

EE 101 LECTURE NOTES FOR TELECOMMUNICATIONS

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?

It is the number of cycles that a signal has in one second.

e.g. if a signal has 1 MHz frequency, it means in one second it has 1 million cycles.

What is the bandwidth of a signal?

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

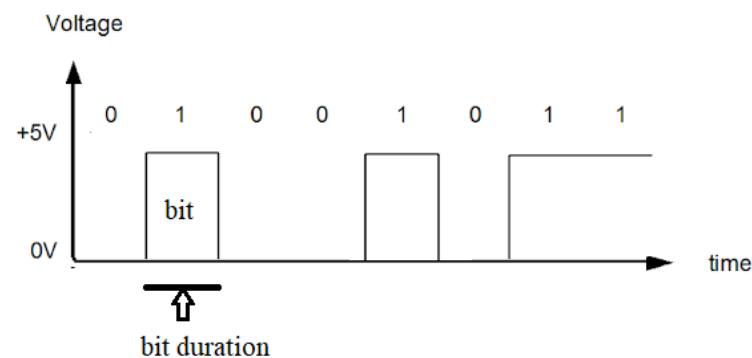
What is analog signal?

It is the natural form of the signal, i.e. as it is.



What is digital signal?

It is a signal that contains a sequence of level 0's and 1's that represent the analog signal.



What is data bit rate?

Data bit rate is the number of bits sent in one second = $1 / \text{bit duration}$.

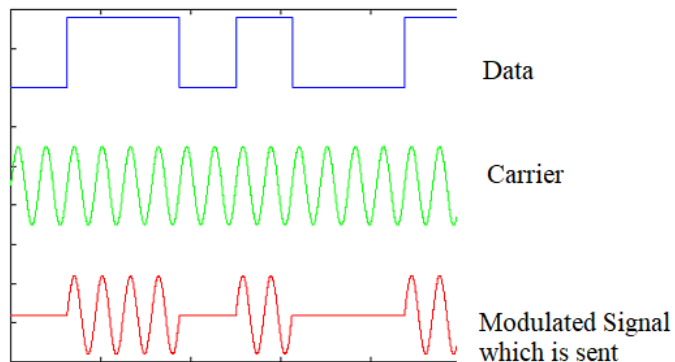
e.g. if bit duration = 1 micro second = 10^{-6} sec, data bit rate = $1 / 10^{-6} = 10^6$ bits / sec

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 is a way of sending many channels over a single line. For example with multiplexing 120 thousand telephone conversations can be transmitted in one system. If there is no multiplexing, each telephone conversation will wait for the other one to finish conversation.

Telecommunication Network

Mainly composed of two parts:

- Core Network (Backbone) in which very high data bit rate traffic flows
- Access Networks in which the end users (subscribers) are connected to the core network. In access networks data bit rates are not very high as in the core network.

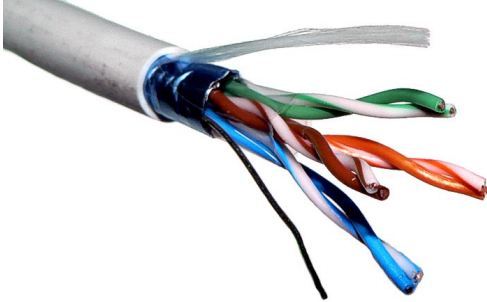
Transmission Systems

These are the systems that carry the signal for communication. Types of transmission media are:

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

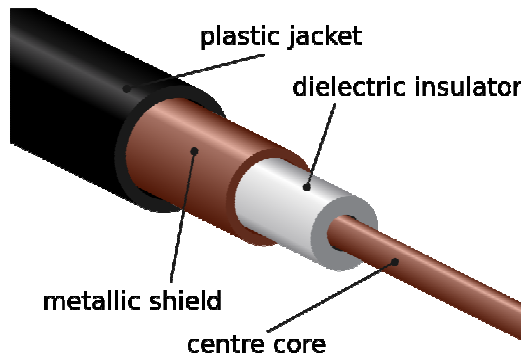
Twisted Pair Copper Cable

- 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.



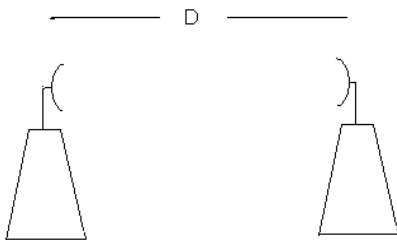
Coaxial Cable

- 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.

