# Data Communications And Networks

Notes MCA 104

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Syllabus

1. Introduction: Data communications, computer Networks, Network Layering – OSI reference model, TCP-IP protocol suite: physical layer: Data and Signals, periodic Analog Signals, Digital Signals, Transmission Impairement, Data rate limits. Digital-to-Digital Conversion, Analog to Digital conversion, Digital to Analog conversion, Anal.
2. physical layer: Transmission and Switching Transmission Modes, Transmission media – Guided, unguided media. Multiplexing, Switching – circuit Switching, packet Switching.
3. Data link layer: Nodes and links, link-layer Addressing error detection and correction. Block coding, cyclic Codes, checksum, Forward Error correction, Simple, Stop and wait, Go-back-N, selective Repeat. Media Acces control: Random Acess – ALOHA, CSMA, CSMA/CD, CSMA/CD, controlled Acess, channelization – FDMA, TDMA, CDMA.
4. Network layer: Services, Routing Algorithms: Distance Vector, link state, path vector and unicast Routing Algorithms.
5. Multicasting Basics: Addresses, Delivery at Data Link layer, Multicast forwarding, Two Approaches to Multicasting, Ip addressing, Classes, Subnetting.

# Module - I - INTRODUCTION: Data Communications - MCA-10

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## Data Communication

Electronically transmission of data from one place to another place by using a medium is called data communication.

There are 3 components of data communication

Sender → Medium → reciever.

Sender :- A computer / device from which data files are sending to specific destination. It is also called as source.

Reciever :- A computer / device at which data files are recieved by source. It is also called destination.

Data :- Digital Information over computer/network which may define with certain type of file extension like .doc, .ppt, .pdf, .exe and etc; file extension denotes nature of data file nature of data file

Message :- The content of transmission is called a message types of message we used as the Information to be communicated through text, numbers, picture, Audio and vedio

protocol :- Set of rules that govern data communications

Transmission Medium :- The physical path by which a message travels from sender to reciever.

Types :- • Twisted pair
• Coaxial

Message :- Message divided into small units are called Packets

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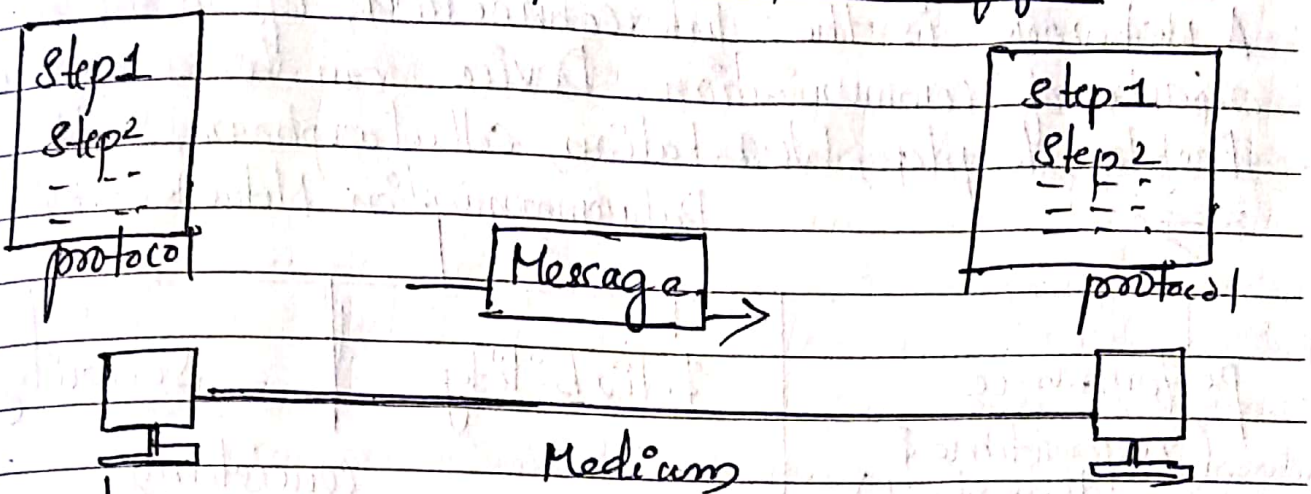
## Data Communication System components ifigure




## Data communication Characteristics

1. Delivery :- The system must deliver data to the correct destination. Data must be recieved by the intended device or user and only by that device or user.
2. Accuracy :- The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.
3. Timeliness :- The System must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, and without significant delay. This kind of delivery is called real-time transmission.
4. Jitter :- Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio ~~or~~ or Videos packets. for example, let us assume that video packets are sent every 30ms. If some of the pakets arrive with 30ms delay and Others with 40-ms delay, an uneven quality in the video is the result.

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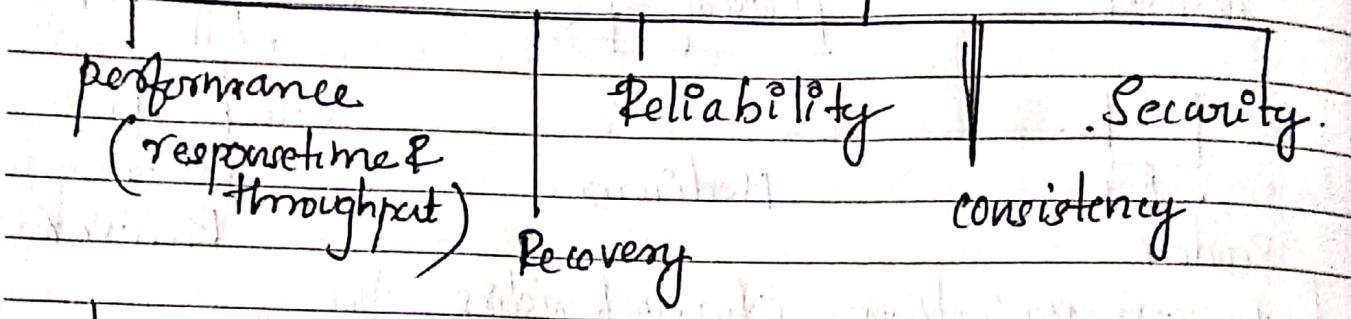
## Network

A Network is the interconnection of a set of devices capable of communication. Device can be a computer, Desktop, Laptop, Workstation, cellularphone, Switch, Modem.

⟹ Datacommunication Network Criteria




1. performance :- It depends on network elements. Measured in terms of delay and throughput. It is defined as the rate of transferring error free data. It is measured by the Response Time. Response Time is the elaped time b/w the end of an Inquiry and the beginning of a response. Request a file transfer and start the file transfer. factors that affect ResponseTime are: Number of users, transmission speed, Media Type, h/w type, s/w programs.
2. Consistency :-
   Consistency is the predictability of response time and accuracy of data. users prefer to have consistent response times, they develop a feel for normal operating conditions. Accuracy of Data determines if the network is reliable
3. Reliability :-
   Reliability is the measure of how often a network is useable, available/robustness. Mean Time Between

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failures is a measure of the average time a component is expected to operate b/w failures. Normally provided by the manufacturer. A Network failure can be: h/w, data carrying medium and Network Operating System.

4. Recovery:-
Recovery is the Network ability to return to a prescribed level of operation after a network failure. This level is where the amount of lost data is non existent or at a minimum. Recovery is based on having Back up files.

5. Security:-
Security is the protection of h/w, s/w and Data from unauthorized uses. Restricted physical access to computers, password protection, limiting user privileges and data encryption are common Security methods. Anti virus monitoring programs to defend against Computer Viruses are a Security Measure.

Physical Structure ⟹

Types of connection

A network is 2 or more devices connected through Links. A Link is a communication pathway that transfers data from one device to another.

Data transmission :- Data transmission is the physical transfer of data over a point to point or point to multipoint channel.

a) point to point :- A point to point connection provides a dedicated link between two devices. The entire capacity of the link is reserved for transmission b/w those two devices. Most point to

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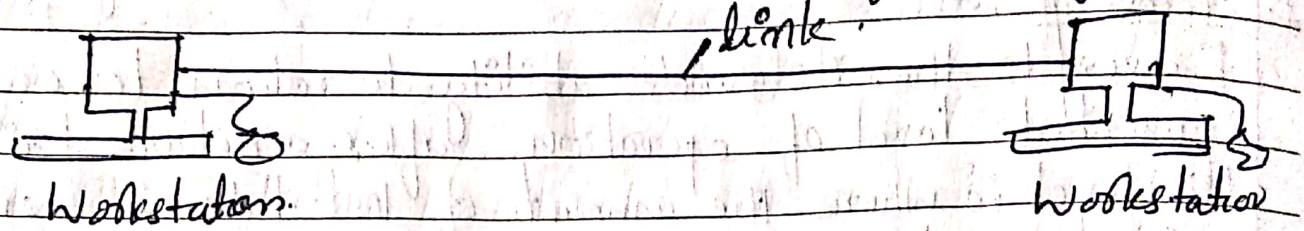
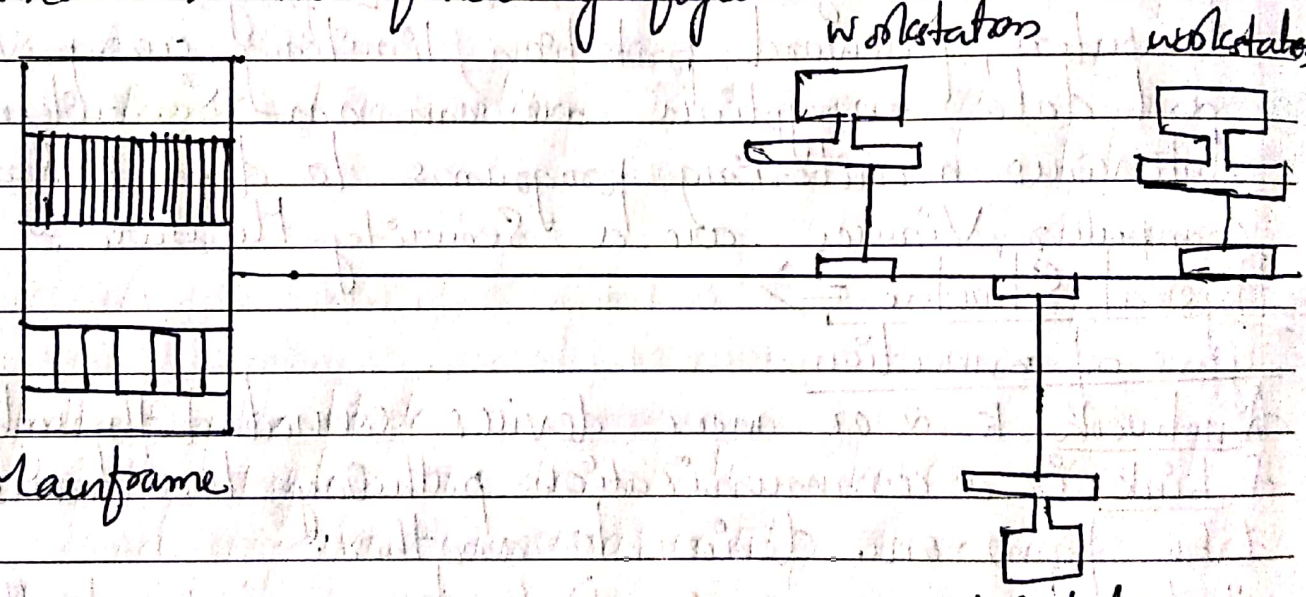
point connections use an actual length of wire or cable to connect the two ends, but other options such as microwave or satellite links, are also possible which are shown in following figure.




b) Multipoint

A multipoint connection is one in which more than two specific devices share a single link as shown in the following figure.




In a multipoint Environment the capacity of the channel is shared, either spatially or temporally. If several devices can use the link simultaneously. It is a spatially shared connection If user must take turns, it is a timeshared connection.

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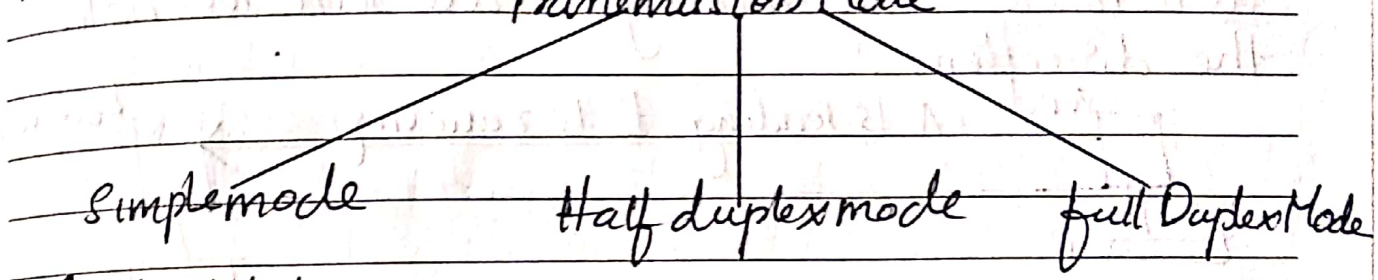
## Transmission Mode

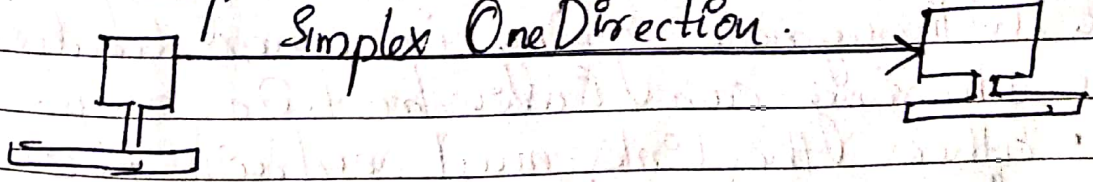
Transmission mode means transferring of data between two devices. It is also known as communication mode. Buses and networks are designed to allow communication to occur between individual devices that are interconnected. There are three types of transmission mode:-

1) Simple Mode 2) Half duplex Mode 3) Full-Duplex Mode




## Simplex Mode

In Simplex Mode, the communication is unidirectional as on a one way street. Only one of the two devices on a link can transmit, the other can only recieve. The simplex mode can use either capacity of the channel to send data in one direction. Example: keyboard and traditional monitors. The keyboard can only introduce input, the monitor can only give the output.




## Half Duplex Mode

In half-duplex mode, each station can both transmit and recieve, but not at the same

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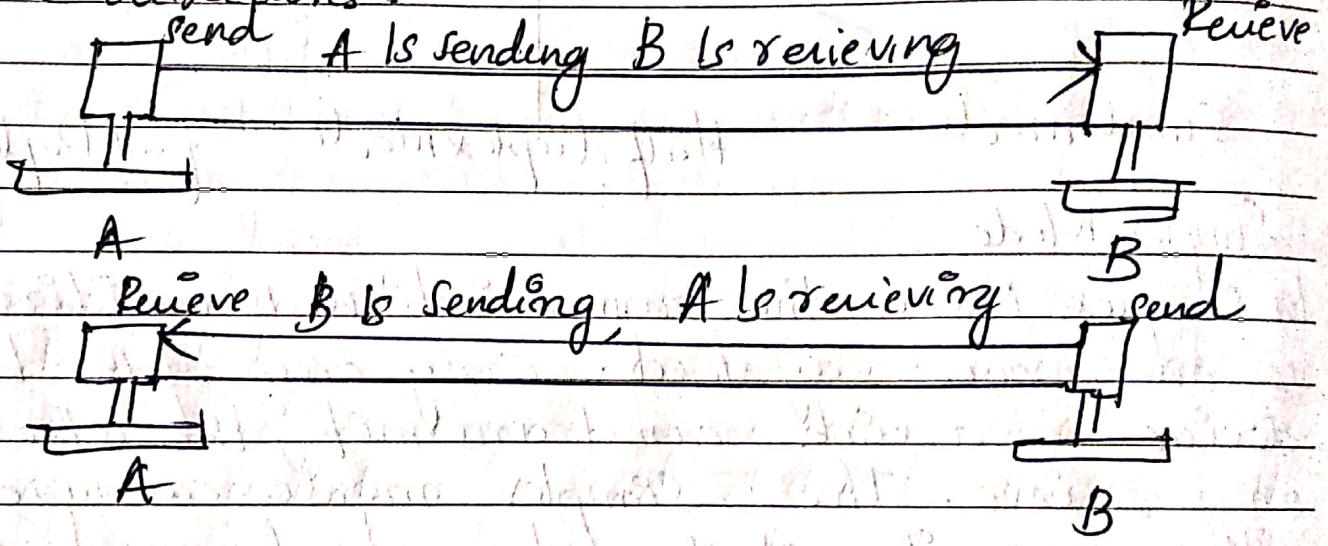
time. When one device is sending, the other can only receive and vice versa. The half duplex mode is used in cases where there is no need for communication in both direction at the same time. The entire capacity of the channel can be utilized for each direction. Example: Walkie-talkie in which message is sent one at a time and messages are sent in both the directions.

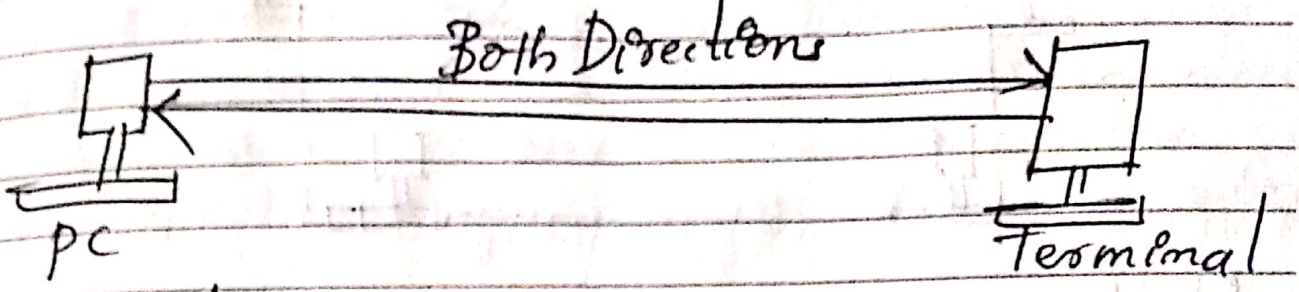



## Full-Duplex Mode

In full Duplex mode, both stations can transmit and receive simultaneously. Here signals going in one direction share the capacity of the link with signals going in other direction, this sharing can occur in two ways.

- Either the link must contain two physically separate transmission paths, one for sending and other for recieving.
- Or the capacity is divided b/w signals

travelling in both directions.
full-duplex mode is used when communication in both direction is required all the time. The capacity of the channel, however must be divided btw the two directions. Enample: Telephone Network in which there is communication btw two persons by a telephone line, through which both can talk and listen at the same time




## Topology

The arrangement of a network which comprises of nodes and connecting lines via sender and reciever is referred as network topologies. It defines the physical or logic arrangement of links in a network.

### a) Mesh Topology

Every device has a dedicated point to point link to every other device. In a mesh topology each physical link carries information only btw the two devices that it connects.

#### Advantages

- It is robust
- Fault is diagnosed easily
- Data is reliable
- Dedicated links
- provides security and privacy.

