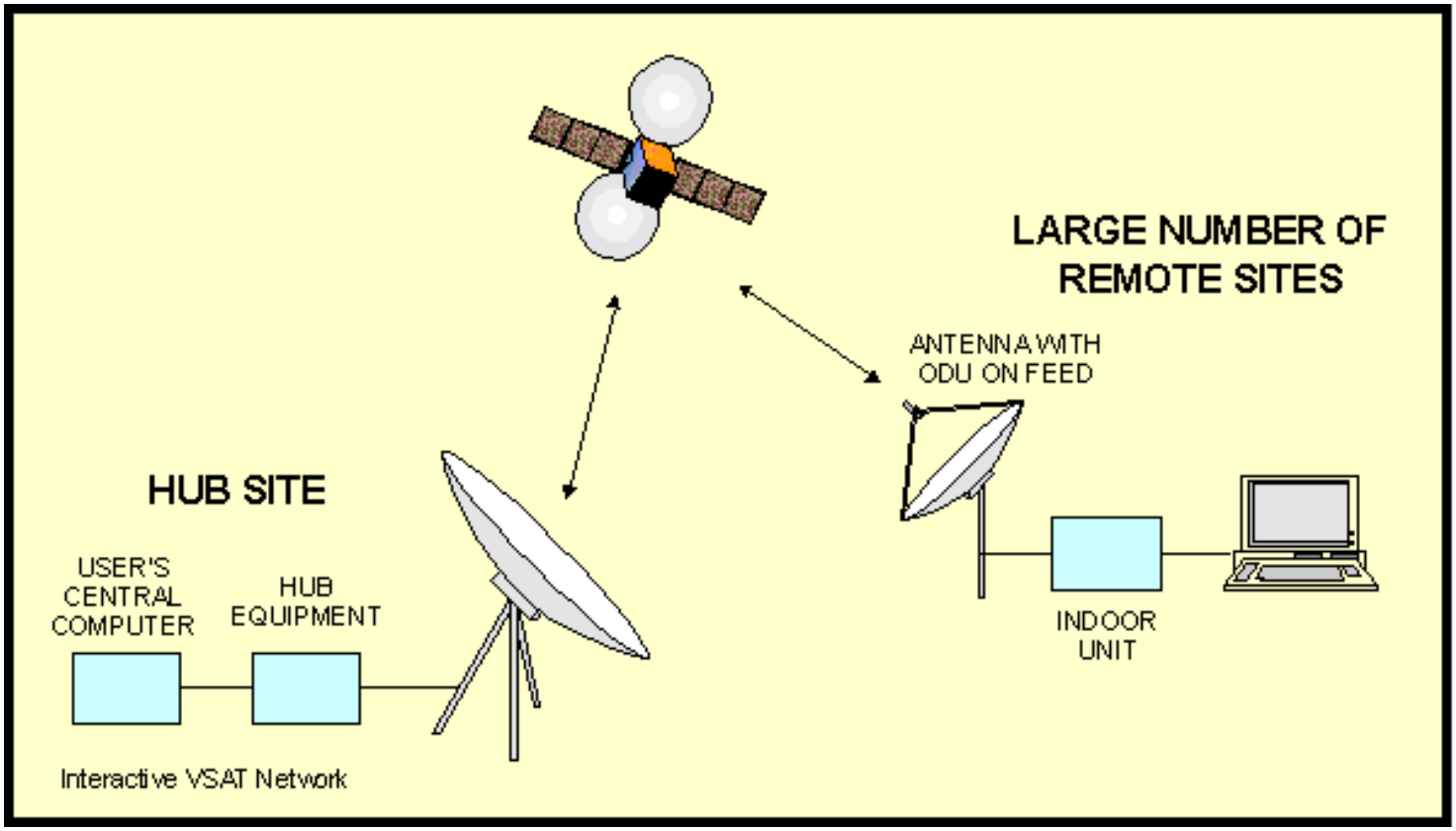
- These satellites are in orbit 35,863 km(nearly 36000 Km) above the earth's surface along the equator.
- Objects in Geostationary orbit revolve around the earth at the same speed as the earth rotates. This means GEO satellites remain in the same position relative to the surface of earth.
- At the Geostationary orbit the satellite covers 42.2% of the earth's surface.
- Theoretically 3 geostationary satellites provides 100% earth coverage