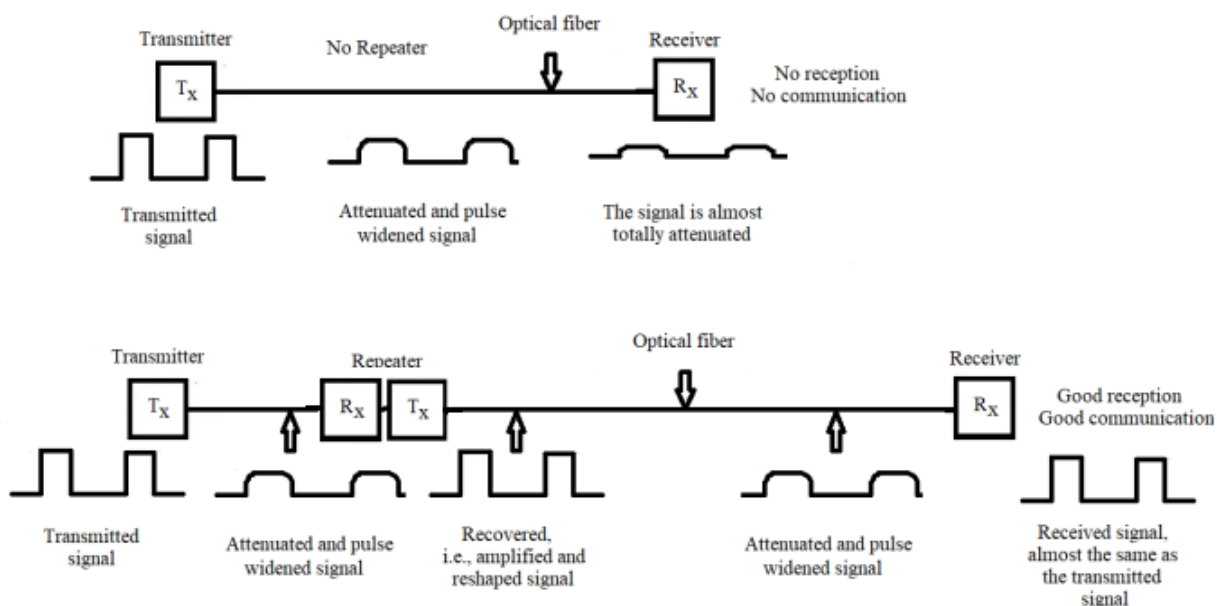
Link Design Considerations

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.

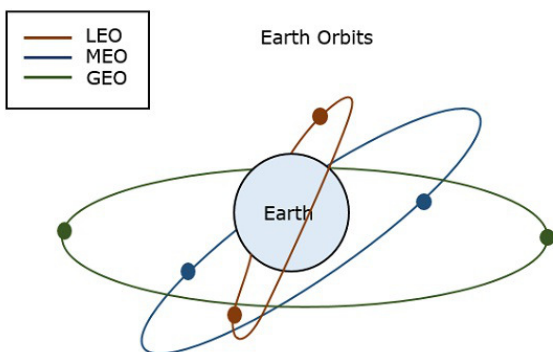
Also dispersion analysis is made to avoid the widening of the pulse at the receiver in order to achieve the required data bit rate.

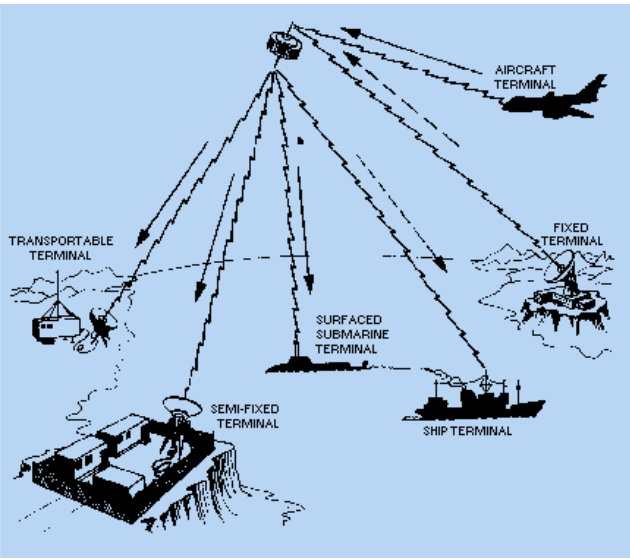
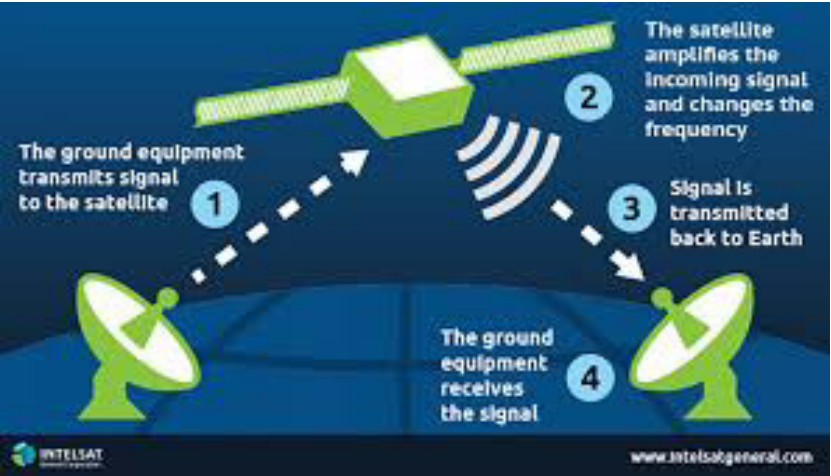
Repeater