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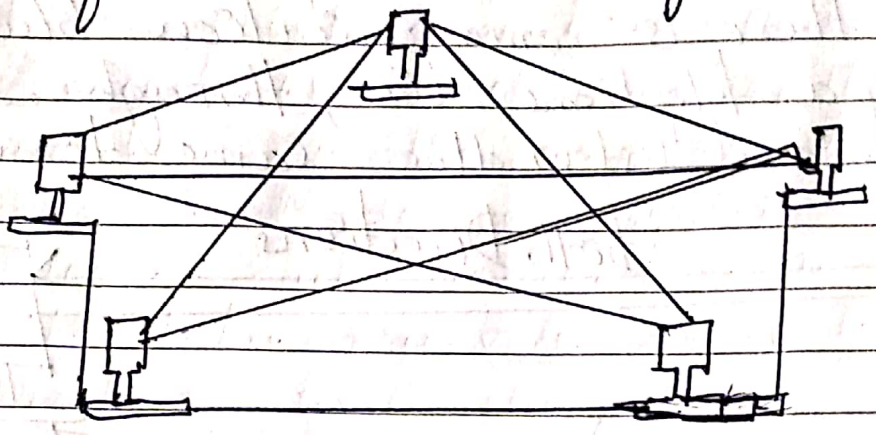
Disadvantages

- Installation and configuration is difficult
- cost of cables are high
- lots of cable is needed
- cost of maintenance is high



b) Star Topology

Each device is connected to a hub through a dedicated point to point link. The devices are not directly linked to each other. If one device wants to send data to another, it sends it first to the hub, which then forwards the data to the other connected devices.

Advantages

- less expensive than mesh
- Easy to install, Easy to configure
- If one link fails the network can still function
- Each device require only 1 port.

Disadvantages

- cabling
- Dependence on hub
- performance is based on the single concentrator.

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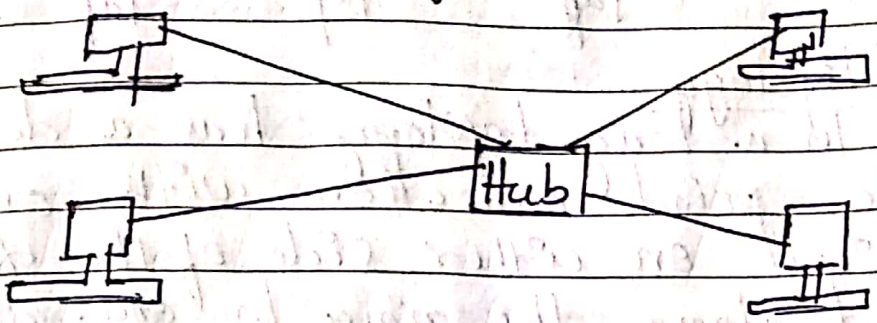
- If hub on which the whole topology relies fails, the whole system will crash down.




c) Bus Topology

Bus: Multipoint connection. One long cable acts as a backbone other devices are connected through a drop line and a tap in the link.

Drop line :- A connection running bld a device and a main cable

Tap :- A physical device that punctures the cable and connects to it. The longer the cable and the more taps it has the weaker the signal becomes. Taps should be a short distance from each other.

Advantages

- Ease of installation
- Elimination of redundancy
- less cabling

Disadvantages

- Difficult reconnection
- Difficult to find the problems
- Difficult to add new devices
- Break stops all transmission of data.

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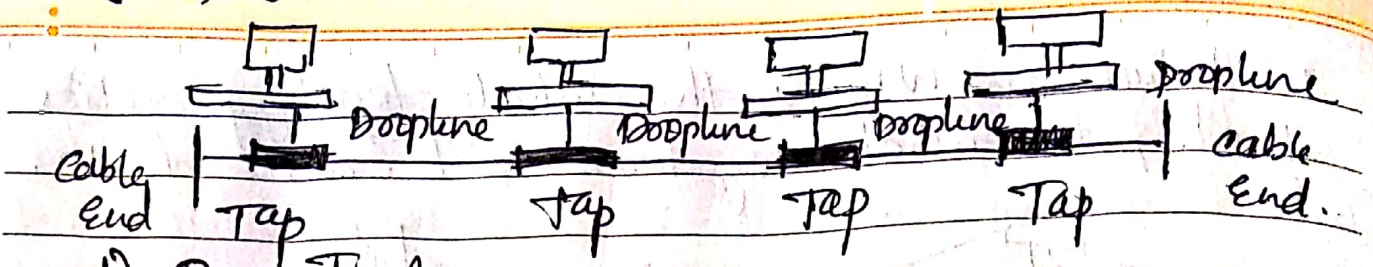



d) Ring Topology

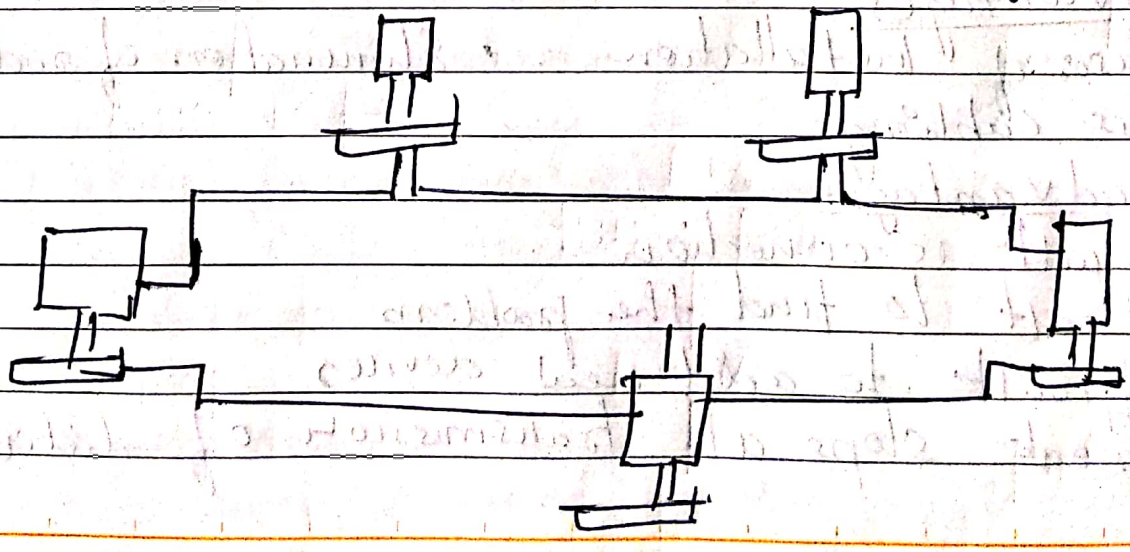
Devices In a ring topology has a dedicated point to point connection with only the two devices on either side of it. A signal is passed along the ring In one direction from device to device until the destination is reach. Each device has a Repeater that passes the data recieved that is Intended for another device along.

Advantages

- Easy to Install and reconfigure
- Simpler fault Isolation
- The possibility of collision is minimum

Disadvantages

- Troubleshooting is difficult in this topology
- less popular
- Unidirectional traffic - Dual ring or Switch



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e) Tree Topology

It also known as Hierarchical topology. This is the most common form of network topology. It initiates as extended star topology and inherits properties of bus topology. This topology devides the network into multiple levels and layers of network. Mainly in LANs a network is bifurcated into three types of network devices. The lowermost is access-layer where computers are attached. The middle layer is known as distribution layer, which works as mediator between upper layer and lower layer. The highest layer is known as core layer and is central point of the network. ie) root of the tree from which all nodes fork

Advantages

- It allows more devices to be attached to a single central hub thus it increases the distance that is travel by the signal to come to the devices

Disadvantages

- If the central hub gets fails the entire system fails
- The cost is high because of cabling
- It allows the network to get isolate and also prioritize from different computers.

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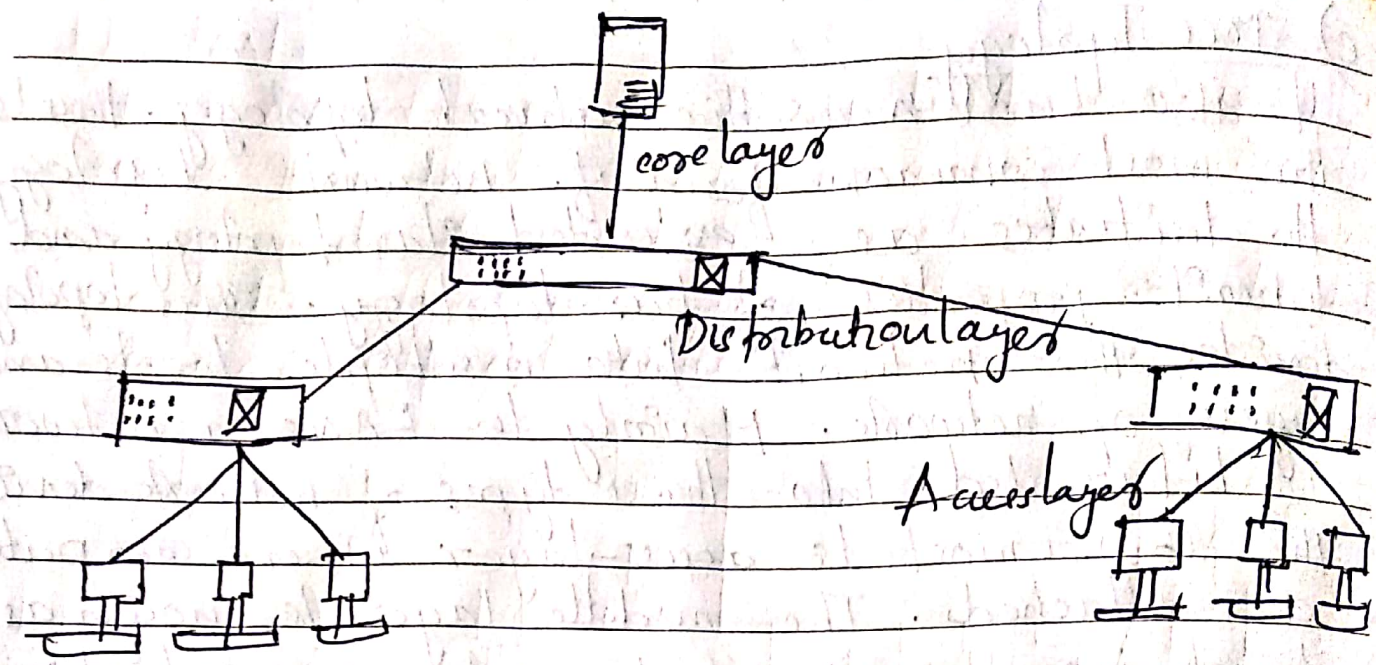
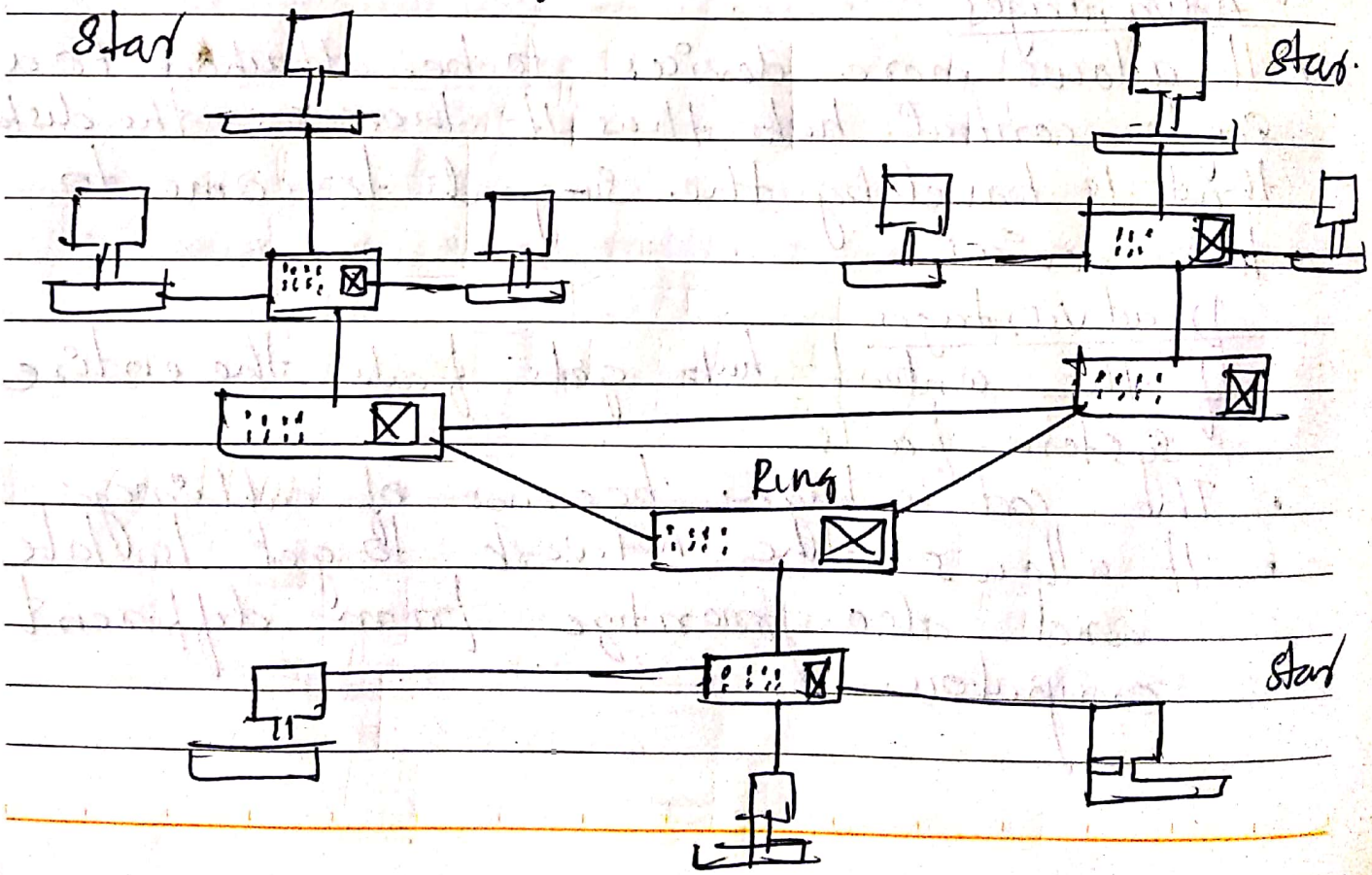



## f) Hybrid Topology

A network structure whose design contain more than one topology is said to be hybrid topology



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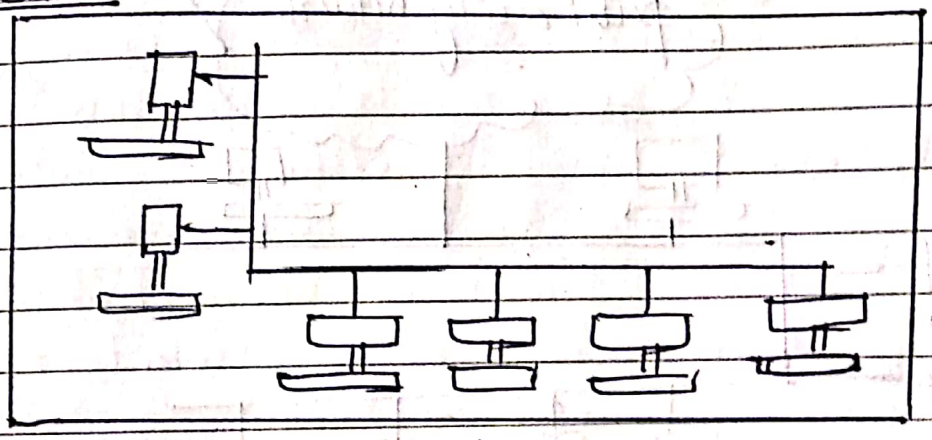
## Network

A network consists of two or more computers that are linked in order to share resources (such as printers and CDs), exchange files or allow electronic communications. The computers on a network may be linked through cables, telephone lines, radio waves, satellites or infrared light beams.

## Network Models

- Network
  - Local area Network (LAN)
  - Metropolitan Area Network (MAN)
  - Wide area Network (WAN)

### a) LAN



Single building LAN

LAN is a group of network devices which allow the communication b/w connected devices. The private ownership has the control over the local area network rather than public. LAN has short propagation delay than MAN as well as WAN. It covers the smallest area such as: college, School, Hospital and Soon.

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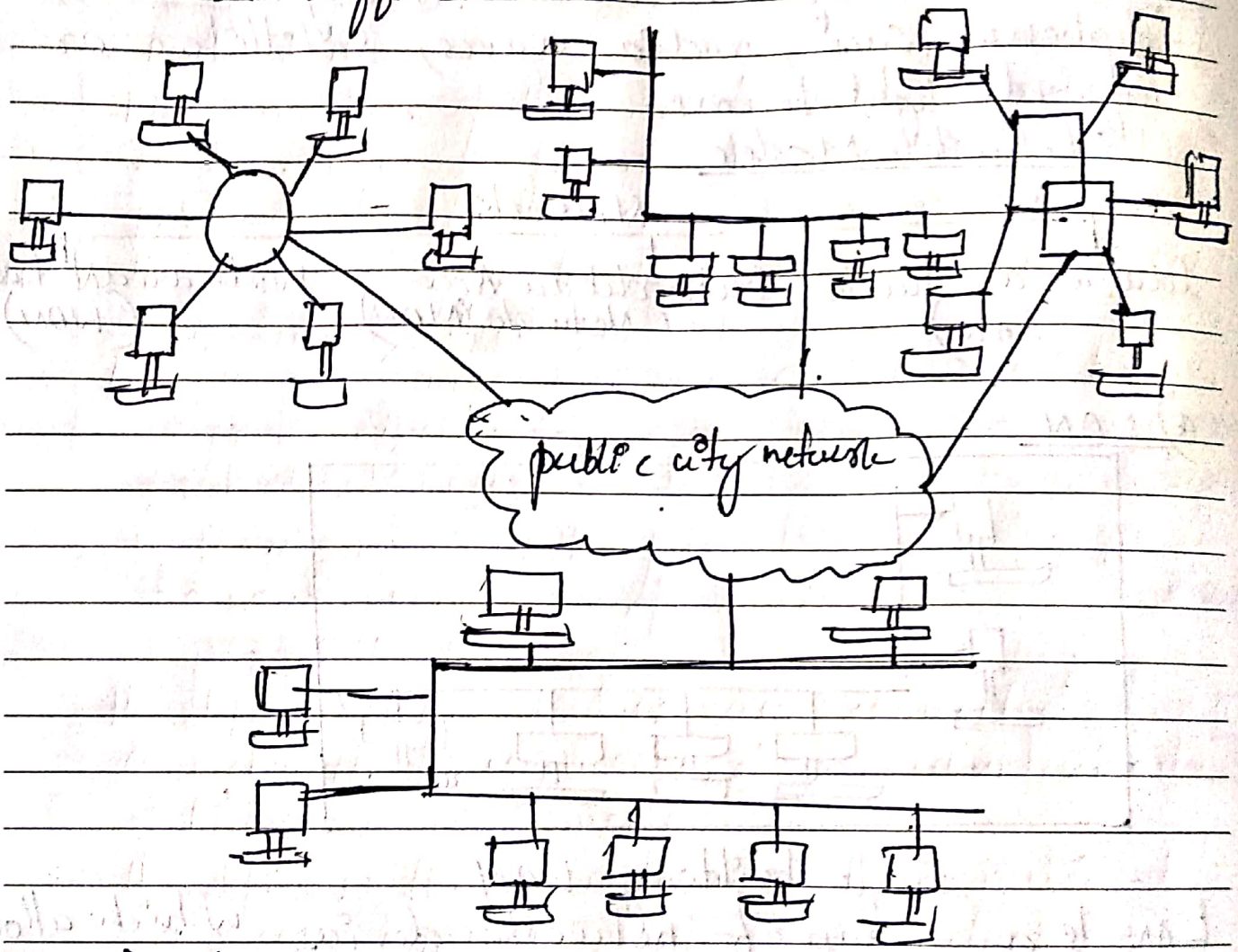
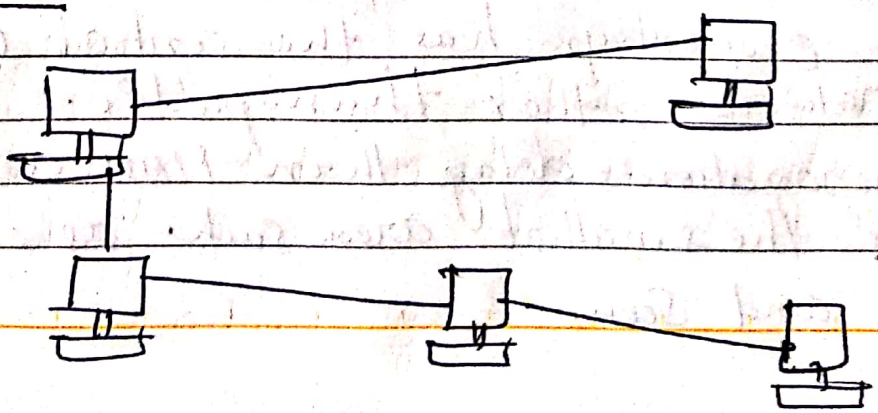
b) MAN

Man or metropolitan area network covers a larger area than that of LAN and smaller area as compared to WAN. It connects two or more computers that are apart but resides in the same or different cities.




c) WLAN



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- Switch, modems and routers
- It covers the large area than LAN and MAN such as country / continent
- It is expensive and should or might not be owned by one organization. PSTN or satellite medium are used for wide area network.