Applications

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

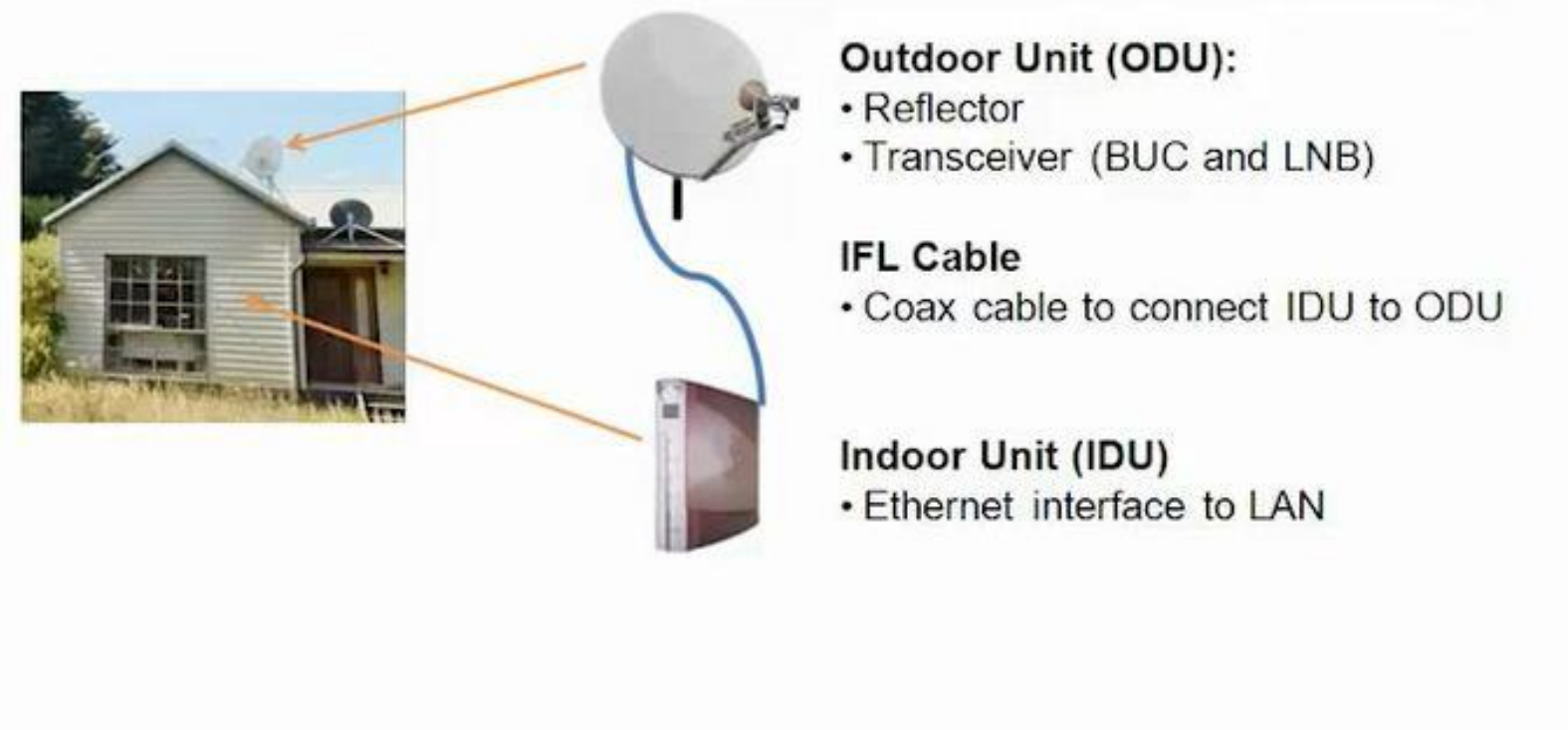
Very Small Aperture Terminal (VSAT)

- VSAT (Very Small Aperture Terminal) is a satellite communications system that serves home and business users.
- A VSAT end user needs a box that interfaces between the user's computer and an outside antenna with a **transceiver**. The transceiver receives or sends a signal to a satellite **transponder** in the sky.
- The satellite sends and receives signals from an earth station computer that acts as a **hub** for the system. Each end user is interconnected with the hub station via the satellite in a star topology.
- For one end user to communicate with another, each transmission has to first go to the hub station which retransmits it via the satellite to the other end user's VSAT.
- VSAT handles data, voice, and video signals.


LARGE NUMBER OF
REMOTE SITES
ANTENNA WITH
ODU ON FEED
HUB SITE
USER'S
CENTRAL
COMPUTER
HUB
EQUIPMENT
INDOOR
UNIT
Interactive VSAT Network

VSAT configuration

VSAT consists of following parts:



Antenna (Reflector)

- An **antenna** (or **aerial**) is an electrical device which converts electric power into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver.

