EE 101: Telecommunication Concepts

What is Telecommunication?

- Telecommunication is sending and receiving certain types of signals.

What Kind of Signals?

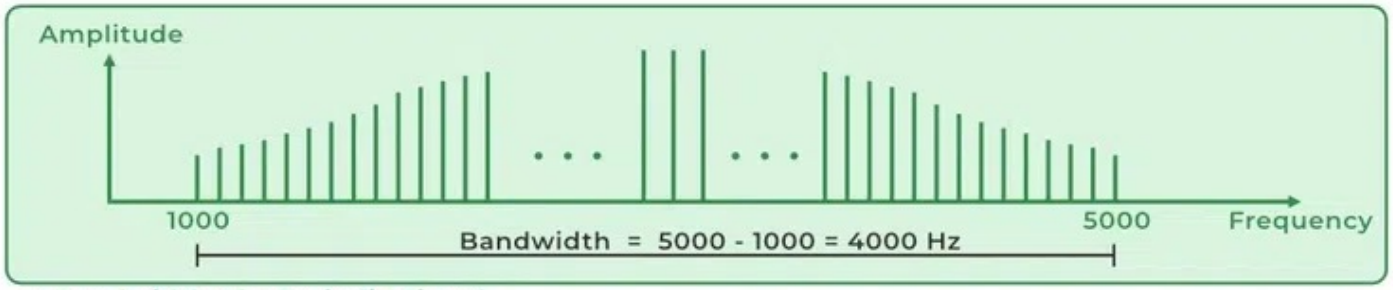
- Voice
- Data
- Image
- Video
- Text
- Combination (Multimedia)

What is Frequency?

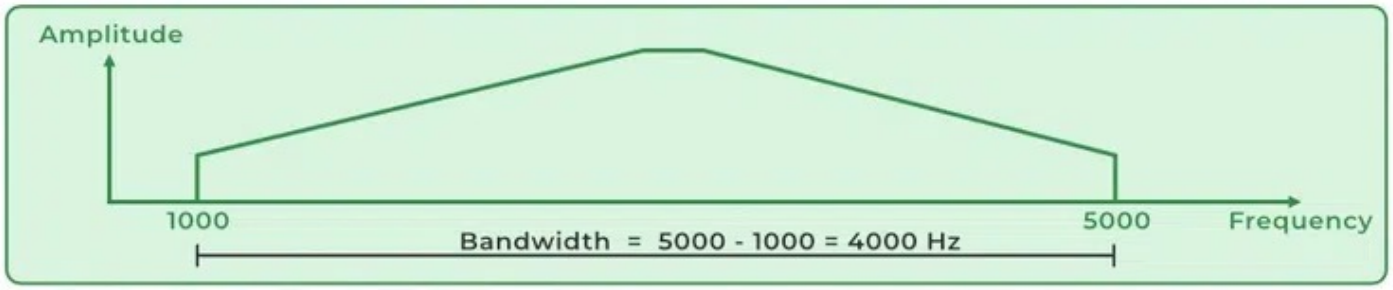
- Frequency is the number of cycles that a signal has in one second.
- Example: If a signal has 1 MHz frequency, it has 1 million cycles per second.

What is the Bandwidth of a Signal?

- Bandwidth is the range of frequencies that make up the signal.