## Network Layering – OSI Model

OSI model is an open systems Interconnection model. It is a model for understanding and designing a network architecture that is flexible, Robust and Interoperable. It is a layered framework for the design of network systems that allows for communication across all types of computer systems.

### Layered Architecture

The OSI model is built of 7 ordered layers. physical, datalink, Network, Transport, session, presentation, Application.

7 Application → Network processes to Applications
6 presentation → Data Representation
5 Session → Interhost communication
4 Transport → End to end connections
3 Network → Address and Best path
2 Datalink → Access to Media
1 physical → Binary Transmission.

### Functions of Layer

A **physical layer**

It deals with the mechanical and electrical

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Specification of the Interface and transmission medium. It also defines the procedures and functions for transmission to occur.

Representation of bits

In the physical layer data consists of stream of bits (Sequence of zeros and ones)

Data Rate

The number of bits send each second is also defined by physical medium.

physical characteristics of Interfaces and medium

It also defines the type of transmission medium

Synchroniz/ation of bits

The sender and reciever clocks must be synchronized.

Link configuration

It is concern with point to point configuration or multipoint configuration.

physical topology

It defines how devices are connected to make a network (bus, mesh, ring, star, hybrid)

Transmission mode

It defines the direction of transmission b/w 2 devices. Simplex, half duplex, duplex.

B Data Link Layer

framing

It divides a stream of bits recieved from network layer into manageble data units called frames.

physical addressing

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If frames are to be distributed to different systems on the network, the data link layer adds a heads to the frame to define the sender or reciever (address) of the frame.

Flow control

If the rate at which the data are absorbed by the reciever is less than the rate at which data are produced at the sender, the data link layer imposes a flow control mechanism to avoid over whelming the reciever.

Error Control

The data link layer adds mechanism to detect and re-transmit damaged or lost frames.

Access Control

When 2 or more devices are connected to the same link, data link layer protocol are necessary to determine which device has control over the link at any given time. Data link layer Ensures hop to hop (Node to Node)

C Network Layer

It is responsible for source to destination delivery of a packet, possibly across multiple networks. It ensures that each packet gets from its point of origin to its final destination.

Logical Addressing

If a packet passes through the network boundary we need another addressing system to help distinguish the source and destination systems. The network layer as a header to a packet that includes

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the logical address of the sender and the reciever.

Routing

When Independent networks are Connected together to create an Inter network (network of networks) or a large network, the connecting devices (the routes or switches) Rout or Switch the packag of final destination.

Congestion Control

Controls congestion

D Transport layer

The transport layer is responsible for process to process communication (End to End delivery)

Service Point Addressing

Source to destination Delivery means delivery not only from one computer to the next but also from a Specific process from one computer to a Specific on the other.

The transport layer header must therefore include a type of address called a Service point address (or port address)

Segmentation & Reassembling

A message is divided into transmittable segments with each segment containing a sequence number. These numbers Enable the transport layer to reassemble the message correctly upon arriving at the destination and to identify the lost packets in transmission.

Connection Control

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The transport layer can be either connectionless or connection oriented. A connection Oriented transport layer establishes a connection before delivering the packets. after all the datas are transfered the connection is terminated.
flow control and Error control (refer Datalink layer)

E Session layer

It establishes, mainframes and synchronises the Interaction among communicating systems. The session layer is the network dialogue controller

Dialogue Control

The session layer allows two systems to enter into a dialogue either half duplex or full duplex mode.

Token management

It decides whose turn it is to transmit data

Synchronization

The session layer allows a process to add check points or Synchronization points to a stream of data. Example. If a s/m is sending a file of 2000 pages it insert check points after every 100 pages to ensure that each 100 page until is recieve and acknowledged Independently.

E Presentation layer

It deals the syntax and semantics. It is concern with the syntax and semantics of Information exchange with two systems.

Translation

The presentation layer at the sender machine

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changes the information from its sender dependent format into a common format. The presentation layer at the receiving machine changes the common format into its reciever dependent format. The information should be change into bit streams before being transmitted.

Encryption

Encryption means that the sender transforms the orginal information to another form and sends the resulting message over the network.

Decryption

It reverses the orginal process to transform the message back to its orginal form.

Compression

It reduces the number of bits contained in the information.

G) Application layer

It enables the user to auess the networks.

Network virtual terminal

It allows a user to logon to a remote host. The users computer talks to the s/w terminal which intern taps to the host.

Final Transfer, auess and Management

This application allows a user to access files in a remote host, to retrieve files and to manage and control files in a remote computer locally.

E-mail services

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This application provides the basis for email forwarding and storage

Directory Services

This application provides distributed database sources and access for global information about various objects and services.

peer to peer process

Between machines layer x on one machine communicates with layer x on another machine. The process on each machine that communicates at a given layer are called peer to peer process. Each layer in the sending machine adds its own information to the message it recieves from the layer just above it. This information is added in the form of headers and Tailers. At the recieving machine the message is Unwrapped layer by layer with each process recieving and removing the data meant for it.

Interface Between layers

Each interface defines the information and services a layer must provide for the layer above each.

The layer 1, 2, 3 are the network support layers and layer 5, 6, 7 are the user support layers.

Protocols and STANDARDS

a) protocols :-

An entity is anything capable of sending or recieving information. For communication to

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access, the entities must agree on a protocol. A protocol is a set of rules that govern data communication. The key elements of a protocol are syntax, semantics and timing. The syntax which refers to the structure or format of the data meaning the order in which they are present. The semantics which refers to the meaning of each section of bits. Timing which refers to two characteristics when data should be send and how fast they can be send.

b) Standards :-

They provide guidelines to manufacture, vendors, government agencies and other service provide to ensure the kind of interconnectivity necessary in todays market place and in International communication standards fall in 2 categories. Defacto (by facts or by connection) and De jure (by law or by regulations)

Defacto :-

Standards that has not being approved by an organized body but have been adopted as standards through wide spread use

Eg:- IBM PC

De jure :-

Those standards that have been legislated by an officially recognised body.

Eg:- ISO, ITU, ANSI, IEEE, EIA

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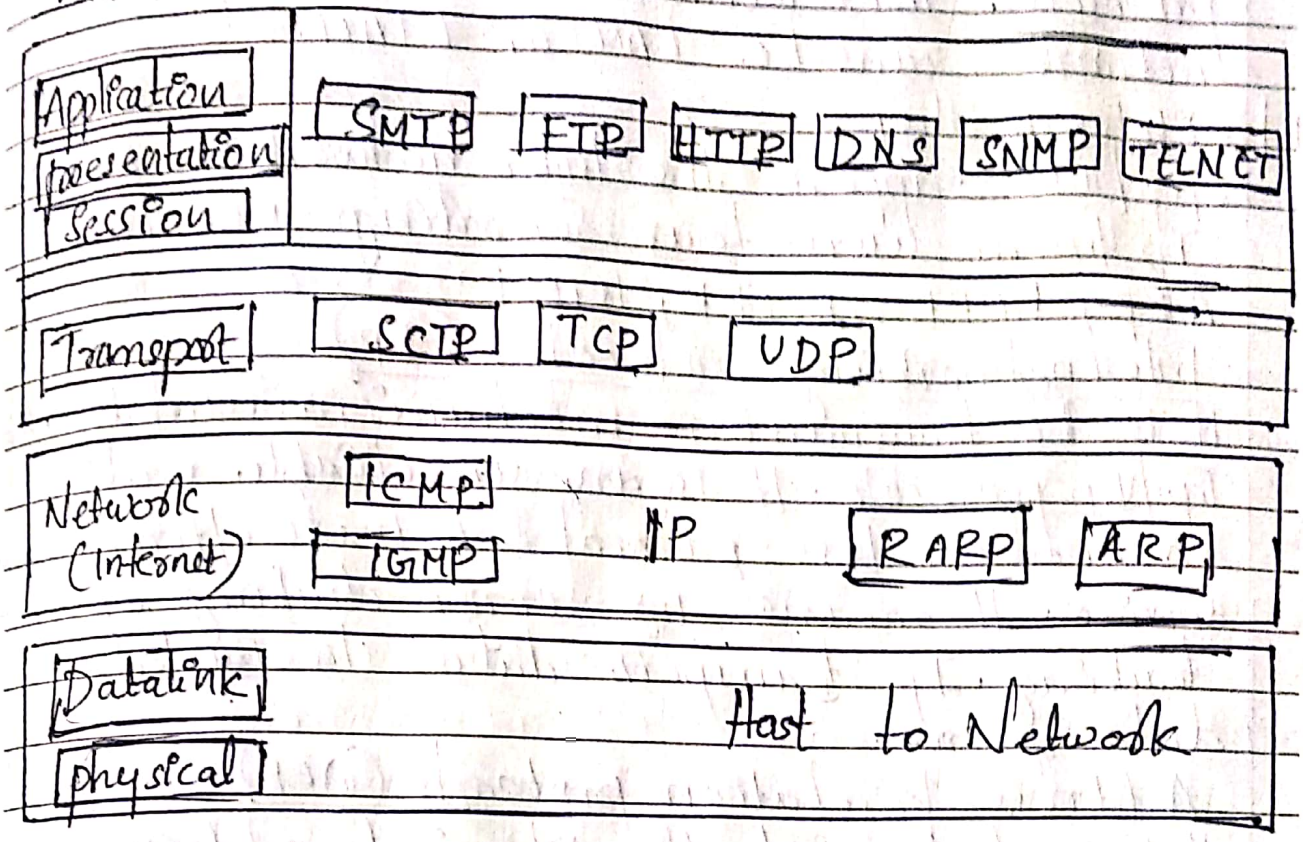
# TCP/IP Protocol Suite




- TCP/IP protocol was developed prior to the OSI model
- The orginal TCP/IP protocol suite was defined as having 4 layers: host-Network, Internet, Transport, application.
- We can say that the host-network layer is Equivalent to the combination of physical and datalink layer
- The Internet layer is Equivalent to the network layer and the application layer is roughly doing the job of session, presentation and application layers

**physical and Datalink layer**

Here it supports all the standard and property

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protocols. The network in a TCP/IP Internetwork can be LAN or WAN.

B. Network layer

TCP/IP supports the Internetworking protocol IP. IP uses four supporting protocols ARP, RARP, ICMP, IGMP.

Internetworking protocol (IP)

It is the transmission mechanism used by the TCP/IP protocols. It is an unreliable and connectionless protocol - A best effort delivery service. It means no error checking or tracking. IP transports data in packets called data gram.

Address Resolution protocol (ARP)

It is used to find the physical address of the node when its Internet address is known.

Reverse address Resolution protocol (RARP). It allows a host to discover its Internet address when it knows only its physical address.

INTERNET Control Message protocol (ICMP)

It is a mechanism used by host and gateway to send notification back to the sender.

INTERNET Group Message protocol (IGMP)

It is used to facilitate the simultaneous transmission of a message to a group of recievers

C. Transport layer

Transmission Control protocol (TCP)

A reliable stream transport protocol. The term stream means connection oriented

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At the sending end of the transmission the Tcp divides stream of the data into smaller units called segments. At the recieving end, TCP records the transmission based on sequence Number.

User Datagram Protocol (UDP)

It is a process to process protocol that adds only port address, checksum error control and length information to the data from the upper layer

Stream Control Transmission protocol (SCTP)

It provides support for new application such as voice over the Internet

Application Layer

It is equivalent to the combined session, presentation and application layer in the OSI model.

Data & Signals

Data must be converted to a form that transmission media can accept so a stream of 1's and 0's must be turned into energy in the form of electromagnetic signals.

A signal is an electric current or electromagnetic field used to convey data from one place to another.

Analog and Digital Data

Data can be analog or digital. The term analog data refers to information that is continuous; digital data refers to information that has discrete states. Analog data, such as the sounds made by a human voice, take on continuous values. When someone speaks

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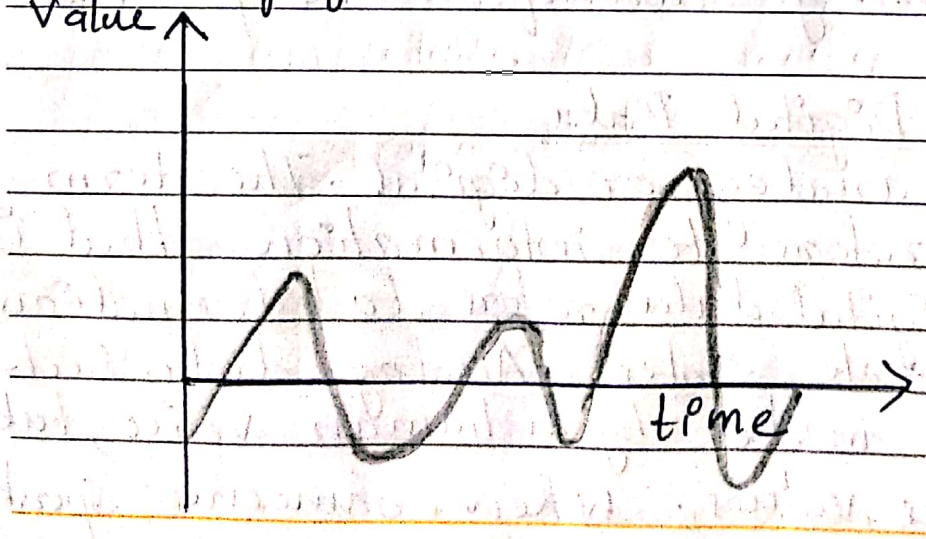
an analog wave is created in the air. This can be captured by a microphone and converted to an analog signal or sampled and convert to a digital signal. Digital data take on discrete values. for example, data are stored in computer memory in the form of 0s and 1s

## Analog and Digital signals

| Analog signal | Digital signal |
|---|---|
| • It is continuous | • It is discrete |
| • Infinite number of values | • finite number of values (0 & 1) |
| • No sudden jump (changes continuosly with respect to time) | • Sudden Jump (changes instantaneously) |
| • Any value in a range eg:- human voice | • limited values in a range eg:- data stored in memory |
| • Used in measurement | • Used in counting |

Analog Signal



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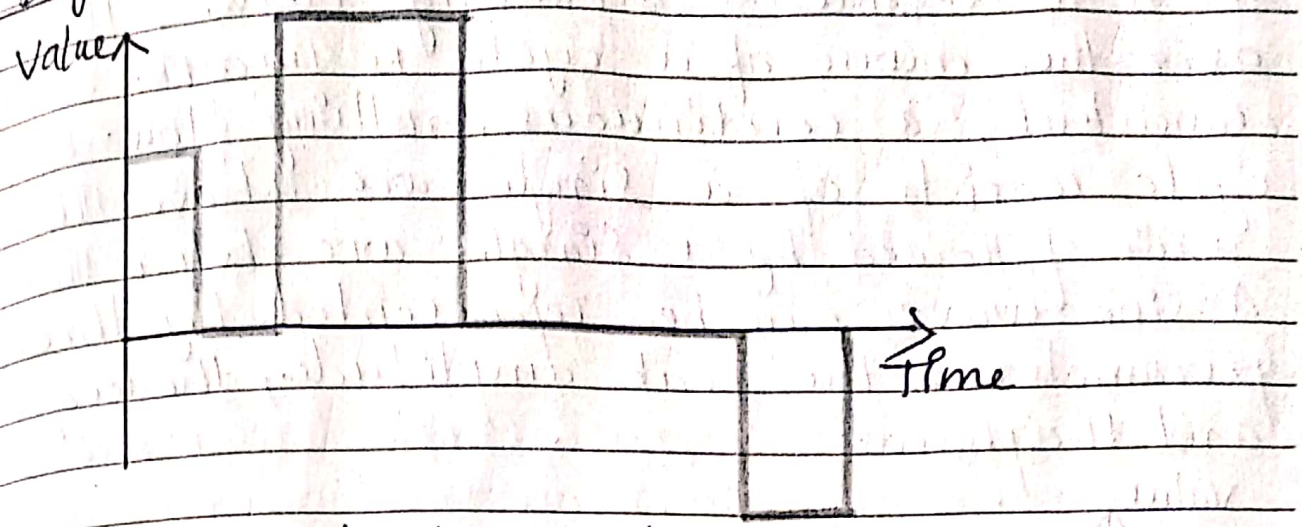
## Digital Signal




## periodic And Nonperiodic

Both analog and digital signals can take one of two forms: periodic or nonperiodic sometimes referred to as a periodic; A periodic signal completes a pattern within a measurable time frame, called a period, and repeats that pattern over subsequent identical periods. The completion of one full ~~perio~~ pattern is called a cycle. A nonperiodic signal changes without exhibiting a pattern or cycle that repeats over time. Both analog and digital signals can be periodic or nonperiodic.

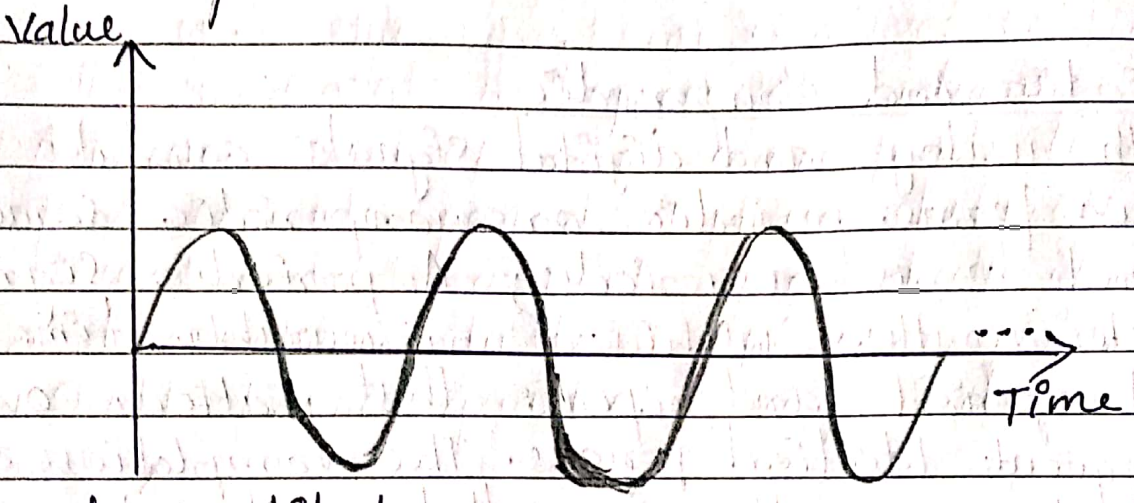
## Periodic Analog Signals

periodic analog signals can be classified as simple or composite. A simple periodic analog signal, a sine wave, cannot be decomposed into simpler signals. A composite periodic analog signal is composed of multiple sine waves.