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.





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.

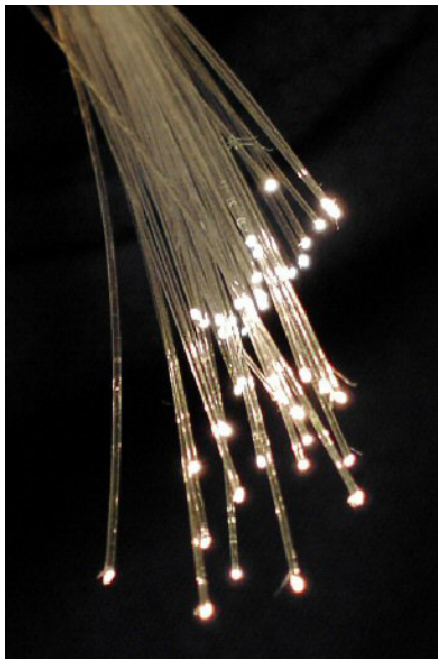
LEOs have polar orbits (north-south direction, descending from north-south, ascending from south-north), with orbital speed of LEO satellites are 27,359 kilometres per hour. They can circle Earth in about 90 minutes.

MEOs (Middle Earth-Orbiting) are at 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

Fiber Optics



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

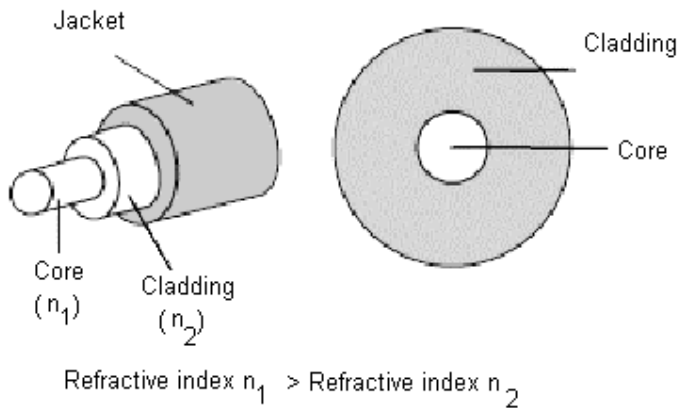
1. Transmitter which converts information to light
2. Medium (i.e. fiber optic cable or atmosphere) which transmits the light signal
3. Receiver which converts the light signal into an electrical signal.

Light Source 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 Optic

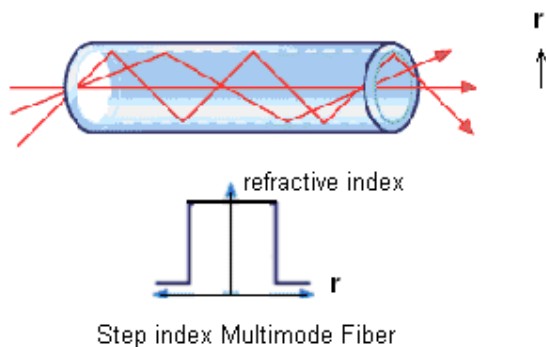
Fiber consists of an inner core, outer cladding and a protective buffer coating



Core is the glass (SiO_2) 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



System performance is measured in Bit Error Rate (BER) for digital systems.

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:

- 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.