a. Bandwidth of a Periodic Signal



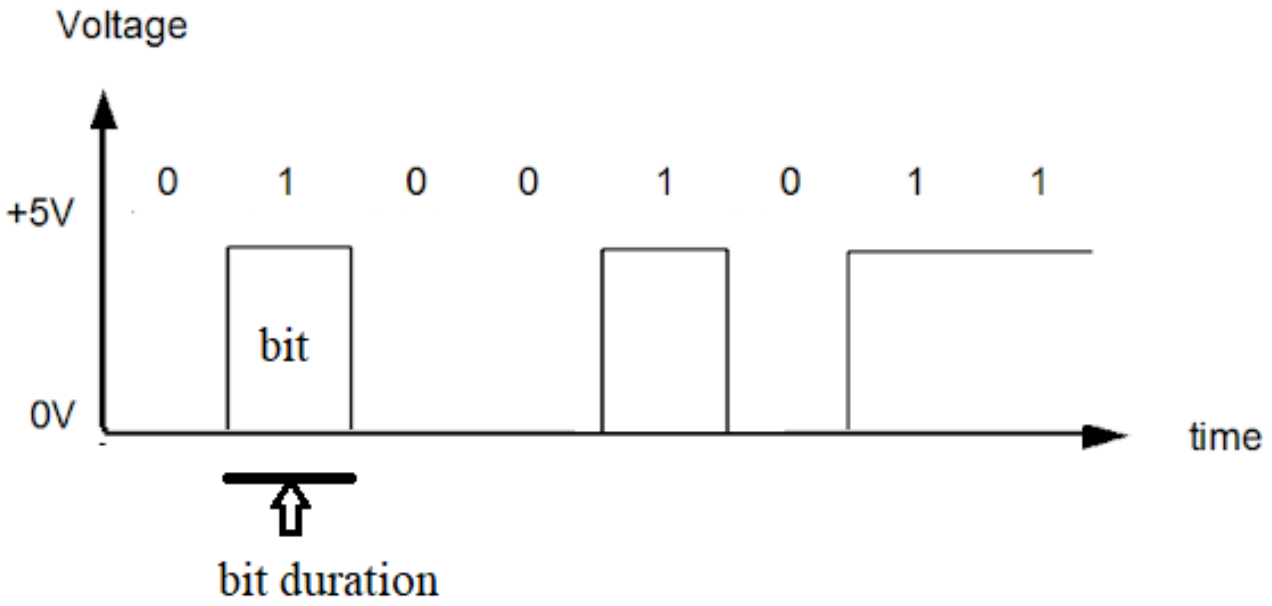
b. Bandwidth of a Non-Periodic Signal

Signal Types

- Analog Signal: Natural form of the signal, i.e., as it is.
- Digital Signal: Contains a sequence of level 0's and 1's representing the analog signal.

What is analog signal?

What is digital signal?



What is Data Bit Rate?

- Data bit rate is the number of bits sent in one second = 1 / bit duration.
- Example: If bit duration = 1 microsecond, data bit rate = 10^6 bits/sec.
- System performance is measured in Bit Error Rate (BER) for digital systems

Example

- If the bit duration in the system is 4 μs, calculate the data bit rate in bits per second (bps).
- If the BER of the system is 10^{-5}, calculate the expected number of errors when transmitting 10^{8} bits.

Solution

- **Calculating Data Bit Rate**
  The bit rate is given by:

Data Bit Rate=1/Bit Duration

Substituting Bit Duration=4 μs=4×10^{-6} s;

Data Bit Rate=$1/4\times10^{-6}=0.25\times10^{6}=250000$ bps.

- **Calculating Expected Number of Errors**
  The number of errors can be calculated using:

Number of Errors=Total Bits Transmitted×BER

Substituting Total Bits Transmitted=10^{8} and BER=10^{-5}

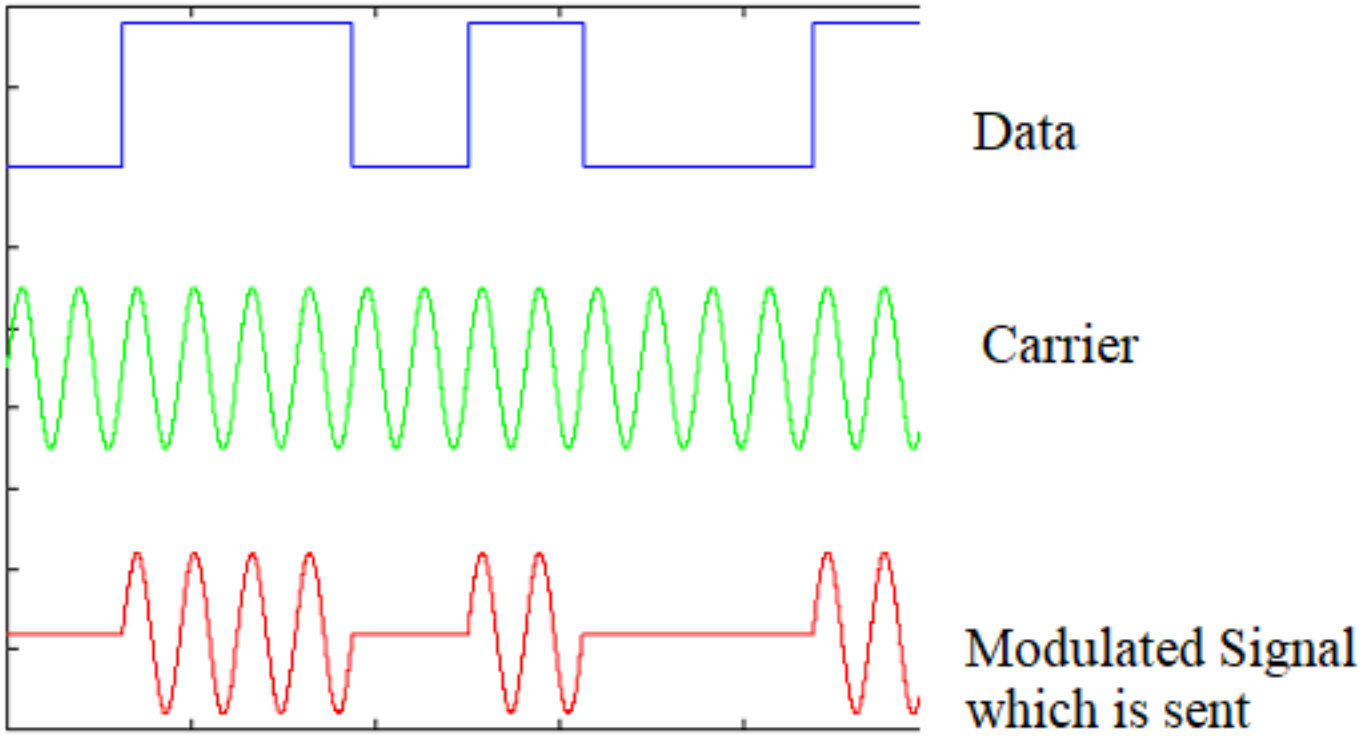
Number of Errors=$10^{8}\times10^{-5}=10^{3}$=1,000 errors

How is data sent?

- Data is sent by putting the data on an electromagnetic wave of carrier frequency like microwave or optical frequency. This technique is called modulation.

Digital Modulation

- Amplitude Shift Keying (ASK)



What is Multiplexing?

- Multiplexing allows sending multiple channels over a single line.
- Example: 120,000 telephone conversations in one system.

Telecommunication Network

- Core Network: High data bit rate traffic flows.
- Access Networks: Connect end-users to the core network with lower data rates.

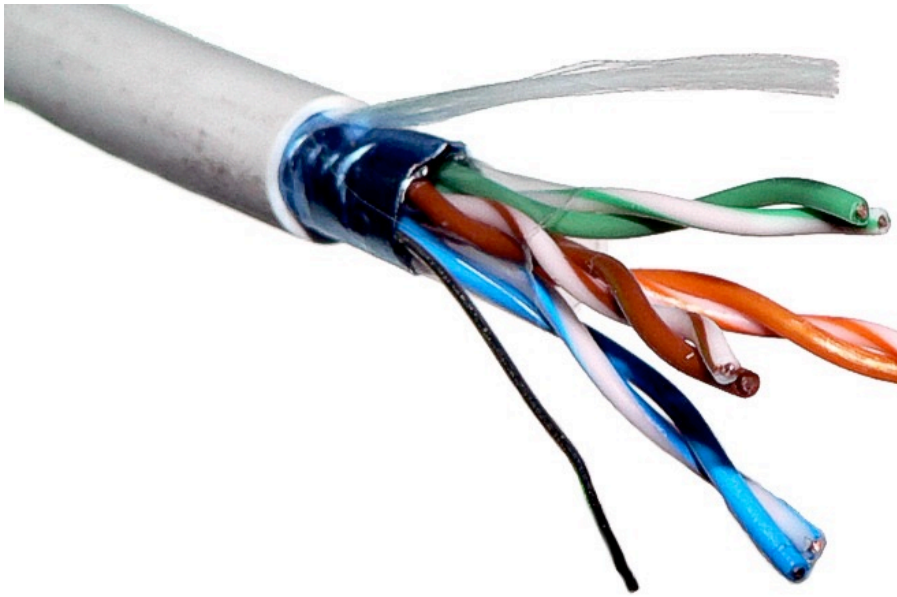
Transmission Systems

- These are the systems that carry the signal for communication.
- Types of Transmission Media:

- Twisted Pair
- Coaxial Cable
- Microwave (Radio-Link)
- Satellite
- Optical Fiber
- Free Space Optics

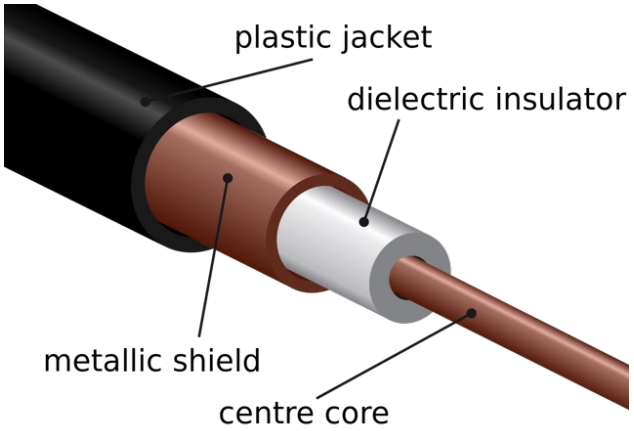
Twisted Pair Copper Cable

- Oldest transmission system.
- It is made up of two thin copper wires which are separately insulated and twisted around each other.
- Mainly used to connect telephone lines to the core network and in local area networks.



Coaxial Cable

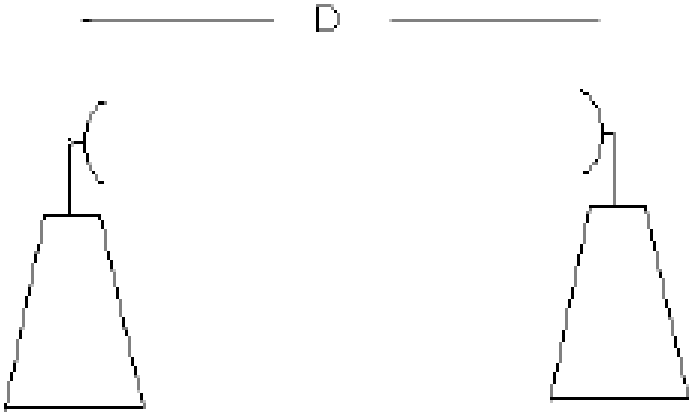
- Formed by single thick solid core copper conductor surrounded by an insulator separating the center conductor from the outer shield of metal foil.
- That insulating material serves to separate the center conductor, over which the data is transmitted, from the shield.
- Surrounding all of that often is a layer of metal mesh for protection, and then a cable sheath
- Cable TV systems uses coaxial cable.



The signal is applied between the centre core (metal) and the metallic shield (ground).

Microwave (Radio Link)