BUC

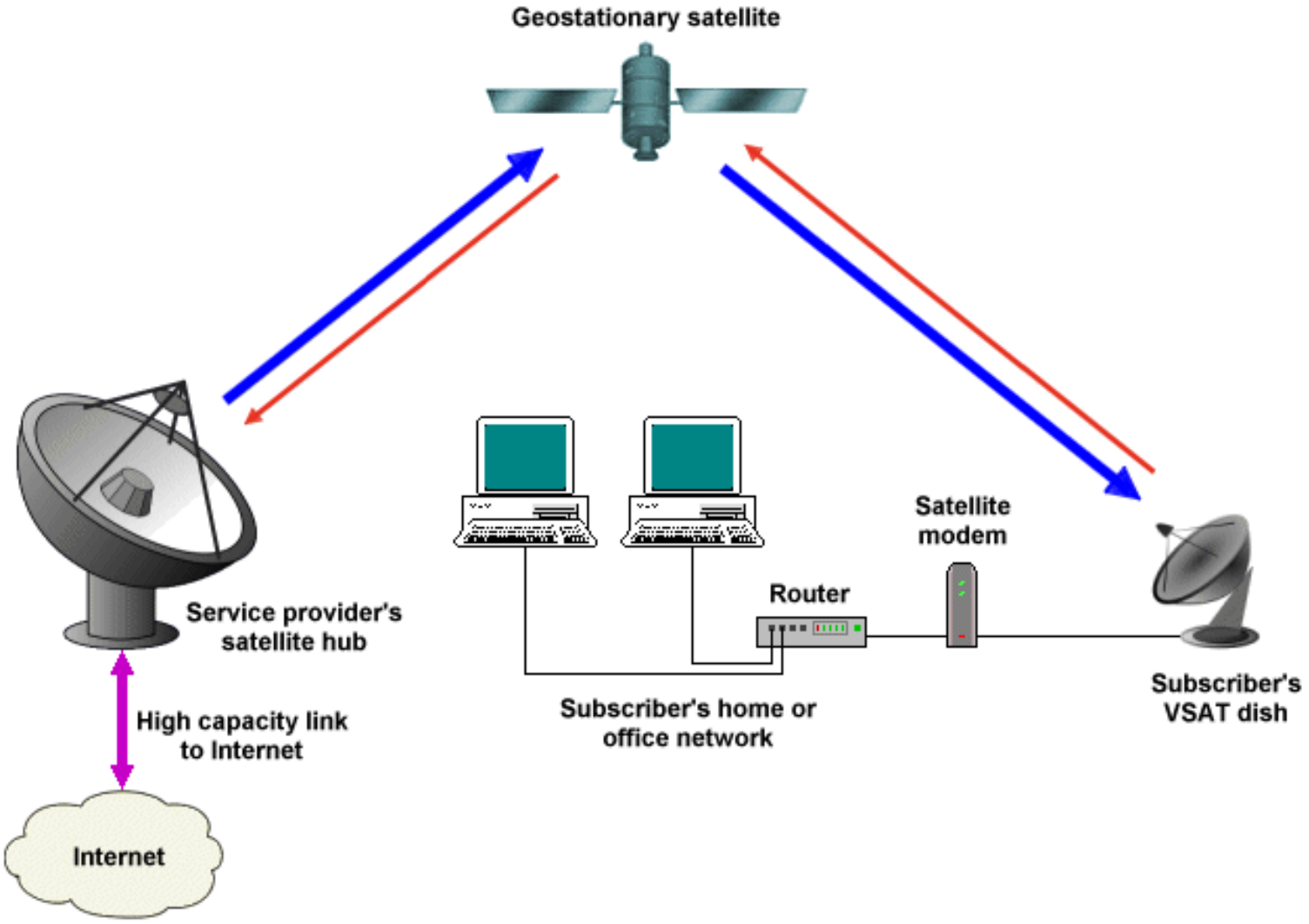
- A **block upconverter** (BUC) is used in the transmission (uplink) of satellite signals. It converts a band of frequencies from a lower frequency to a higher frequency. Modern BUCs convert from the L band to K_u band, C band and K_a band.