## Sine wave

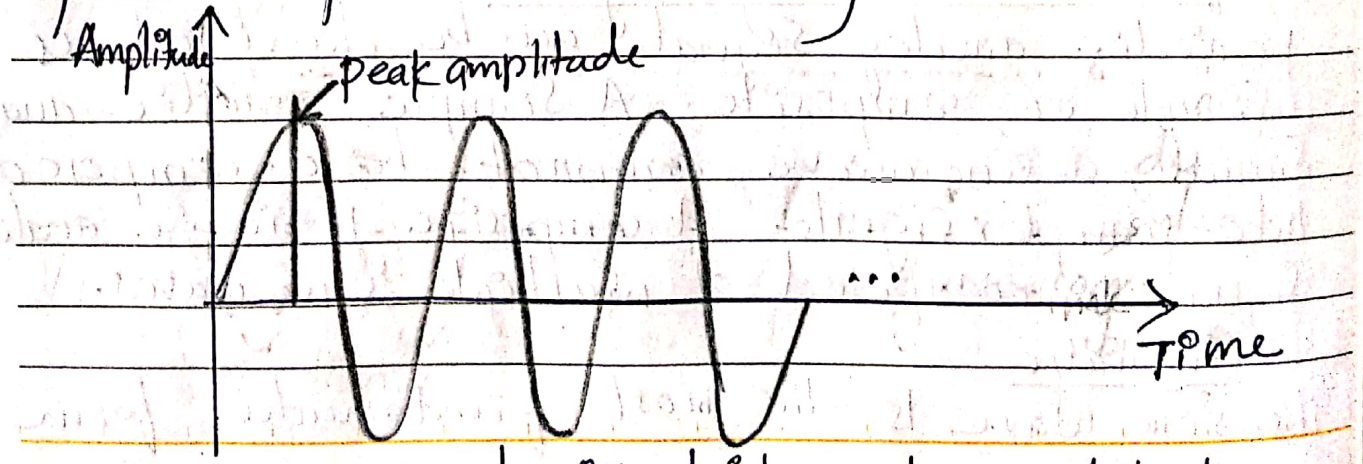
The sine wave is the most fundamental form

of a periodic analog signal. When we visualize it as a simple oscillating curve, its change over the course of a cycle is smooth and consistent, a continuous, rolling flow. Each cycle consists of a single arc above the time axis followed by a single arc below it. A sine wave can be represented by three parameters: the peak amplitude, the frequency and the phase.




a) Peak Amplitude

The peak amplitude of a signal is the absolute value of its highest intensity, proportional to the energy it carries. For electronic signals, peak amplitude is normally measured in volts.




A signal with high peak amplitude

Frequency → Extremes → 1) signal not changing at all – If signal does not change at all, it never completes a cycle and its frequency is zero.

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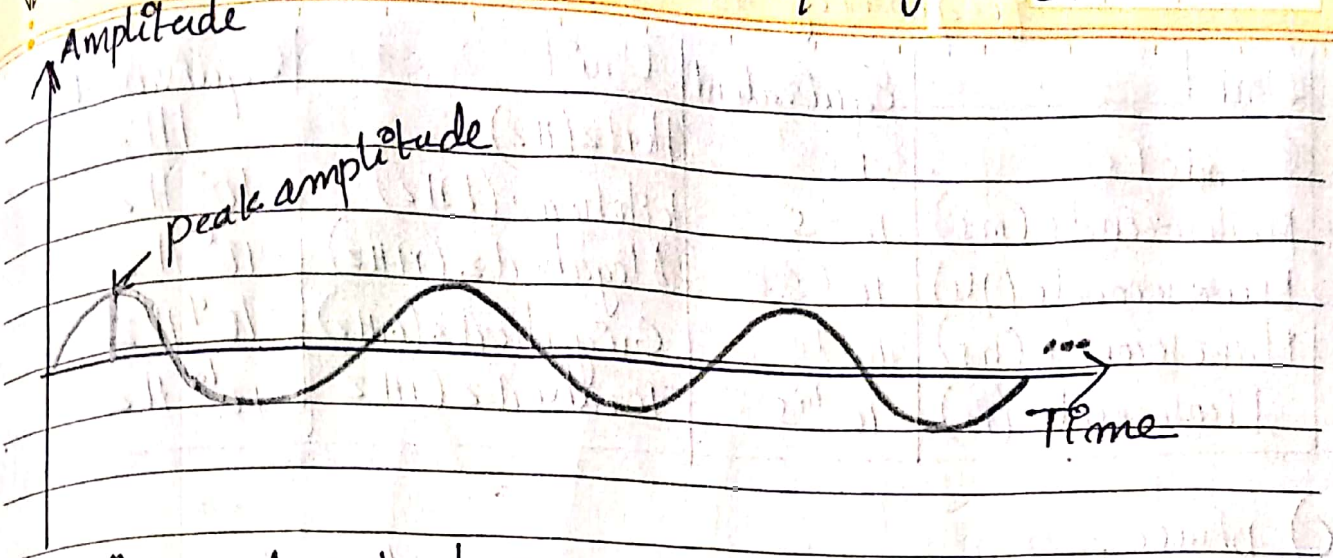
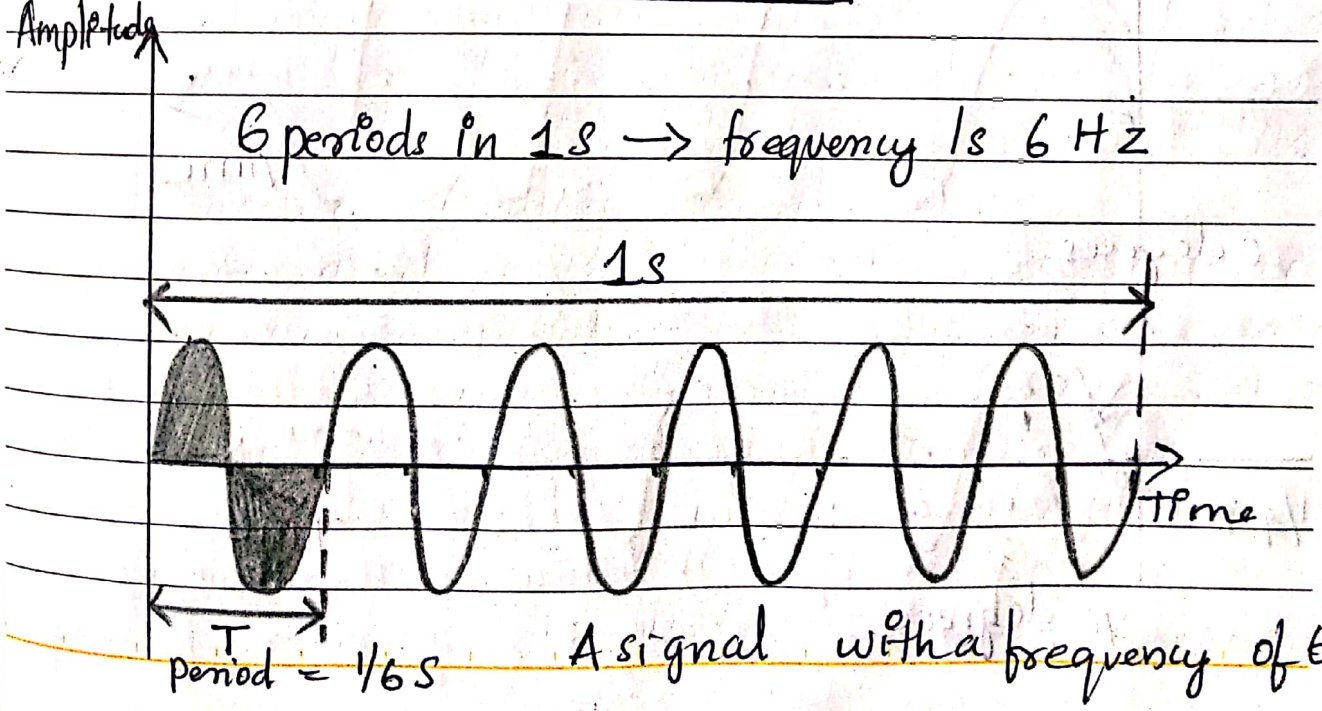



A signal with low peak amplitude

b) Period And Frequency

Period refers to the amount of time in seconds, a signal needs to complete 1 cycle. Frequency refers to the number of periods in 1s. Note that period and frequency are just one characteristic defined in two ways. period is the inverse of frequency and frequency is the inverse of period.

$$f = \frac{1}{T} \quad \text{and} \quad T = \frac{1}{f}$$




A signal with a frequency of 6 Hz

- Signals changes instantaneously — When it jumps from one level to another in no time. period is zero

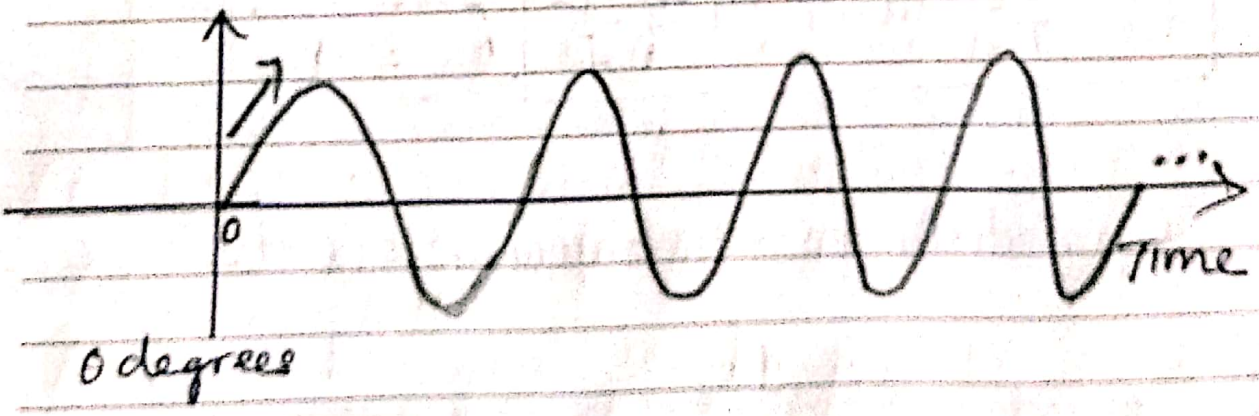
Notes: Since frequency is inverse of period, frequency is infinite

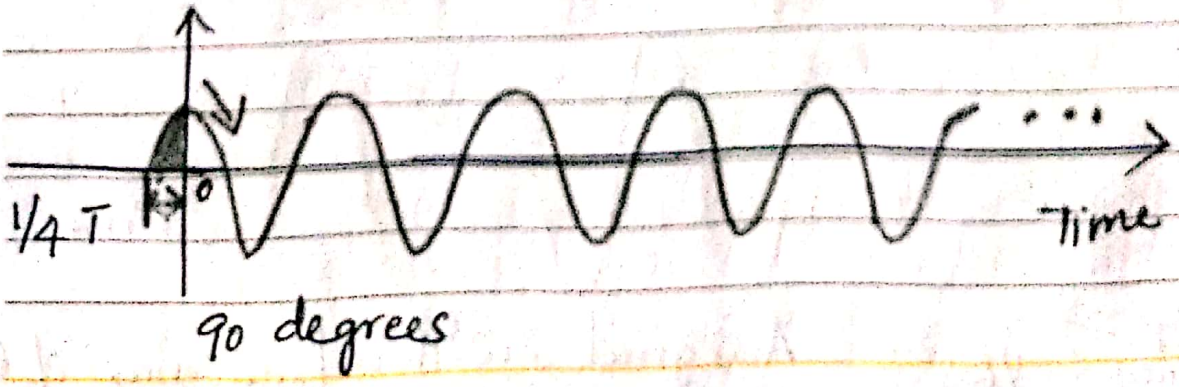
| Unit | Equivalent | Unit | Equivalent |
|---|---|---|---|
| Seconds (s) | 1 s | Hertz (Hz) | 1 Hz |
| Milliseconds (ms) | $10^{-3}$ s | kilohertz (kHz) | $10^{3}$ Hz |
| Microseconds (μs) | $10^{-6}$ s | Megahertz (MHz) | $10^{6}$ Hz |
| Nanoseconds (ns) | $10^{-9}$ s | Gigahertz (GHz) | $10^{9}$ Hz |
| Picoseconds (ps) | $10^{-12}$ s | Terahertz (THz | $10^{12}$ Hz |

c) phase

The term phase, or phase shift describes the position of the wave form relative to time 0. It is measured in degrees or radians.

A phase shift of 360° corresponds to a shift of a complete period; a phase shift of 180° corresponds to a shift of one-half of a period; and a phase shift of 90° corresponds to a shift of one-quarter of a period.



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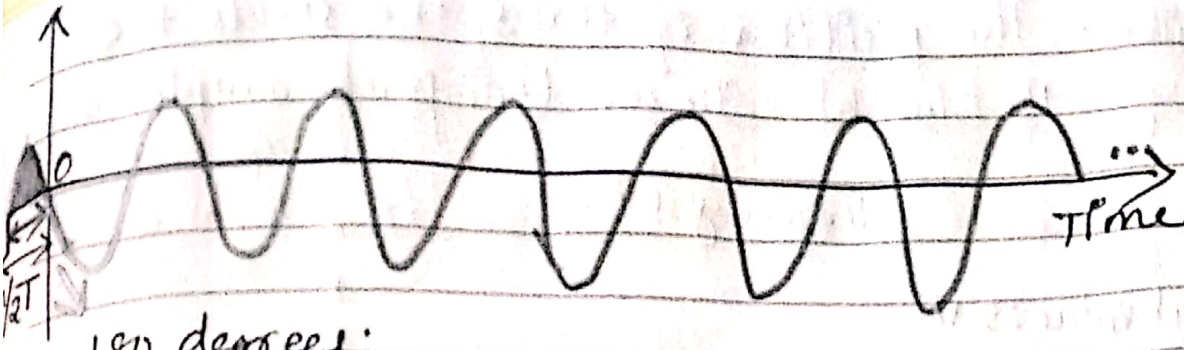


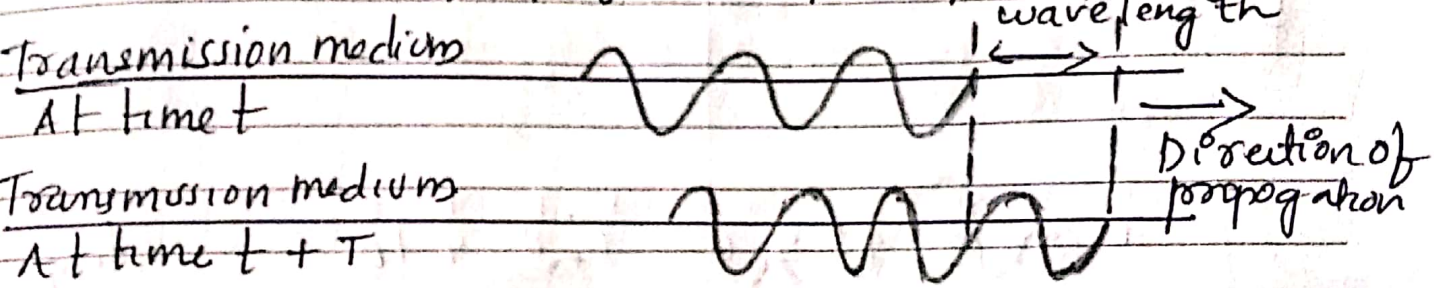

180 degrees.

d) Wave length

Wavelength is another characteristic of a signal travelling through a transmission medium. Wavelength binds the period or the frequency of a simple sine wave to the propagation speed of the medium.

wavelength = (propogation speed) * period

= propagation speed / Frequency.



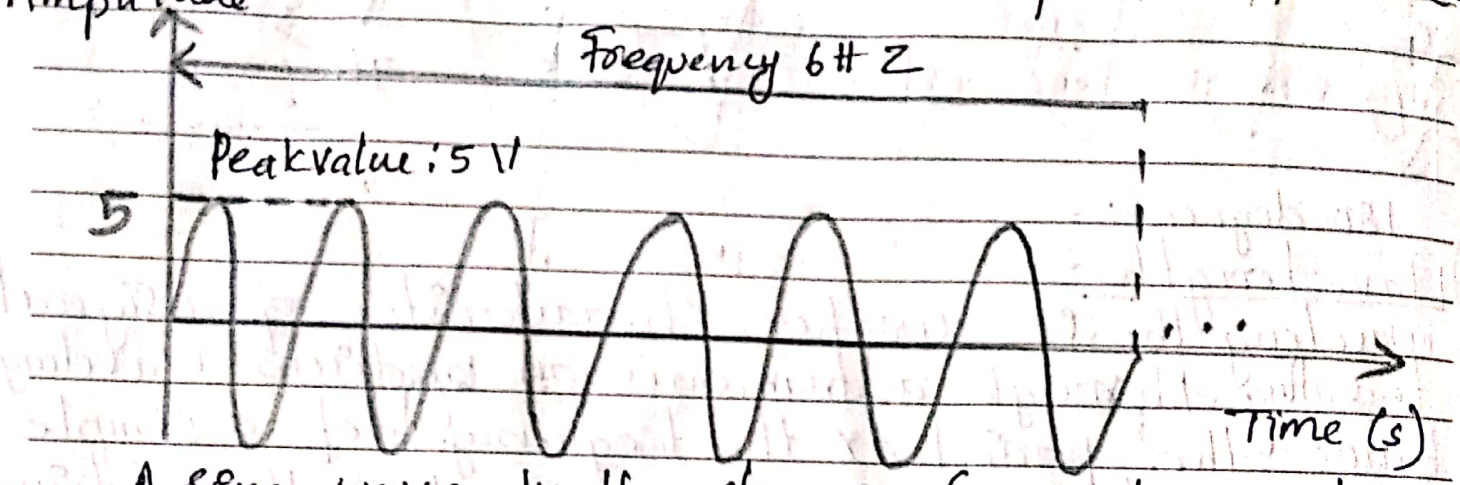

## Time And Frequency Domain

The time domain plot shows changes in Signal amplitude with respect to time.

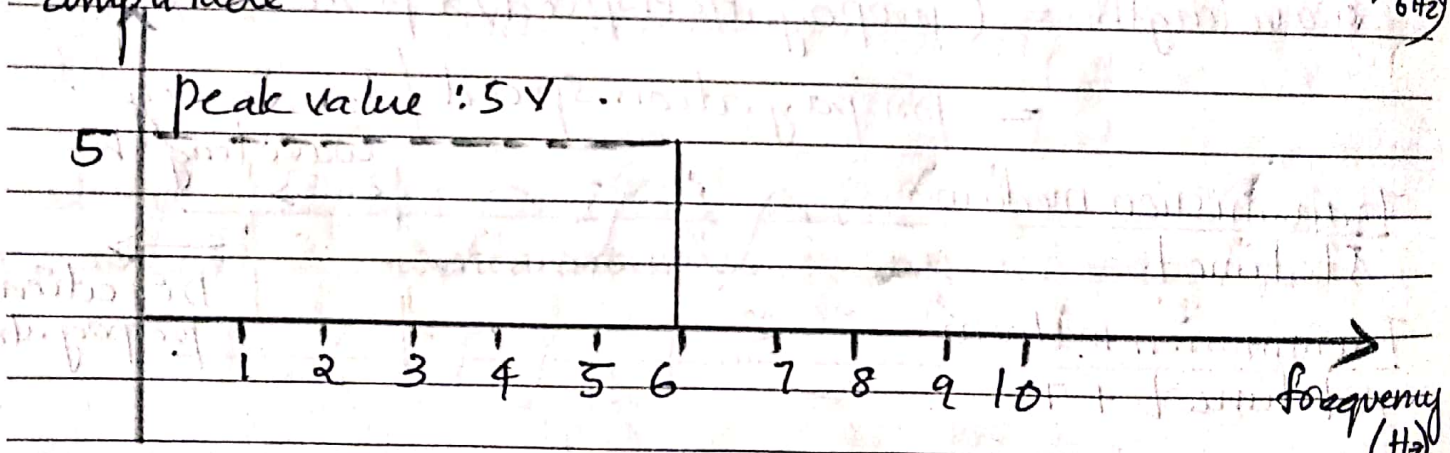
To show the relationship between amplitude and frequency we can use what is called a frequency-domain plot. It is concerned with only the peak value and the frequency.