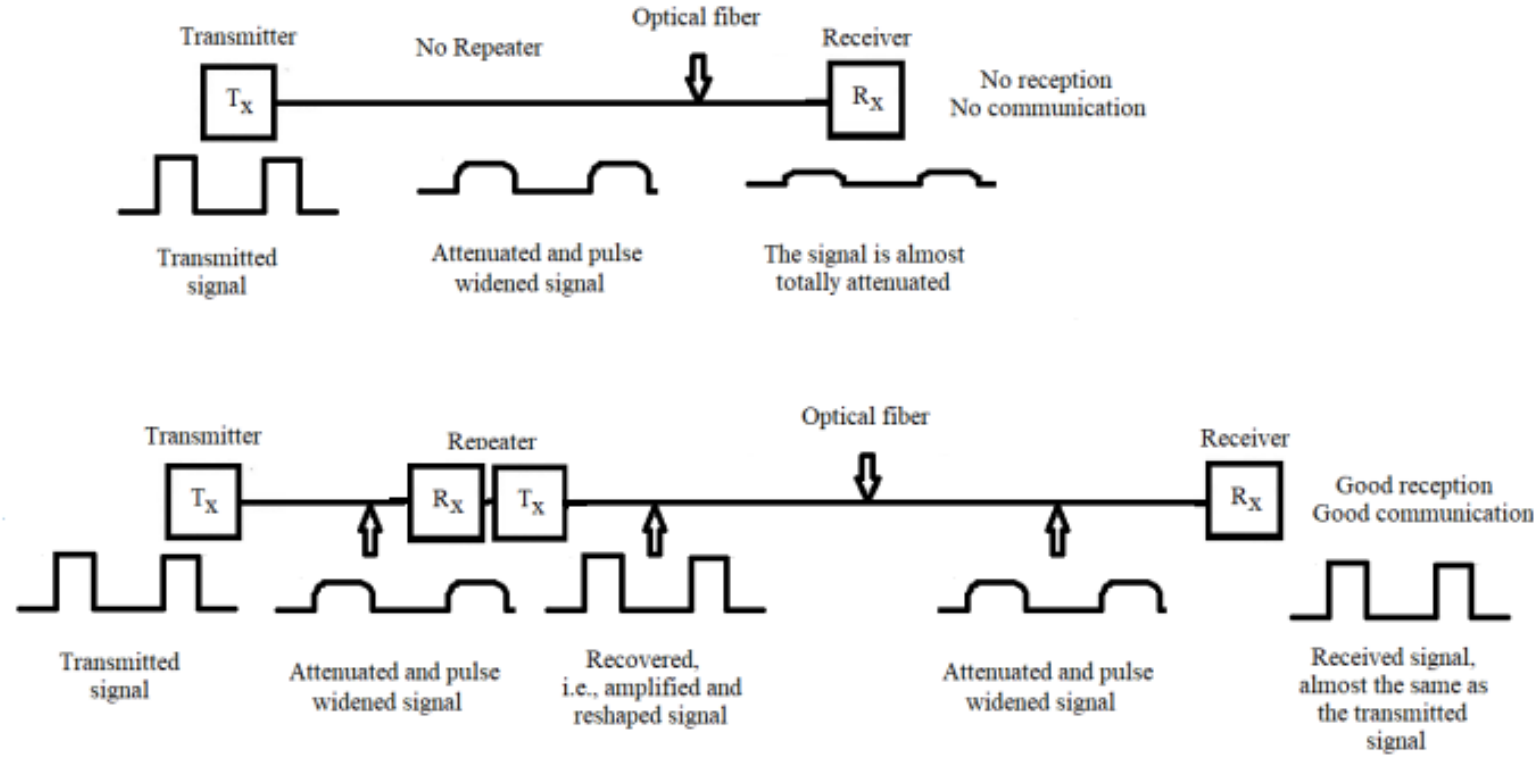
- It is a system composed of transmitter and receiver installed on top of two mountains in order to have wireless communication using electromagnetic waves at microwave frequencies.
- Operates in the UHF (Ultra-High Frequency) up to the EHF (Extremely High Frequency) bands, which covers the range between 300 MHz and 300 GHz, current practice being mainly from 1 GHz up to 45 GHz.



Link Design Considerations

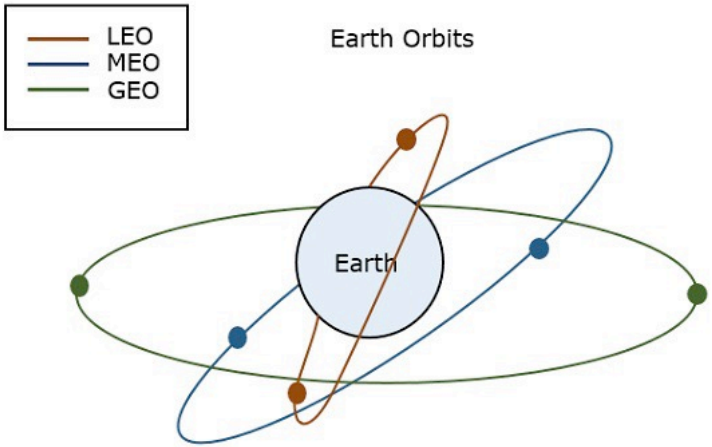
- In a link, the transmitted signal attenuates and is distorted as it propagates along the link length.
- To make the link design power budget analysis is made to obtain the required signal power level at the receiver.
- Also dispersion analysis is made to avoid the widening of the pulse at the receiver in order to achieve the required data bit rate.