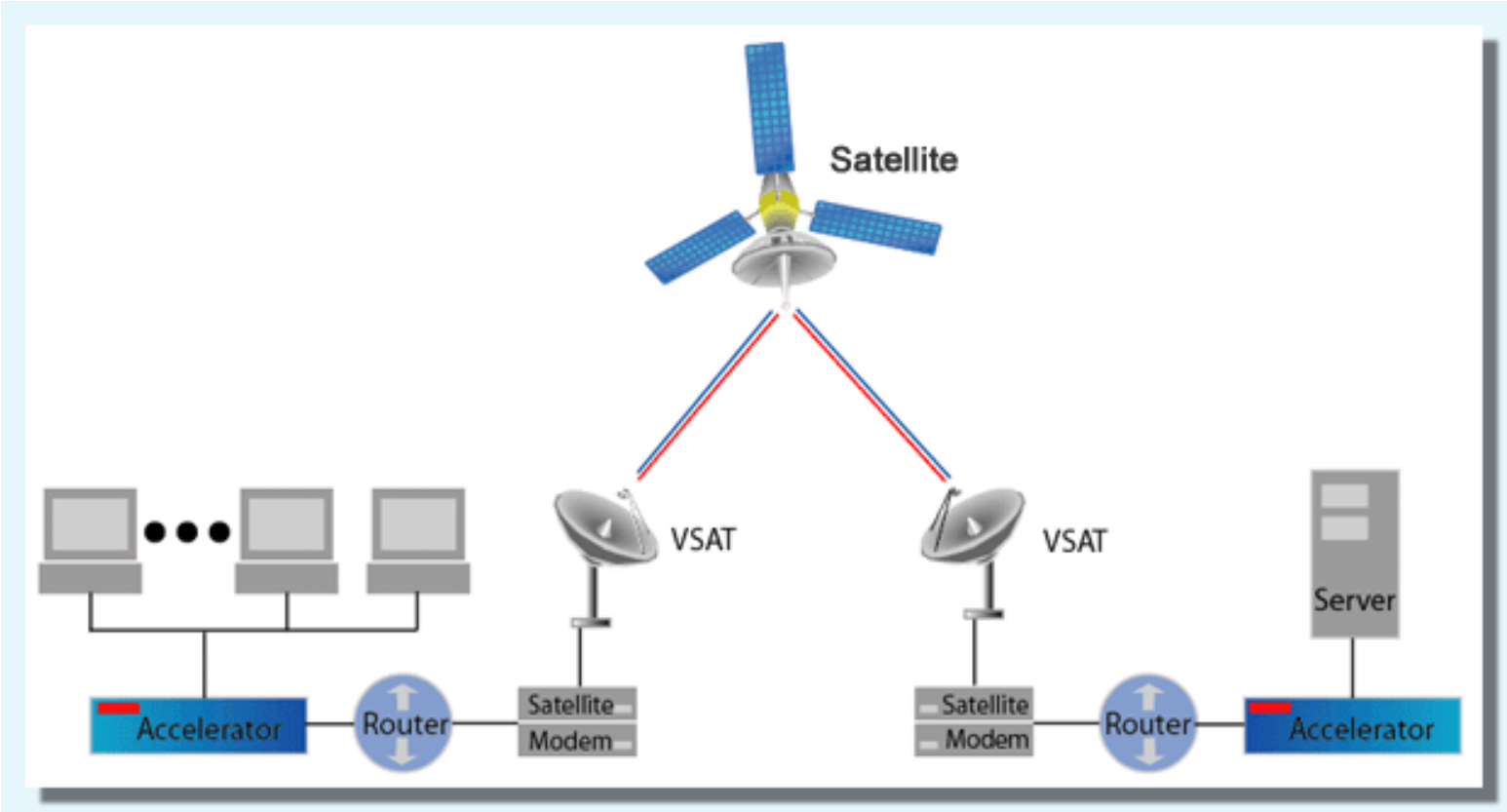
LNC (Low Noise Block Converter)

- A **low-noise block downconverter** (or **LNB**) is the receiving device mounted on satellite dishes, which collects the radio waves from the dish, amplifies it, and downconverts the block of frequencies to a lower block of intermediate frequencies (IF). This downconversion allows the signal to be carried to the indoor receiver using relatively cheap coaxial cable.

IDU

- Consists of satellite modem and IP router, which is interface with ethernet network.


Geostationary satellite
Service provider's satellite hub
High capacity link to Internet
Internet
Router
Satellite modem
Subscriber's home or office network
Subscriber's VSAT dish


Satellite
VSAT
VSAT
Server
Accelerator
Router
Satellite
Modem
Satellite
Modem
Router
Accelerator

Transmission Characteristic

- Attenuation
- Noise
- Signal-to-Noise Ratio
- Propagation Delay