The advantage of frequency domain is that we can immediately see the values of frequency and peak amplitude. A complete Sine wave is represented by

One spike. The position of the spike shows the frequency; its height shows the peak amplitude.




A sine wave in the time domain (peak value: 5V, frequency 6Hz)




The same sine value in the frequency domain (peak value: 5, frequency: 6 Hz)

## Composite Signals

A composite signal can be periodic or nonperiodic. A periodic composite signal can be decomposed into a series of simple sine waves with discrete frequencies that have integer (1, 2, 3 and so on) A nonperiodic signal can be decomposed into a combination of an infinite number of simple sine waves with continuous frequencies, frequencies that have real values.

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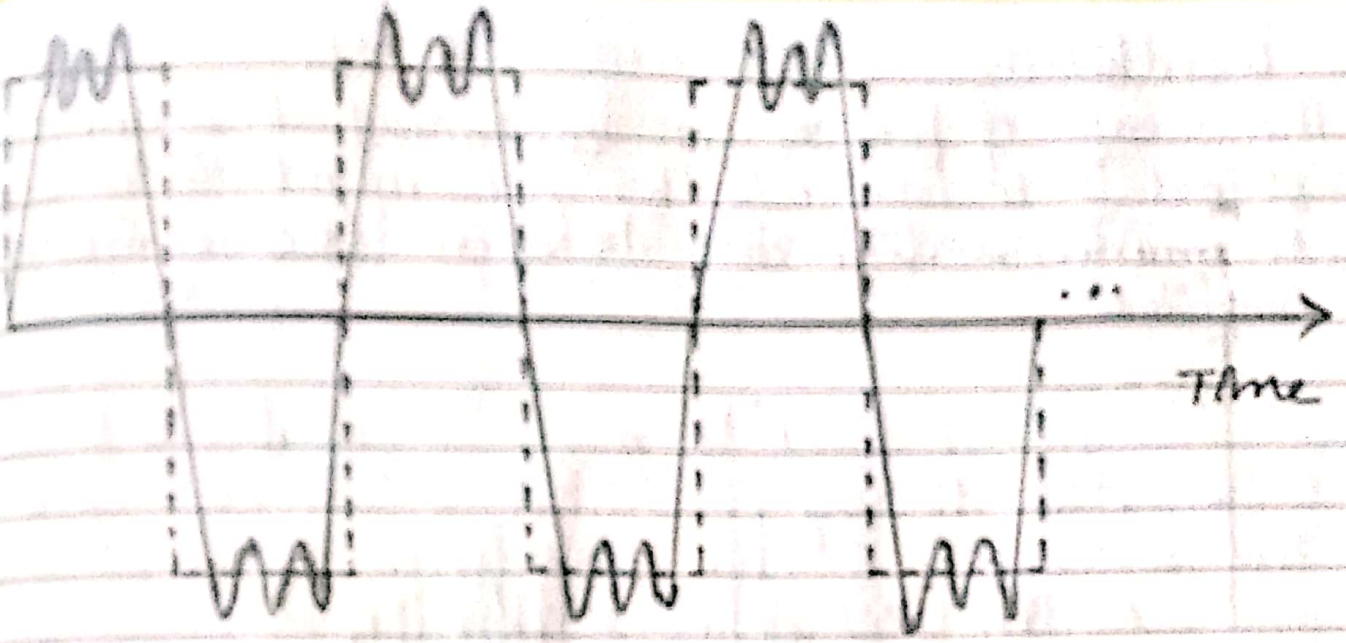
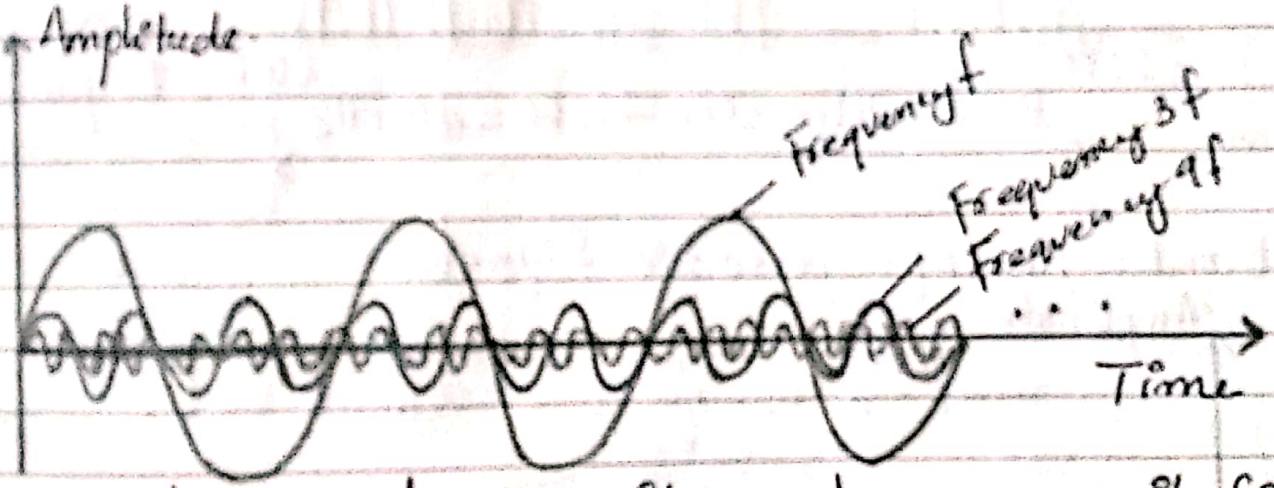
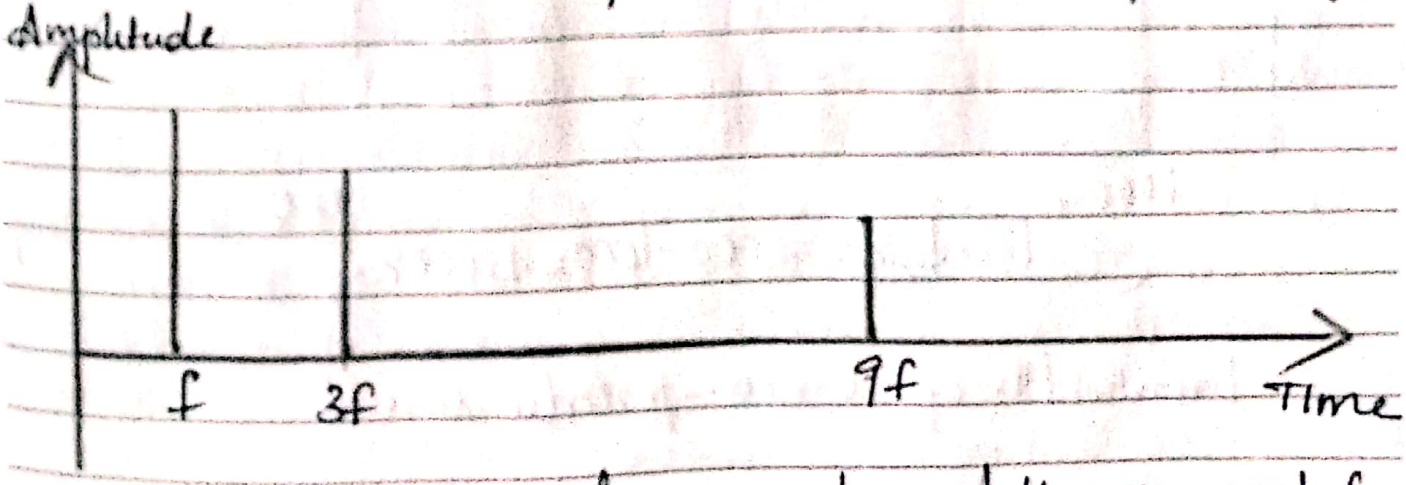



Time domain decomposition of a composite signal




Frequency-domain decomposition of the composite signal

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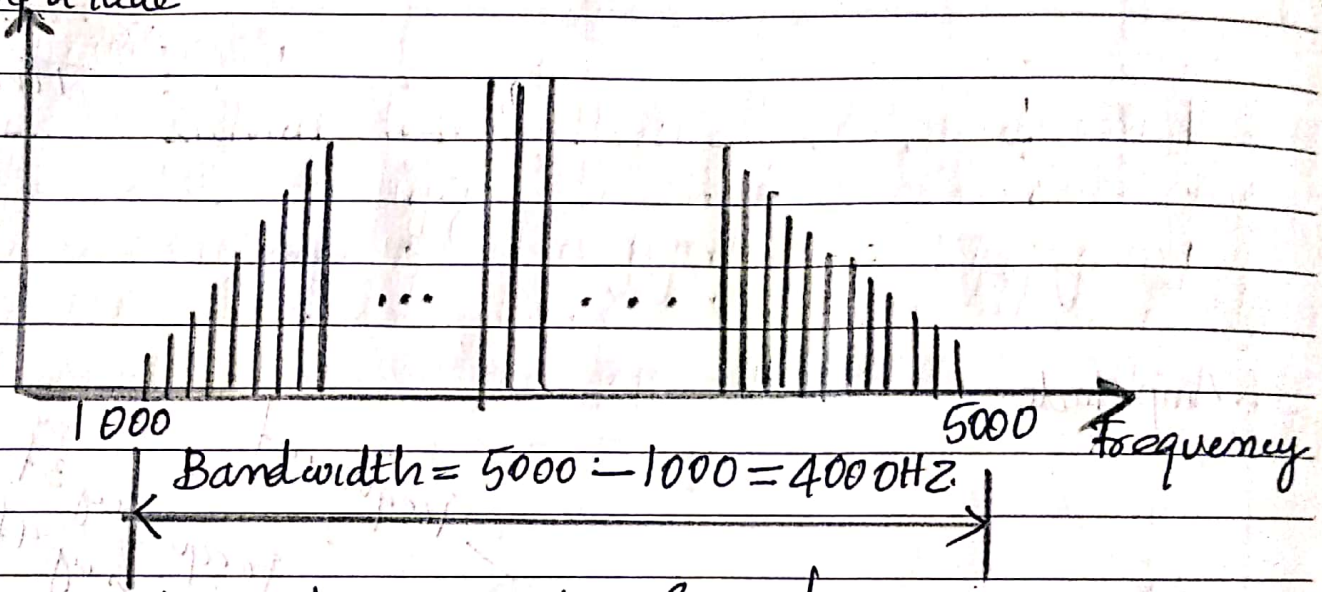
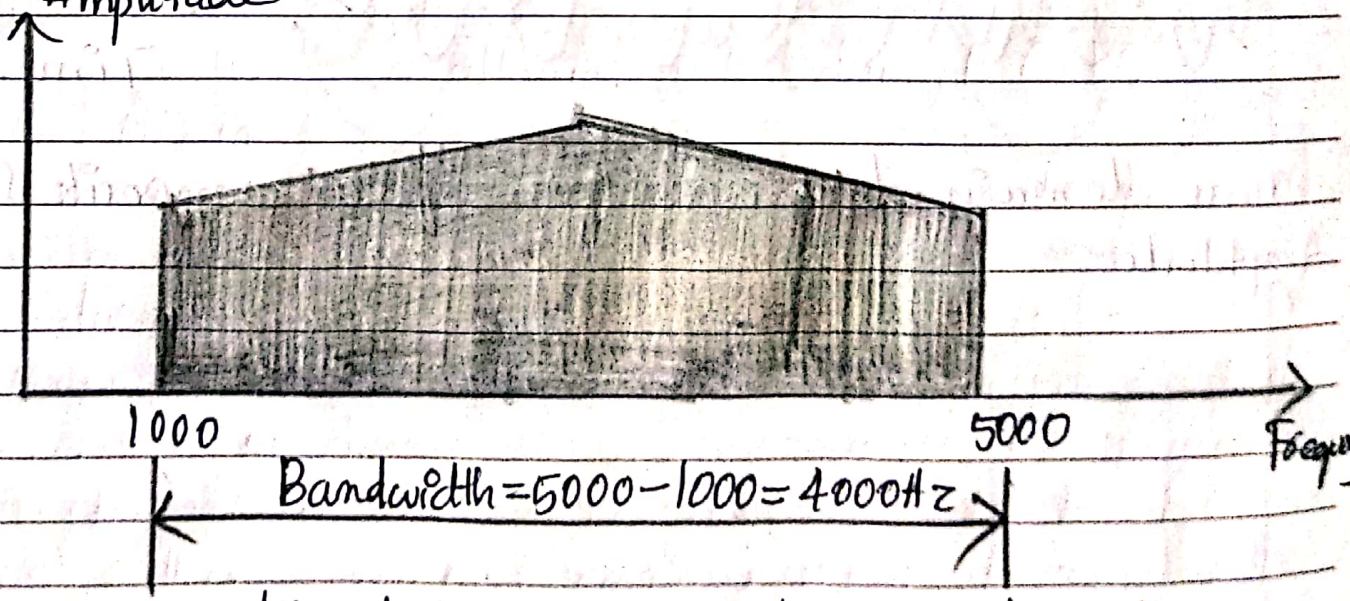
## Bandwidth

The range of frequencies contained in a composite signal is its bandwidth. The bandwidth is normally a difference between two numbers.




Bandwidth of a periodic signal




Bandwidth of a non-periodic signal

$$B = f_n - f_1$$

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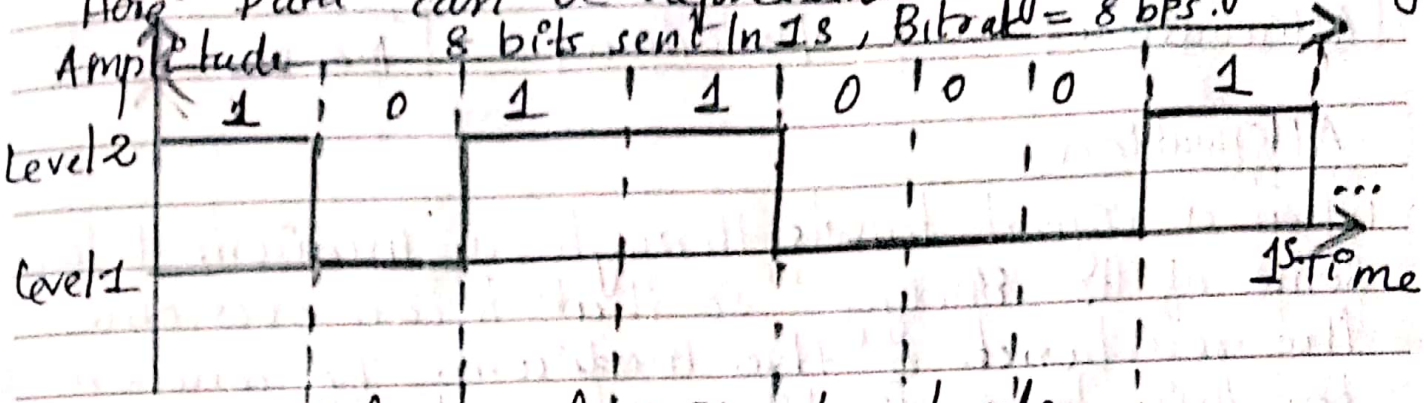
## Digital Signals

A digital signal can have more than two levels. Here data can be represented by a digital signal




A digital signal with two levels.

## Bit rate and Bit Interval

The Bit Interval is the time required to sent one ~~signal~~ single bit. The bit rate is the number of bit Intervals per second. Bit Intervals is the Inverse of bit rate. The Bit rate is expressed in bits per second (bps)

Bit Interval = 1/Bitrate.

## Bit length

It is the distance one bit occupies on the transmission medium.

Bit length = propagation speed * bit duration

## TRANSMISSION IMPAIRMENT

Transmission media are not perfect. The imperfections cause Impairement. In the signal send through the medium. This means that the signal at the beginning and end of the medium are not the same. What is send is not what is received.

There ~~th~~ Are three types of Impairements Usually,

Imp.

Attenuation : $dB = 10 \log_{10} P_2/P_1$

Notes $P_1$ : Input signal $P_2$ : Output signal

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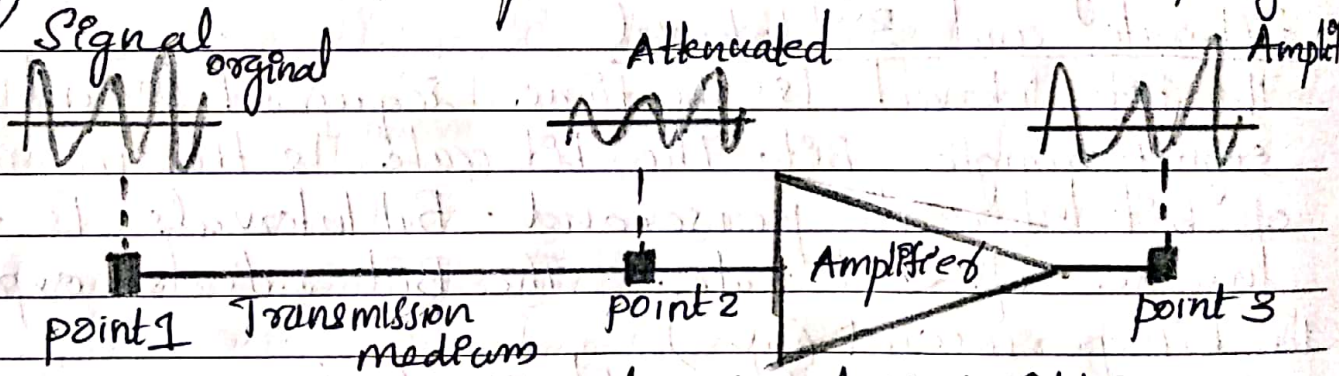
To show the signal has lost or gained strength

## Impairement Causes

- Attenuation
- Distortion
- Noise

### Attenuation

When a signal travels through a medium it loses some of its energy so that it can overcome the resistance of the medium. To compensate for this lose, amplifies are used to amplify the signal




unit of attenuation is decibel (dB)

### Distortion

It means that a signal changes its form or shape. Distortion occurs in a composite signals made of different frequencies has its own propogation speed through a medium and therefore its on delay in arriving at the final destination. The velocity tends to be highest near the center frequency and falls off towards the 2 edges

Deubel (dB) – measures the relative strength of two signals or one signal at different points. If deubel is negative If a signal is attenuated and positive If a signal amplified

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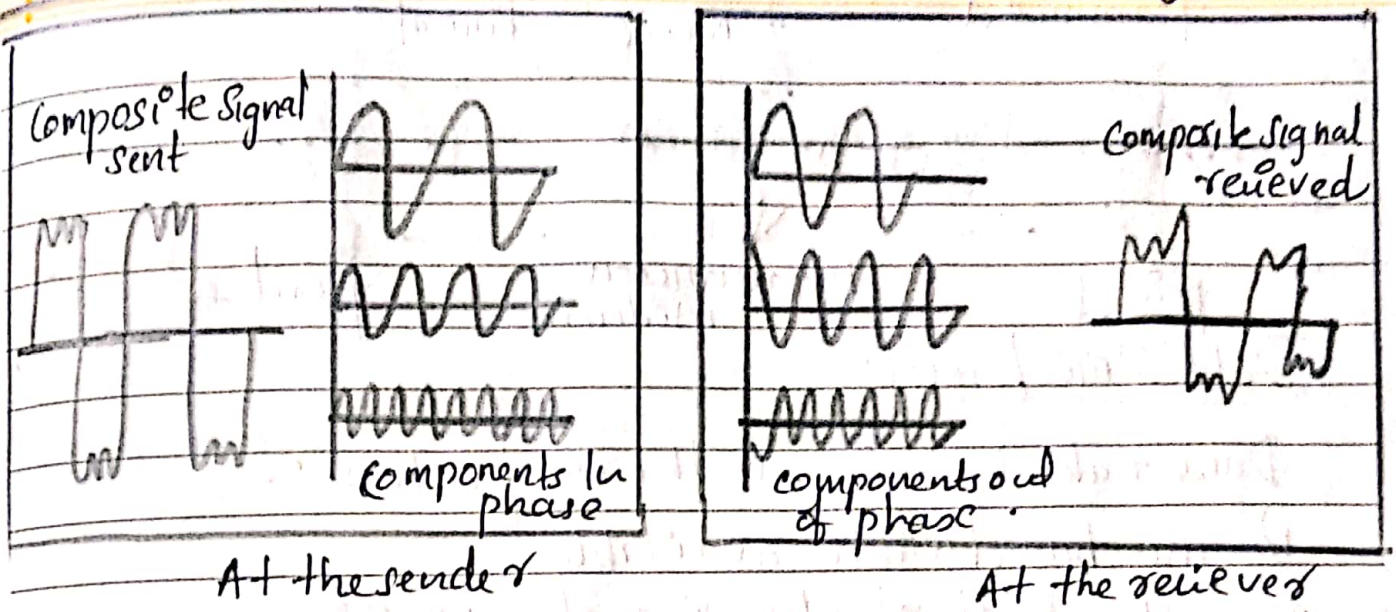


Noise

Unwanted Energy from Sources other than transmitter

a) Thermal Noise
It is due to the random motion of electrones in a wire that creates an extra signal not orginally send by the transmitter.

b) INDUCED Noise
It comes from Sources such as motors and appliances

c) CROSS TALK
It is the effect of one wire on the other one wire act as sending antena and the other as recieving antena.

d) IMPULSE NOISE
It is a SPIKE (a signal with high Energy in very short period of time) that comes from power lines, lightening etc.)