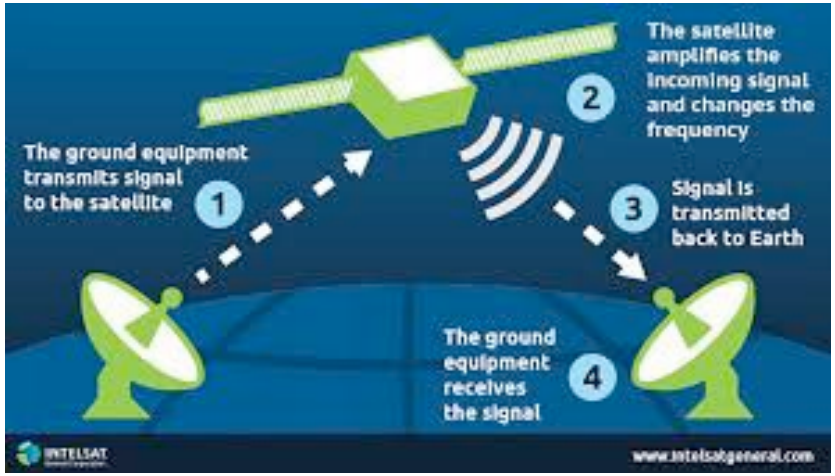
Repeater


Transmitter
No Repeater
Optical fiber
Receiver
T_X
R_X
No reception
No communication
Transmitted signal
Attenuated and pulse widened signal
The signal is almost totally attenuated
Transmitter
Repeater
Optical fiber
Receiver
T_X
R_X
T_X
R_X
Good reception
Good communication
Transmitted signal
Attenuated and pulse widened signal
Recovered, i.e., amplified and reshaped signal
Attenuated and pulse widened signal
Received signal, almost the same as the transmitted signal

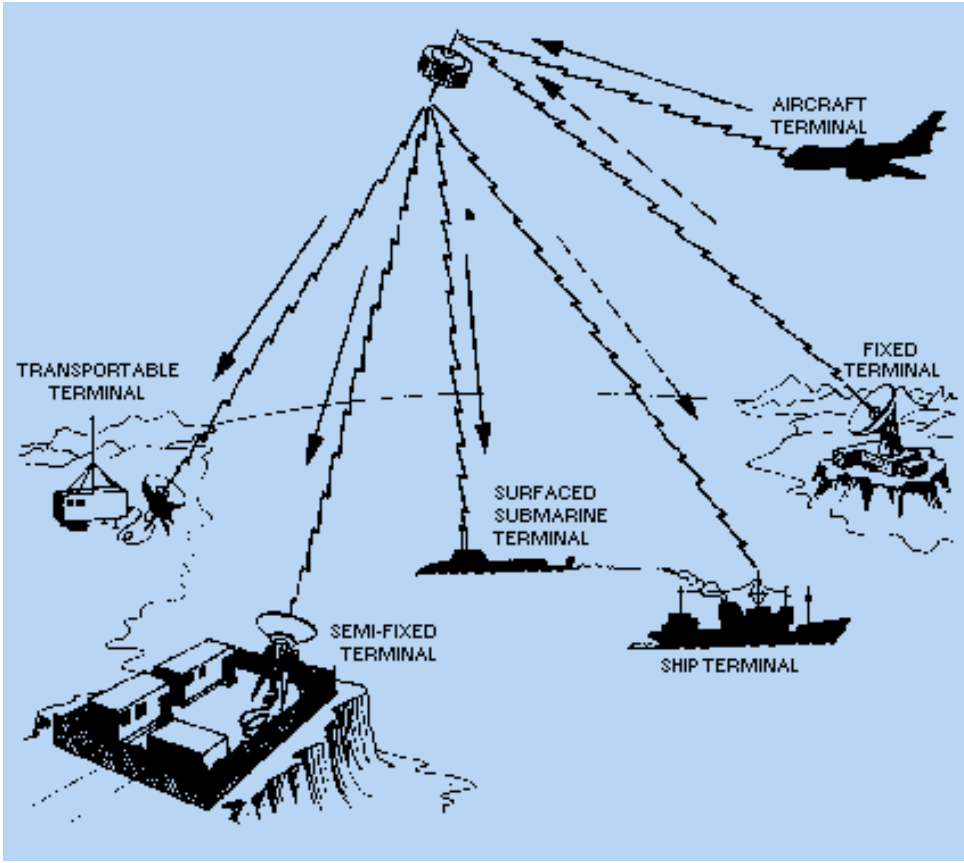
Satellite Systems

- A satellite is a body that moves around another body in a mathematically predictable path called an orbit.