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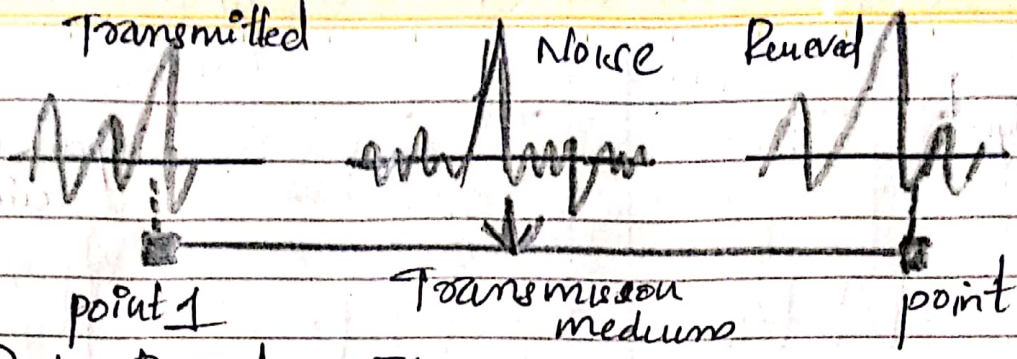


## Data RATE LIMITS

Data rate depends on three factors :-

1) The bandwidth available
2) The level of the signals we use
3) The quality of the channel (the level of noise)

Two theoretical formulas was developed to calculate the data rate : one by Nyquist for a noiseless channel. Another by shannon for a noisy channel.

### Noiseless channel : Nyquist Bit rate

For a noiseless chanel, the Nyquist bitrate formula defines the theoretical maximum bitrate

$$\text{BitRate} = 2 * \text{bandwidth} * \log_2 L$$

bandwidth is the bandwidth of the channel, L is the number of signal levels used to represent data, and BitRate is the rate in bits per second.

### Noisy channel : Shannon capacity

In reality we cannot have a noiseless chanel, the channel is always noisy. Shannon introduced a formula, called Shannon capacity to determine the theoretical highest data rate for a noisy channel:

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**capacity = bandwidth * log2 (1+SNR)**

bandwidth is the bandwidth of the channel, SNR is the signal to noise ratio, and capacity is the capacity of the channel in bits per second. for shannon formula, there is no indication of the signal level, which means that no matter how many levels we have, we cannot achieve a data rate higher than the capacity of the channel. In other words, the formula defines a characteristic of the channel, not the method of transmission.

## Signal-to-Noise Ratio (SNR)

We need to know the ratio of the signal power to the noise power. The signal to noise ratio is defined as

**SNR = average signal power / average noise power**

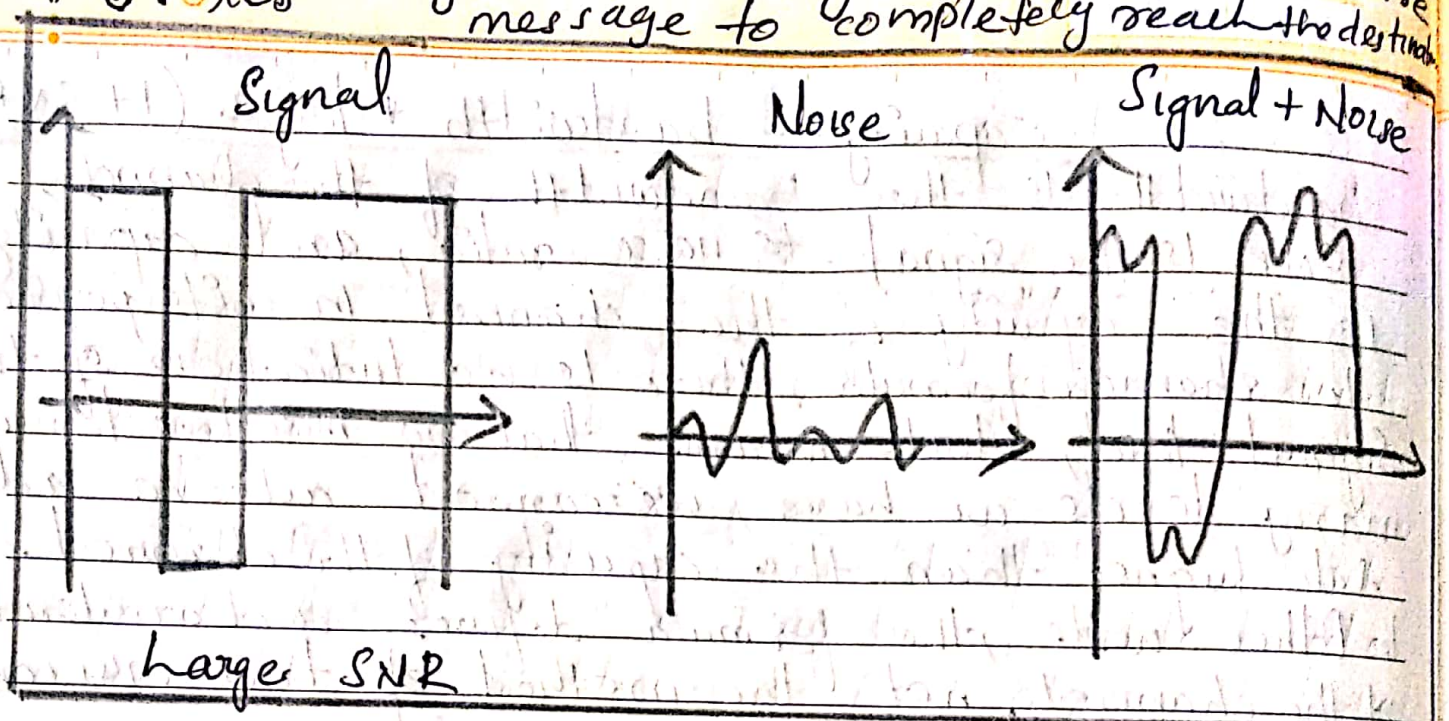
we need to consider the average signal power and average noise power because these may change with time.

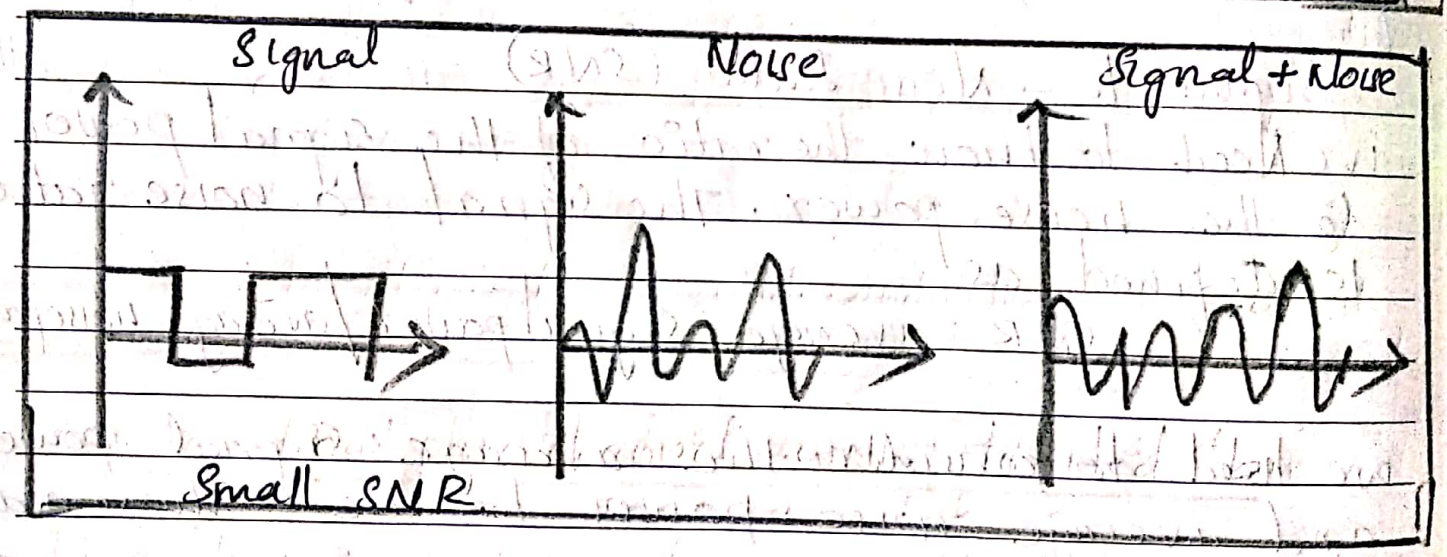
A high SNR means the signal is less corrupted by Noise; a low SNR means the signal is more corrupted by Noise. Because SNR is the ratio of two powers, it is often described Units $SNR_{db}$ defined as

$$SNR_{db} = 10 \log_{10} SNR$$

Throughput – Measure of how fast we can send data through a network

Notes latency = is how long it takes DATE the entire message to completely reach the destination




## Transmission of Digital Signals

A digital signal, periodic or non periodic, is a composite analog signal with frequencies between zero and Infinity. let us consider the case of a Non periodic digital signal, similar to the ones we encounter in data communication. We can transmit a digital signal by using one of two different approaches:

Latency = propagation time + transmission time + queuing time + processing delay.

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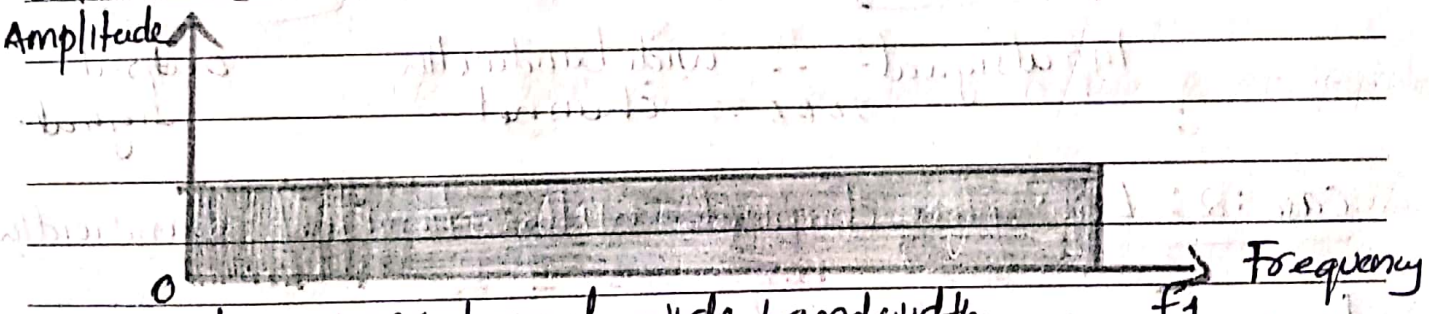
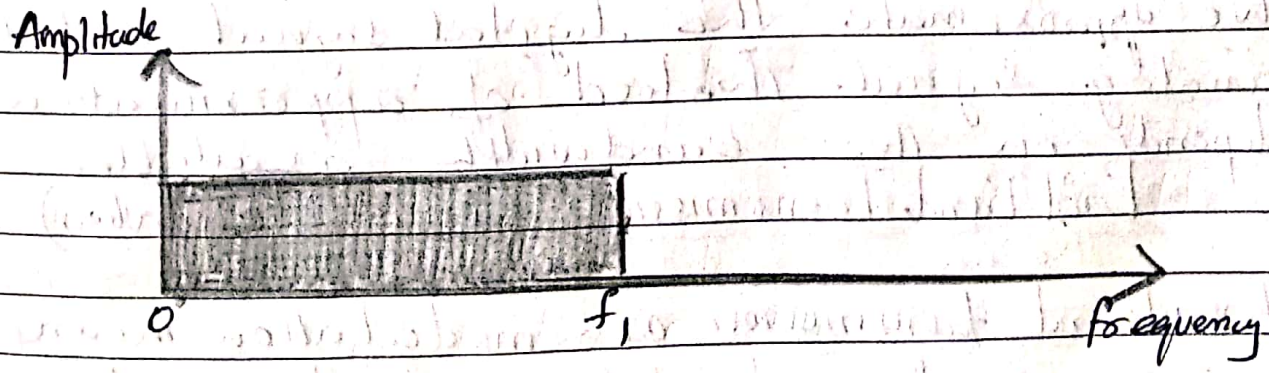
1) Baseband transmission
2) Broad band transmission (using modulation)

## Baseband Transmission

Baseband Transmission means sending a digital signal over a channel without changing the digital signal to an analog signal. Requires that we have a low-pass channel, a channel with a bandwidth that starts from zero. This is the case if we have a dedicated medium with a bandwidth constituting only one channel. The figure shows two low pass channels: one with a narrow bandwidth and the other with a wide bandwidth.




Low pass channel, wide bandwidth




### case 1: Low pass channel with wide Bandwidth

If we want to preserve the exact form of

- lowpass channel – A channel with bandwidth that starts from zero

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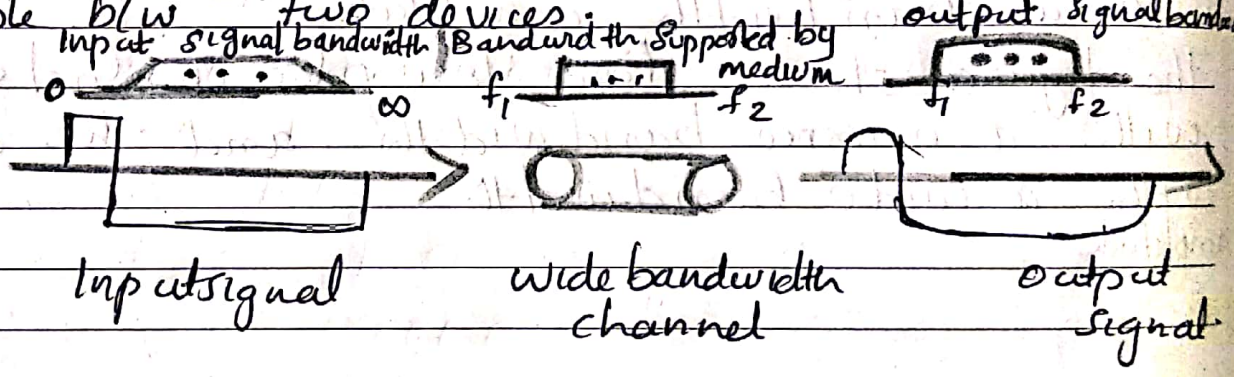
a non periodic signal with vertical segments vertical and horizontal segments horizontal, we need to send the entire spectrum, the continuous range of frequencies b/w zero and Infinity. This is possible if we have a dedicated medium with an Infinite bandwidth b/w the Sender and reciever that preserves the exact amplitude of each component of the composite signal. Although this may be possible Inside a computer (eg: b/w cpu and mly), It is not possible b/w two devices.




## Case :2: Low pass channel with limited bandwidth

In a low pass channel with limited bandwidth we approximate the digital signal with an analog signal. The level of approximation depends on the bandwidth available.

### Broad Band Transmission (using Modulation)

Broadband transmission or modulation means changing the digital signal to analog signal for transmission. Modulation allows us to use a bandpass channel + a channel

Band pass channel – A channel starting with a bandwidth is not zero.

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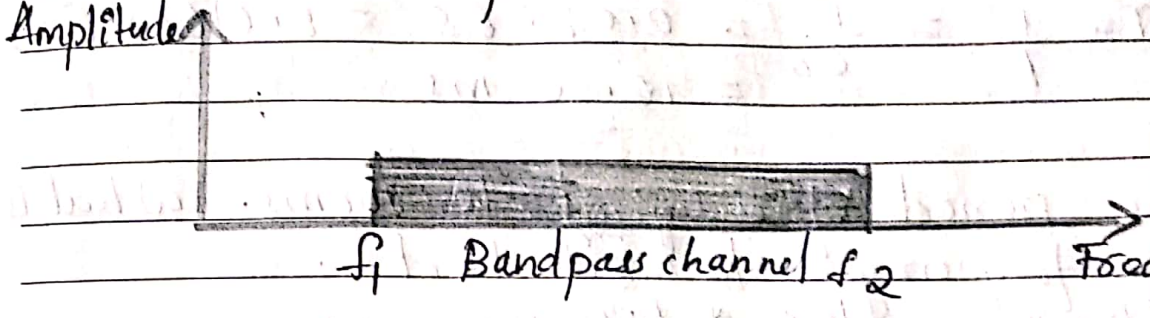
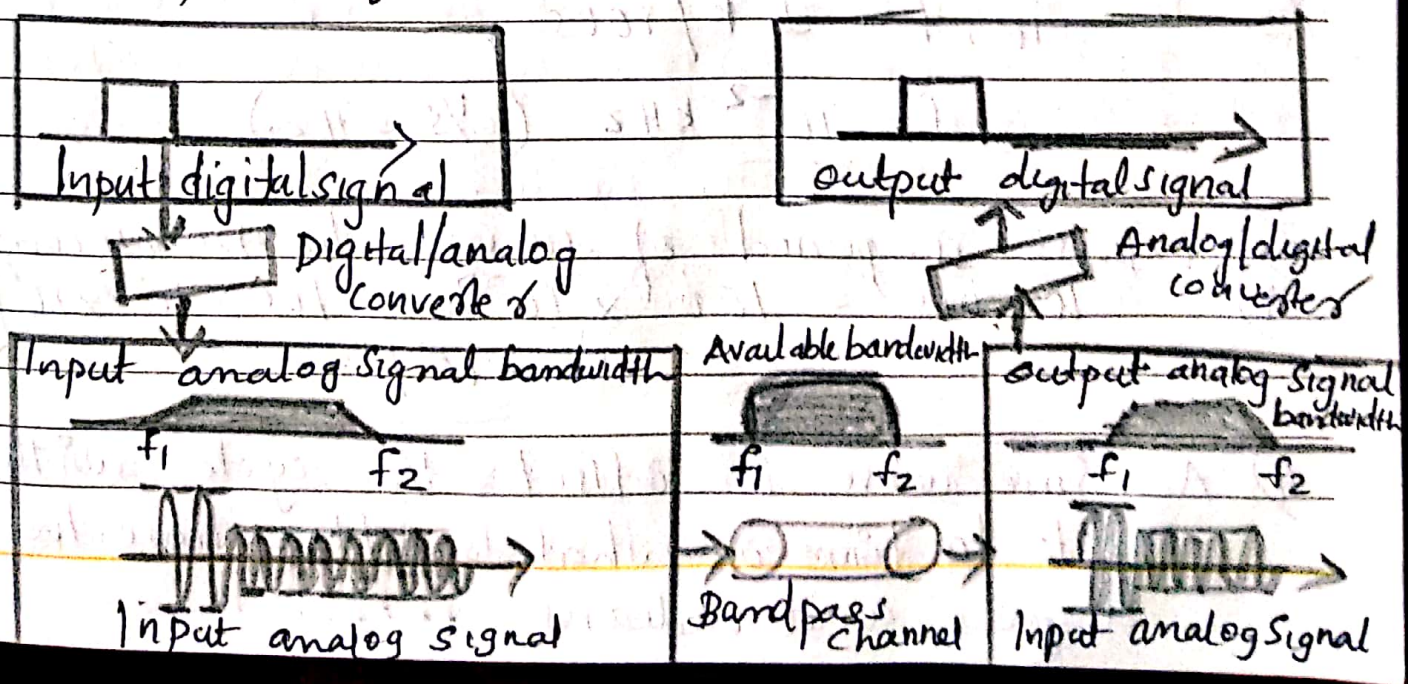
with a bandwidth that does not start from zero. This type of channel is more available than a low-pass channel.




The modulation of a digital signal, Here the digital signal is converted to a composite analog signal. We have used a single frequency analog signal (called a carrier); the amplitude of the carrier has been changed to look like the digital signal. The result, however, is not a single-frequency signal; it is a composite signal. At the reciever, the recieved analog signal is converted to digital, and the result is a replica of what has been sent.



Notes Problems DATE

1) The power we use at home has a frequency of 60 Hz. What is the period of this sine wave

A) $T = \frac{1}{F} = \frac{1}{60} = 0.01665 = 0.0166 \times 10^{3}$ ms

$= 16.6$ ms

2) The period of a signal is 100ms. What is the frequency in kilo hertz.

A) 100 ms = 100 * 10 power -3 s

$F = \frac{1}{T}$

Given time period (T) = 100 ms

$f = \frac{1}{100}$ ms

$f = \frac{1000}{100000}$ ms

we know that 1000 ms = 1sec and we can write 1000 as 1 k

ie; f = 1 k / 100 s

$f = 10^{-2}$ kHz ($1/s = Hz$)

3) Exporess a period of 100 ms in microseconds

A) $100 \text{ ms} = 100 \times 10^{-3} s = 100 \times 10^{-3} \times 10^{6} \mu s$

$= 10^{5} \mu s$

4) A sine wave is offset 1/6 cycle with respect to time 0. What is its phase in degrees and radians

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A) we know that 1 complete cycle is 360°.

∴ 1/6 cycle is

$$\frac{1}{6} \times 360 = 60^\circ$$

$$= \frac{60 \times 2\pi}{360} \text{ rad}$$

$$= \frac{\pi}{3} \text{ rad} = 1.046 \text{ rad}$$

5) If a periodic signal is decomposed into five waves with frequencies of 100, 300, 500, 700 and 900 Hz what is the band width?

A) $B = f_h - f_l$

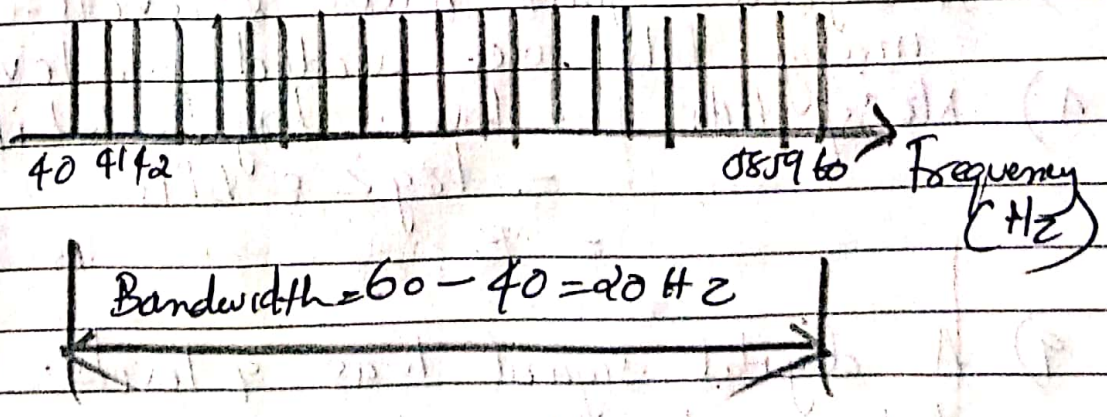
$= 900 - 100 = 800 \text{ Hz}$

6) A periodic signal has a bandwidth of 20 Hz. The highest frequency is 60 Hz. what is the lowest frequency? Draw a spectrum if the signal contains all frequencies of the same amplitude.

A) $B = f_h - f_l$

$20 = 60 - f_l$

$f_l = 40 \text{ Hz}$



Notes

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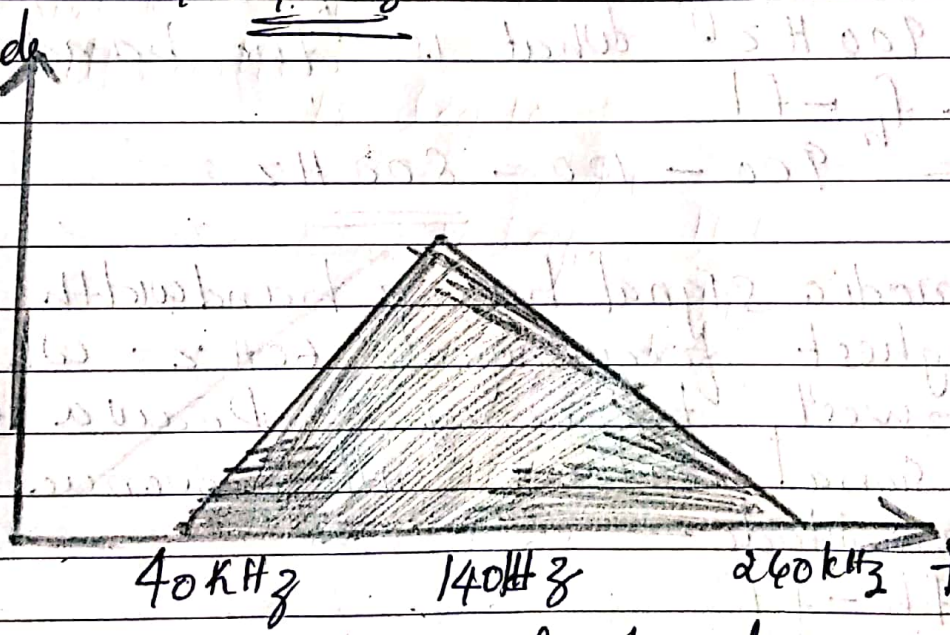
7) A non-periodic composite signal has a bandwidth of 200 Hz, with a middle frequency of 140 Hz and peak amplitude of 20 V. The two extreme frequencies have an amplitude of zero. Draw the frequency domain of the signal.

A) $B = fh - fl$

$200 = 240 - fl$

$fl = 40\,Hz$




8) ~~If a periodic signal is decomposed into five waves with frequencies of 100,~~

8) A digital signal has 8 levels. How many bits are needed per level?

4) No. of bits per level = $\log_2 8$ bits

$= \log_2 8$ bits

$= 3$

9) A digital signal has 9 levels. How many bits per level?

Note: $\log_{10} 1 = 0$ $\log_{10} 10 = 1$

10 pow 0 = 1 10 pow 1 = 10 DATE

Notes

A) No. of bits per level $= \log_2 L$ bits
$= \log_2 9$ bits
$= 3.17$ bits.

10) Assume we need to download a text document at the rate of 100 pages per second. What is the required bit rate of the channel?

A) A page is an average of 24 lines with 80 characters in each line.
If we assume 1 character requires 8 bits
Bit rate $= 100 * 24 * 80 * 8$
$= 1,536,000$ bps
$= 1.536$ Mbps.

11) What is the bit rate for high definition TV (HDTV)?

A) HDTV uses Digital signals to broadcast high quality video signals
1920 by 1080 pixels per screen
Screen is renewed 30 times per second
24 bits represents one colour pixel
Bit rate $= 1920 * 1080 * 30 * 24$
$= 1492992,000$
$= 1.5$ Gbps

12) A signal travels through a transmission medium and its power is reduced to one half. Calculate attenuation.

A) $Db = 10 \log_{10} P_2/P_1$

$SNR\,db = 10 \log 10\, SNR$

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Here $p2 = \frac{1}{2} p1$

$= 10 \log_{10} 0.5 = \log_{10} (1/2)$

$= \log_{10} 1 - \log_{10} 2$

$= 0 - 0.3 = -0.3$

$= -.3$ db

13) A signals travels through an amplifier and its power is increased 10 times. Calculate attenuation.

$10 \log 10 \frac{P2}{P1}$

$= 10 \log_{10} \frac{10 P1}{P1}$

$= 10 \log_{10} 10$

$= 10(1)$

$= 10dB$

14) The power of a signal is 10mw and the power of noise is 1 μw. What is the value of SNR

A) $SNR = 10000\ \mu w / 1\ \mu w$

$SNR\,db = 10 \log_{10} SNR$

$= 10 \log_{10} 10000 = 10 \log 10\ 10$ power 4

Notes

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15) Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with 2 signal levels. calculate bit rate

A) bit rate = $2 * 3000 * \log_2 2$
= 6000 bps.

16) Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with 4 signal levels. calculate the bit rate

A) bitrate = $2 * 3000 * \log_2 4$
= 12000 bps

17) We need to send 265 kbps over a noiseless channel with bandwidth of 20 kHz. How many signal levels do we need

A) $265000 = 2 * 20000 * \log_2 L$
$\log_2 L = 6.625$
$L = 2^{6.625}$
= 98.7 levels

18) A telephone line normally has a bandwidth of 3000 Hz assigned for data communication. The signal to noise ration is 3162. Find the capacity

A) Capacity = bandwidth $* \log_2 (1 + SNR)$
$= 3000 * \log_2 (1 + 3162) = 3000 * 11.62$
= 34860 bps

# DCCN - Module - II - Physical Layer.

Notes

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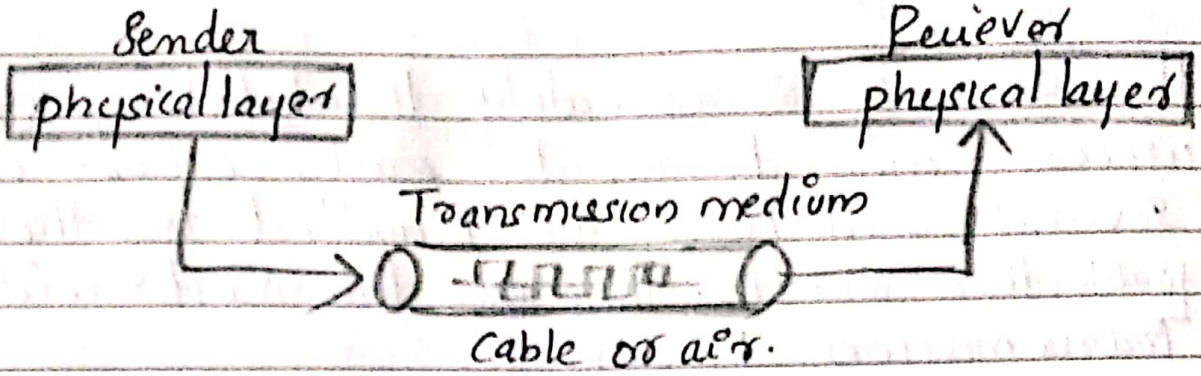
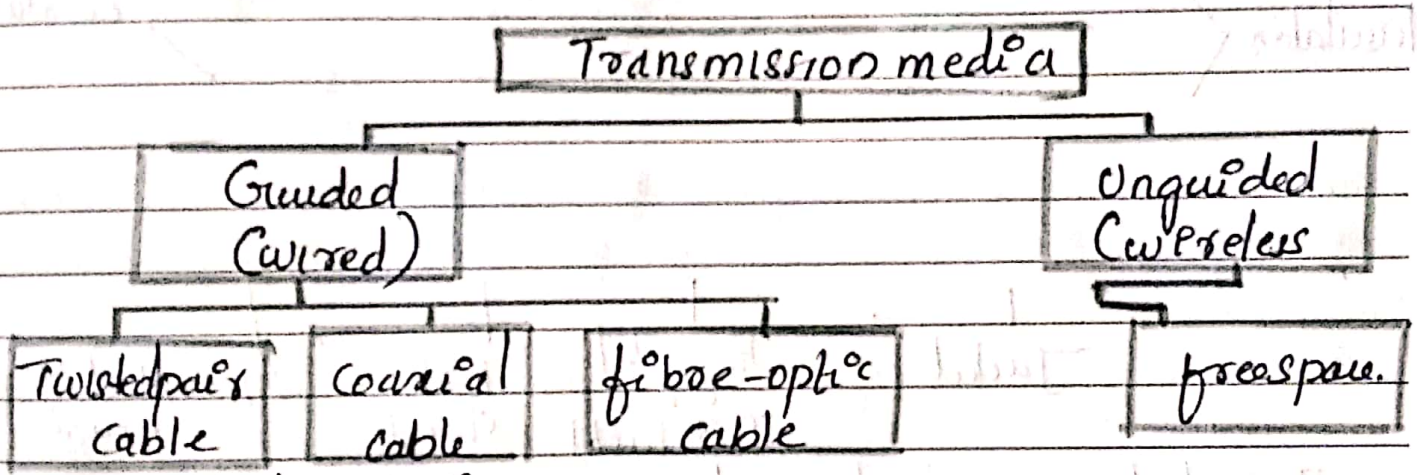
## Transmission Media.

A transmission medium can be broadly defined as anything that can carry information from a source to a destination.




## Classes of transmission media




## Guided Media

Guided Media which are those that provide a medium from one device to another, include twisted pair cable, coaxial cable, and fiber-optic cable. It is also referred to as wired or Bounded transmission media. Signals being transmitted are directed and confined in a narrow pathway by using physical links.

### features

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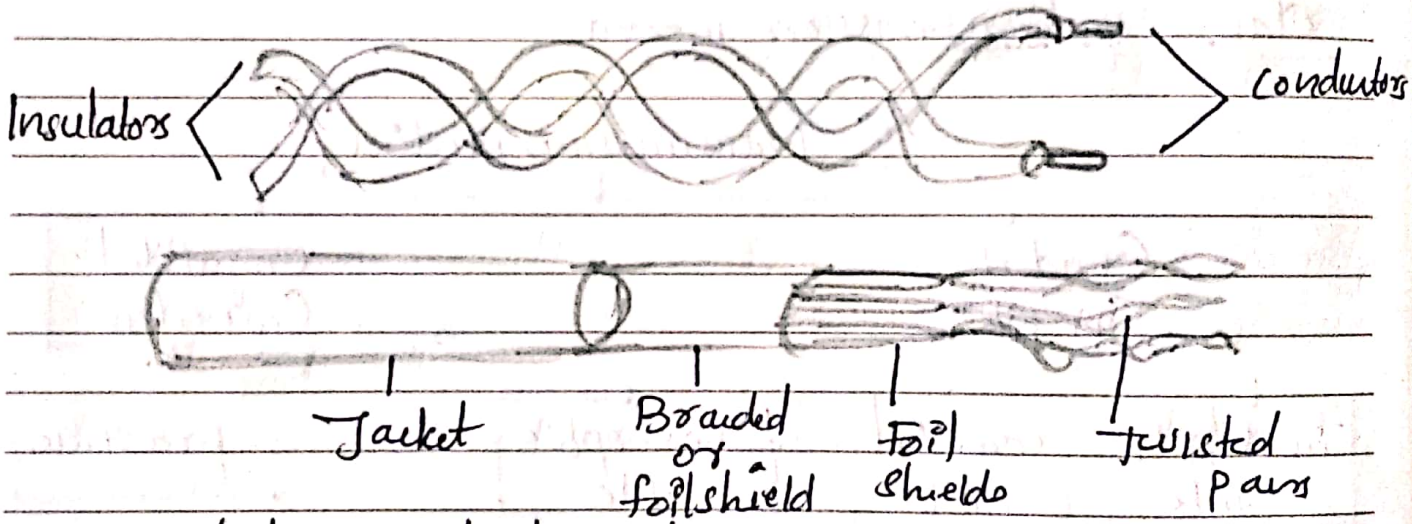
*) Highspeed *) Secure *) Used for comparitively shorter distances.

There are 3 major types of Guided Media

(i) Twisted pair cable

It consists of 2 Separately Insulated conductor wires wound about each other. Generally several such pairs are bundled together In a protective sheath. They are the most widelyused Transmission Media




Twisted pair of two types

a) Unshielded Twisted pair (UTP):

This type of cable has the ability to block Interefference and does not depend on a physical shield for this purpose. It is used for telephonic applications.

Advantages

*) least expensive *) High speed capacity

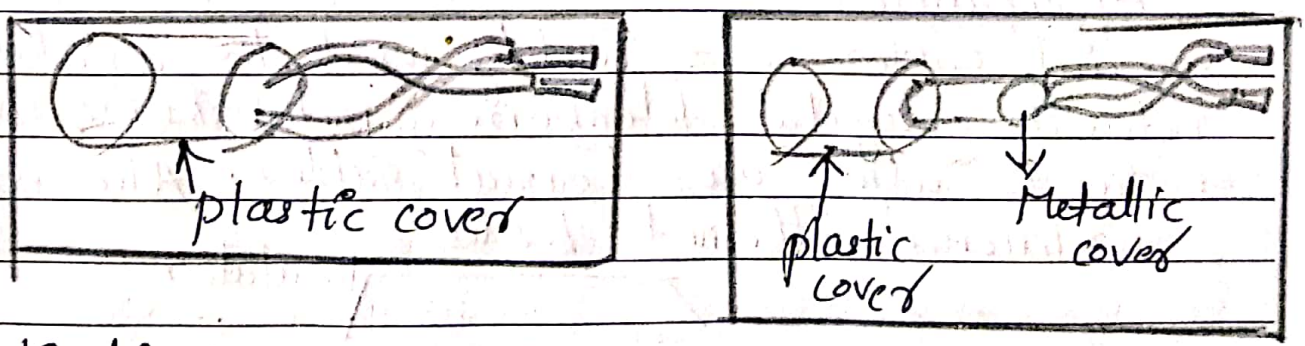
*) Easy to Install
*) susceptible to external Interference
*) Lower capacity and performance in comparison to STP
*) short distance transmission due to attenuation

b) Shielded Twisted pair (STP)

This type of cable consists of aspecial Jacket to block external Interference. It is used in fast data-rate Ethernet and in voice and data channels of telephone lines.