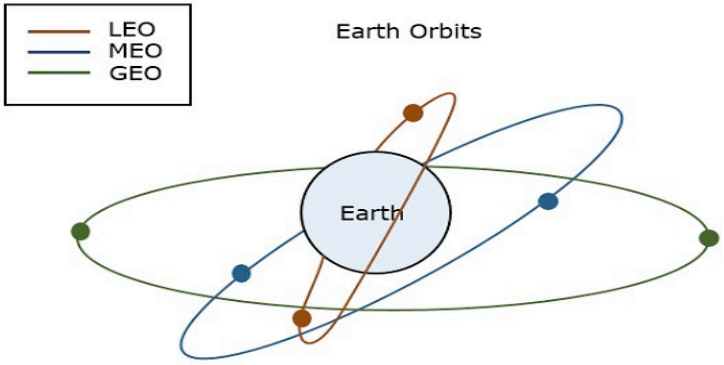


A communication satellite is a microwave repeater station in space that is helpful in telecommunications, radio, and television along with internet applications.



GEO, LEO, MEO

- In some cases satellites can operate in the same frequency range as terrestrial systems
- GEO (Geosynchronous Earth-Orbiting) satellites are positioned directly above the equator at altitudes of 35,786.1 km. GEOs maintain their positions relative to the Earth's surface. Orbital travel is in east-west direction.
- GEOs are used for communication.



LEO (Low Earth-Orbiting) satellites have altitudes of 320 - 800 - 1500 kilometres and mainly used in Remote Sensing applications.

LEOs have polar orbits (north-south direction, descending from north-south, ascending from south-north), with orbital speed of LEO satellites are 27,359 kilometres per hour. They can circle Earth in about 90 minutes.

MEOs (Middle Earth-Orbiting) are at at altitudes of 10.000 - 15.000 km.

Applications of Satellite Communications

- Long distance telephone network among countries
- Television Broadcasting (Analog and digital):
- Direct free reception by home dishes (Free or scrambled channels)
- Terrestrial distribution after the satellite reception at the ground station
- Automotive Navigation: Inmarsat applications as Global Positioning System GPS, Vehicle
- Tracking in a Fleet, Land Navigation as Maps in Cars, Maritime applications

Optical Communication

Any optical communications system can be studied in three main parts:

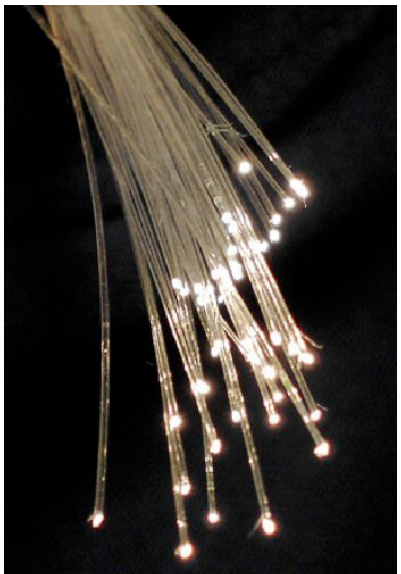
1. Transmitter which converts information to light

2. Medium (i.e. fiber optic cable or atmosphere) which transmits the light signal

3. Receiver which converts the light signal into an electrical signal.

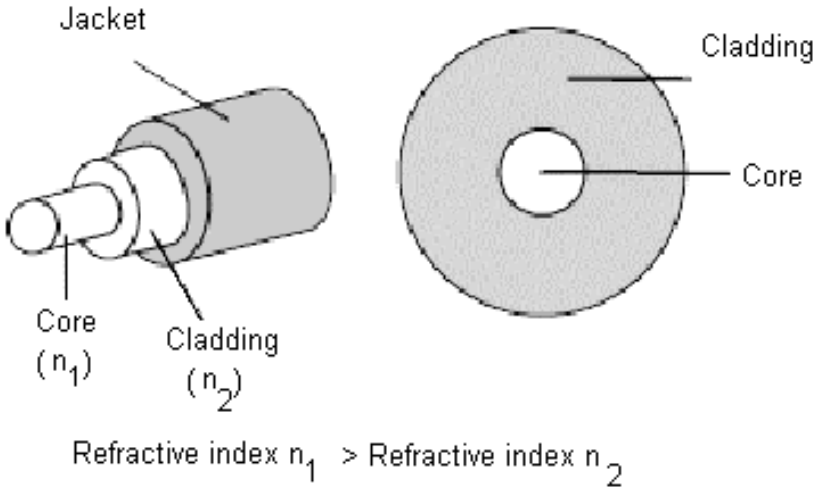
Light Source

- Light Source is either a semiconductor Light Emitting Diode (LED) or a semiconductor Laser Diode
- LED or Laser Diode receives a modulated electrical signal and converts it into a light signal
- Light signal is coupled into the fiber optic cable
- Light sources emit light at wavelengths of 850, 1300 or 1550 nanometers