Advantages

*) Better performance at a higher data rate in comparison to UTP
*) Eliminates crosstalk
*) comparitively faster
*) comparitively difficult to Install and manufature
*) More expensive
*) Bulky.




Applications

Twisted cables are used in telephone lines to provide voice and data channels. Local area

networks, such as 10Base-T and 100Base-T, also use Twisted pair cables.

(ii) Coaxial cable

It has an outer plastic covering containing 2 parallel conductors each having a separate insulated protection cover. Coaxial cable transmits Information in two modes: Base band mode (dedicated cable bandwidth) and Broadband mode (cable bandwidth is split into separate ranges). cable TVs and analog Television networks widely use coaxial cables.

Advantages

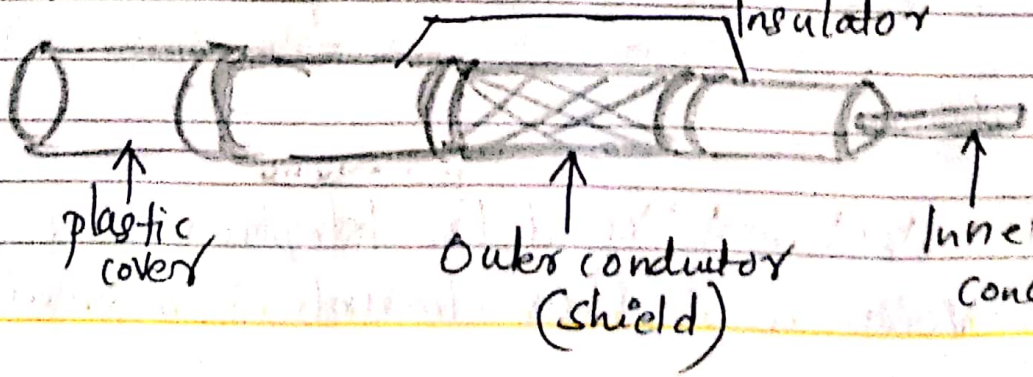
*) High bandwidth *) Better noise Immunity
*) Easy to Install and expand *) Inexpensive.

Disadvantages

*) Single cable failure can disrupt the entire network.

Applications

Coaxial cables was widely used in analog telephone networks, digital telephone networks. Cable TV networks also use coaxial cables. Also used in traditional Ethernet LANs.



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(iii) Optical Fibre cable

It uses the concept of reflection of light through a core made up of glass or plastic. The core is surrounded by a less dense glass or plastic covering called the cladding. It is used for transmission of large volumes of data.

The cable can be unidirectional or bidirectional The WDM supports two modes, namely uni-directional and bidirectional mode.

Advantages

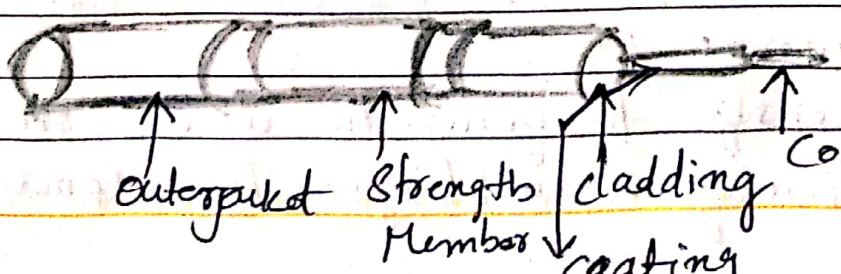
*) Increased capacity and bandwidth
*) Light weight
*) Less signal attenuation
*) Immunity to electromagnetic Interference
*) Resistance to corrosive materials

Disadvantages

*) Difficult to install and maintain
*) High cost *) Fragile.

Applications

*) It found in backbone networks.
*) Some cable TV companies use a combination of optical fiber and coaxial cable thus creating a hybrid network.



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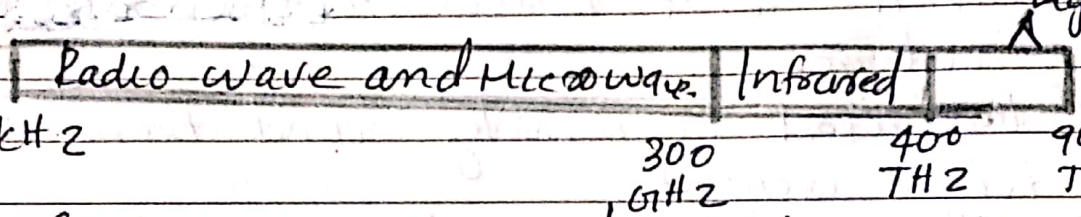
## Unguided Media (Wireless)

It is also referred to as wireless or Unbounded transmission media. No physical medium is required for the transmission of electromagnetic signals.

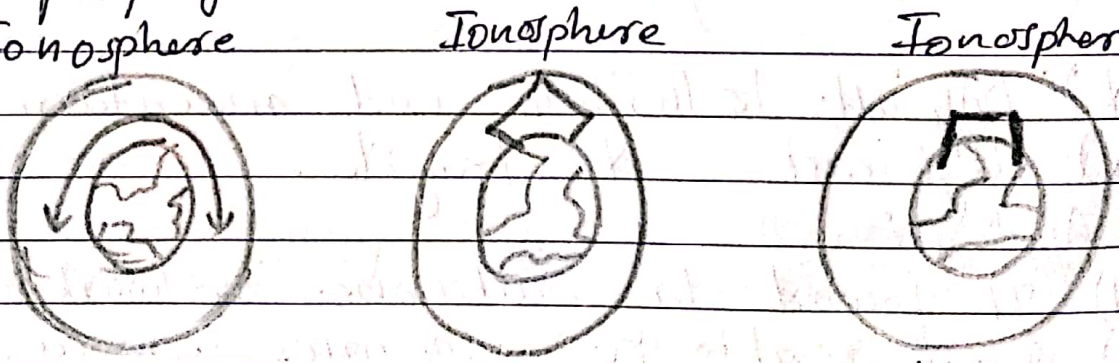
Features

*) Signal is broadcasted through air
*) Less secure *) used for larger distances.

There are three major types of Unguided Media.




Unguided signals can travel from the source to destination in several ways: ground propagation, sky propagation and line of sight propagation.




Ground propagation (below 2 MHz)

Sky Propagation (2-30 MHz)

Line of sight propagation (above 30 MHz)

a) Radio waves,

These are easy to generate and can penetrate through buildings. The sending

unidirectional antenna

Dish Antenna, horn antenna

Notes

Dish Antenna - parabolic antenna - works like a funnel catching wide range of waves and directs into common point.

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and receiving antennas need not be aligned. Frequency range: 3KHz - 1GHz. AM and FM radios and cordless phones use Radiowaves for transmission. eg: OMNI directional Antenna. further categorized as (i) Terrestrial and (ii) Satellite.

b) Microwaves

It is a line of sight transmission. ie; the sending and receiving antennas need to be properly aligned with each other. The distance covered by the signal is directly proportional to the height of the antenna. Frequency Range: 1 GHz - 300 GHz. These are mainly used for mobile phone communication and television distribution.

Application: Microwaves are used for unicast communication such as cellular telephones, Satellite networks and wireless LANs.

c) Infrared waves

Infrared waves are used for very short distance communication. They cannot penetrate through obstacles. This prevents interference b/wn systems. Frequency Range: 300GHz - 400THz. It is used in TV remotes, wireless mouse, keyboard, printer etc.)

Applications: Infrared signals can be used for short range communication in a closed area using line of sight propagation.

Horn antenna – It directs and divides into multiple points.

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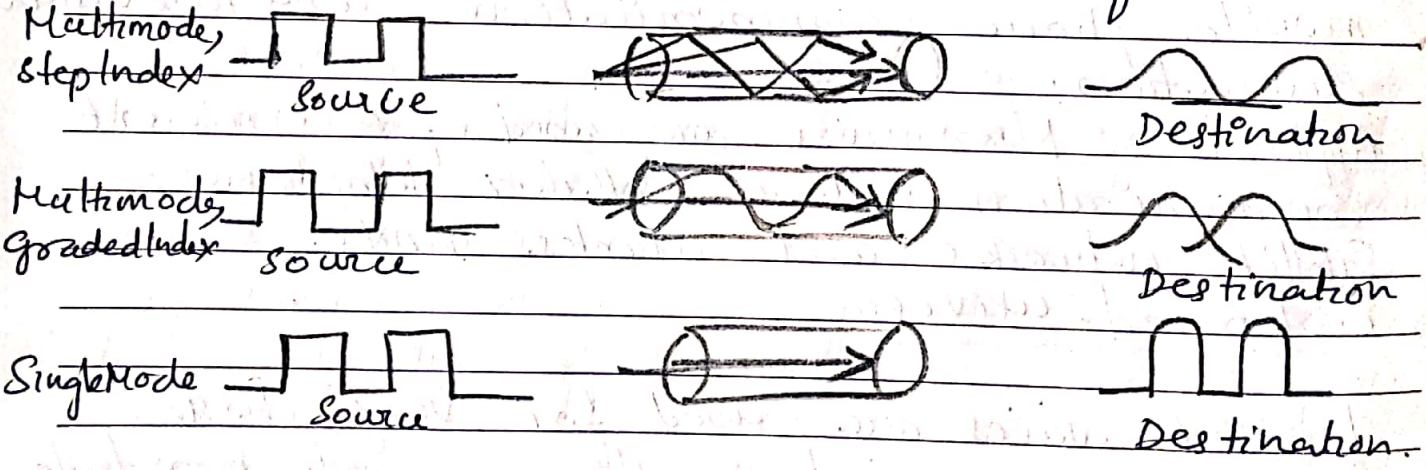
## Propagation Modes (In OPTIC fibre cable)

- Mode
  - Multimode
    - Step Index
    - Graded Index
  - Single Mode

### Multimode

Multiple beams from a light source move through the core in different paths. How they move depends on the structure of the core




- In Multimode step Index fibre – density of the core remains constant from the centre to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding.
- Multimode grade Index fibre – decreases the distortion of the signal through the cable.

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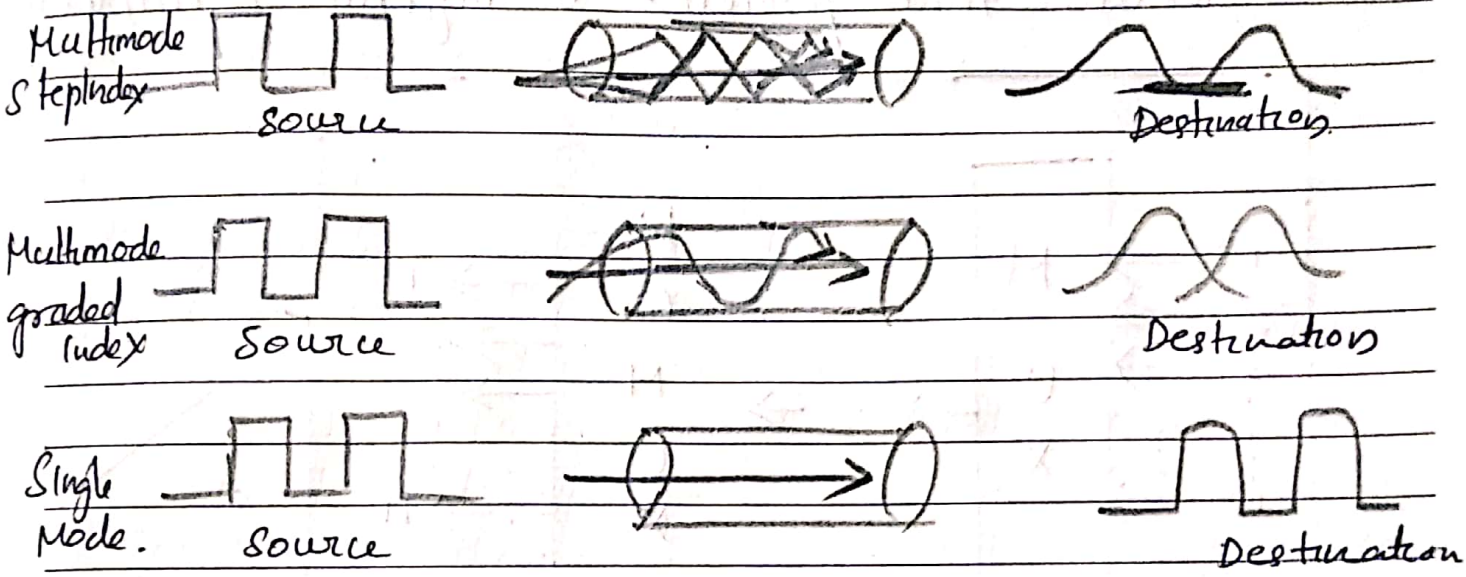
Density is highest at centre of the core and decreases gradually to its lowest edge.




- Single Mode – highly focuses source of light that limits beam to a small range of angles all close to the horizontal. Propagation of different beams is almost identical and delays are negligible.

Advantages (Optic fibre cable)

* Higher bandwidth
* Less signal Attenuation
* Resistance to corrosive materials
* Light weight

## Multiplexing

Multiplexing is the process of combining multiple signals into one signal, over a shared medium.

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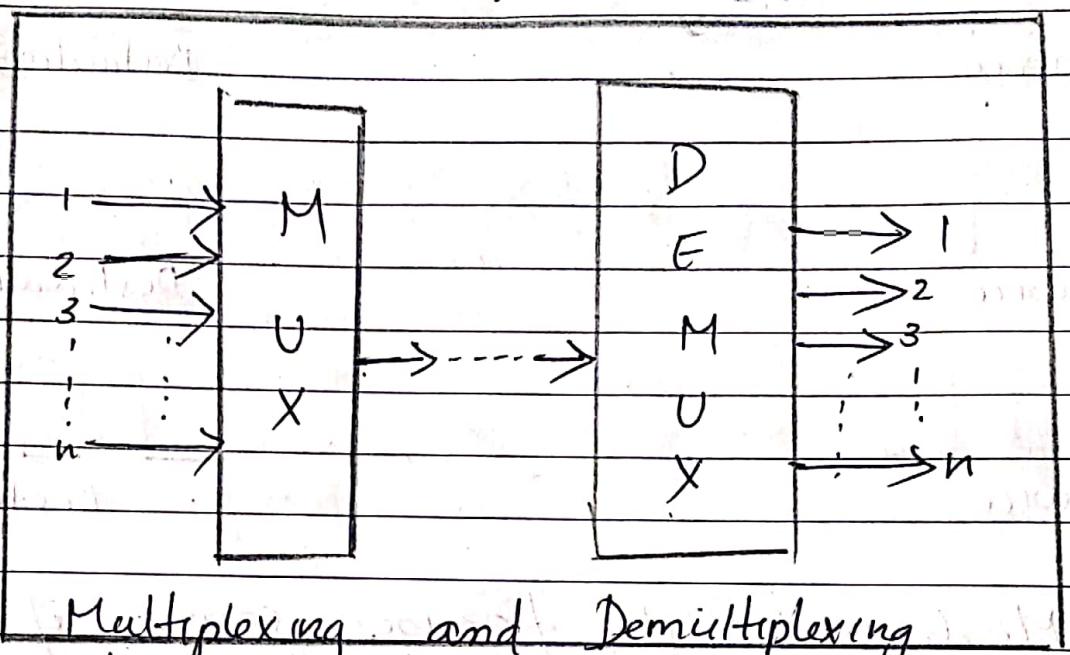
If analog signals are multiplexed, it is Analog Multiplexing and if digital signals are multiplexed, that process is Digital Multiplexing




Multiplexing and Demultiplexing

The process of multiplexing divides a communication channel into several number of logical channels, allocating each one for a different message signal or a data stream to be transferred. The device that does multiplexing can be simply called as a MUX while the one that reverses the process which is demultiplexing is called DEMUX

## Types of Multiplexers

There are mainly two types of multiplexers, namely analog and digital. They are further divided into FDM, WDM and TDM

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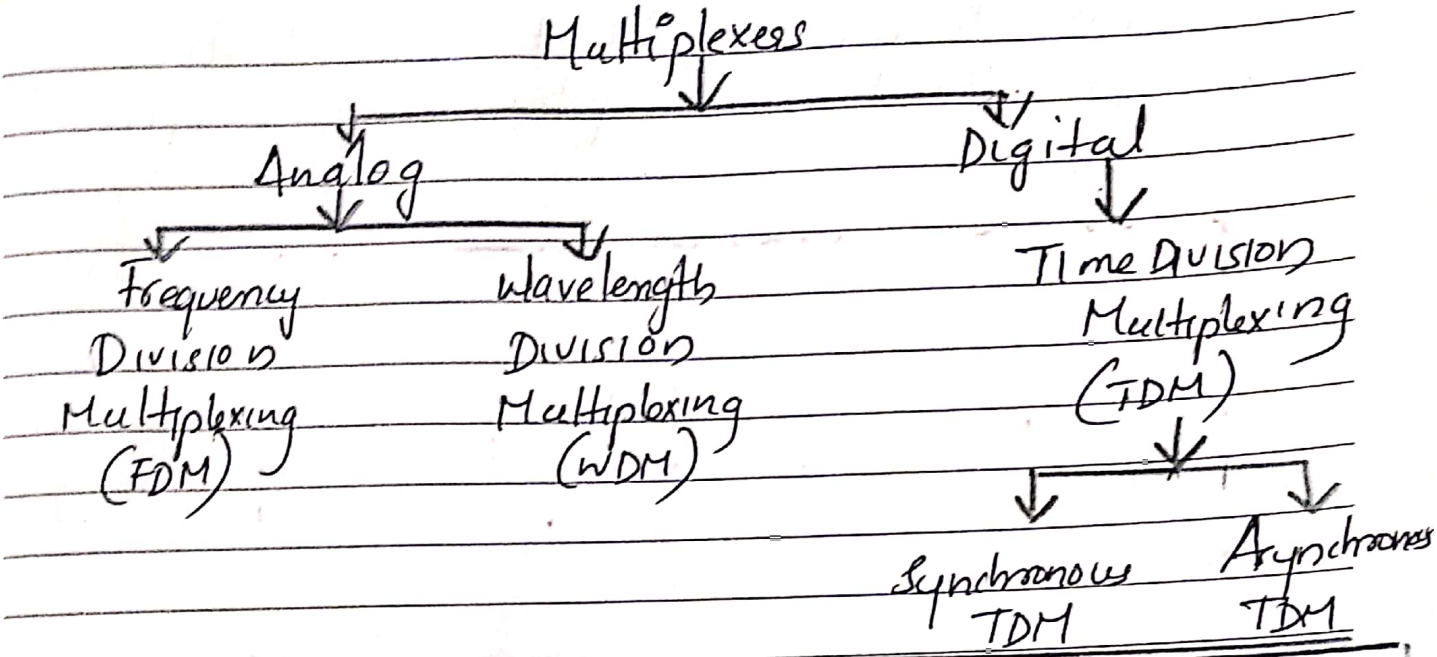


| Multiplexing process | Demultiplexing process |
|---|---|
| * Each source generates a signal of a similar frequency range<br>* Inside the multiplexer, these similar signals modulate different carrier frequencies ($f_1$, $f_2$, $f_3$)<br>* The resulting modulated signals are then combined into single composite signal that is sent out over a media link that has enough bandwidth to accommodate it. | *) Demultiplexing uses a series of filters to decompose the multiplexed signals into its constituent component signals<br>*) The individual signals are then passed to a demodulator that separates them from their carriers and passes them to the output lines |