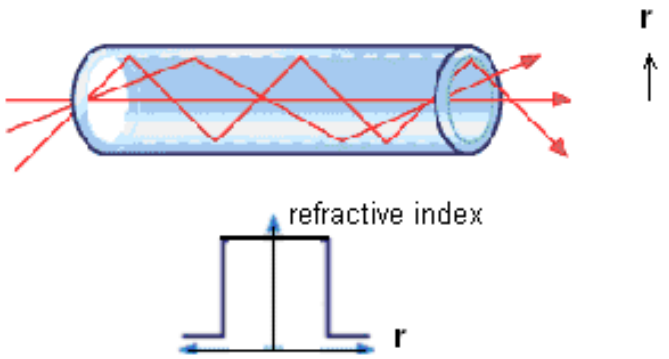
Fiber Optics

- Fiber consists of an inner core, outer cladding and a protective buffer coating



Fiber Optics

- Core is the glass (SiO2) area through which light travels and the information is carried
- Surrounding the core is the cladding which is also of glass but with a lower refractive index than the core
- The lower refractive index causes the light to be totally reflected in the core, thus staying in the core until the receiver



Step index Multimode Fiber

Free Space Optics (FSO)

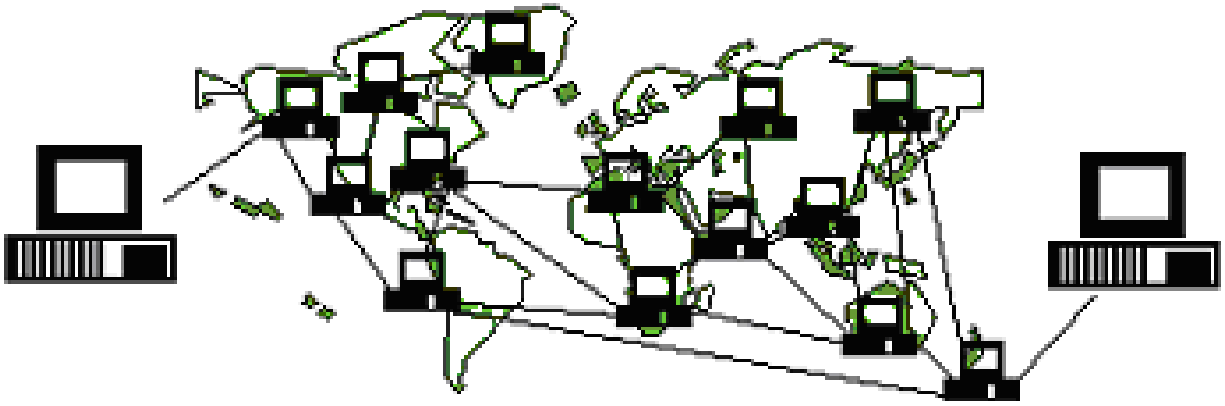
-FSO is a wireless optical transmission in the atmosphere
- Two infrared wavelengths, around 1550 nm (194 THz) and around 800 nm (375 THz)

Packet Switching

- A packet is a container carrying control and data bits.
- Control and data bits can contain different number of bits

Internet Infrastructure

A piece of data (eg. a Web page) when it is transferred over the Internet:



A piece of data (eg. a Web page) when it is transferred over the Internet:

- Is broken up into a whole lot of pieces (called packets).
- A header is added to each packet that explains where it came from, where it should end up and how it fits in with the rest of the packets.
- Each packet is sent from computer to computer until it finds its way to its destination.
- Each computer along the way decides where next to send the packet. This could depend on things like how busy the other computers are when the packet was received.
- The packets may not all take the same route.
- At the destination, the packets are examined. If there are any packets missing or damaged, a message is sent asking for those packets to be resent. This continues until all the packets have been received.
- The packets are reassembled into their original form.