PAGE NO. :
DATE : / /

OSI Model Layers

ISO 1984

1. Application
2. Presentation
3. Session
4. Transport
5. Network
6. DATA LINK
7. Physical layer

Web browsers perform all fn of these 3 layers

each layer is a package of protocol

1. Application layer - is used by Network Appl^n
   Chrome, Skype etc

   Protocols - HTTP, HTTPS, FTP, NFS
   SMTP, DHCP, SNMP, TELNET, IRC, NNTP

   these protocols from Appl^n layer.

   File transfer - FTP, web surfing - HTTP/S email - SMTP

2. Presentation layer : this layer receive data from Appl^n layer. this layer convert these characters and numbers to machine understandable binary format.
   e.g - ASCII → EBCDIC

   → Translation → Data Compression → Encryption.

   Protocol - SSL (Secure Socket layer)

PAGE NO.:
DATE: / /

3. Session Layer - it helps setting up and managing connections enabling sending and receiving data followed by connection and sessions.

API - Application Programming Interface
NETBIOS - Basic I/O System

Session Layer keep track the which data packets belong to which file. like - text, image and tells where the receive data packets go.

It helps in
- session Management
- Authentication
- Authorization

4. Transport Layer: It control reliability of Communication through segmentation, Flow control, Error control

On segmentation : data received from session layer is divided in to small segments
- each segment contain seq. No., source Port No., destn Port No.

Flow control - it controls amount of data being transmitted

Error control - helps in error control also. If some data lost then transport layer use Automatic Repeat request

to retransmit the loss or corrupted data.
A group of bits (checksum) is added to each segment by T.L to find out receive corrupted segment

Protocals - TCP (transmission control Protocal)
- UDP (User Datagram Protocal)

TCP	UDP
- Connection-oriented Transmission.	Connection-less transmission.
- loves than UDP	- It faster than TCP.
- Feedback required for data lost or not.	- No feedback Provide
- lost data is retransmitted again. (Full data delivery is must)	- It doesn't matter whether received all data or not.
- eg- www, email, FTP	eg- Video games, Songs, online Streaming movie.

Transport layer involves
- Segmentation
- Flow control
- error control
- Connection less
- Connection oriented

PAGE NO.:
DATE: / /

Network Layer:

Transport layer passing data segment to Network layer. transfer data one Network to another. Data Unit is Packet in N.L.

Functions of N.L

- Logical addressing — IPV4 & IPV6 — N.L assign sender receiver IP add. to segment and then Form a packet.
- Path determination — + Mask
- Routing —

Data Packet
[IP1 | IP2 | segment]

Moving data packets from Sou. to dest.

255.255.255.0 — based on IP add. Routing decision are made.
- this represent Network
- host or Computer

Choose best Possible path for data delivery.

Protocols — OSPF — Open shortest path first
BGP — Border Gateway
IS-IS — Intermediate Sys. to Inter. Sys.

DATA Link Layer:

Receive Packet from Network Layer
Data Unit is Frame.
Physical addressing is done in Data Link Layer.

Data Packet
[Mac1 | Mac2 | IP1 | IP2 | Segment | Tail]
Frame

PAGE NO.:
DATE: / /

MAC - 12 digit No. embedded in network interface Card in Comp.

Frame → Access the Media for lower layers of OSI Model

Control how data is placed and received from the media.

Media Access Control - Using CSMA data link layer keeps an eye when shared Computer Media is free.

Error Detection: Tail of each frame contain bits which are used to detect error in received frame.

⇒ Physical layer.

Segment
[Hi] — Transport layer

Packet
[SourceIP | Dest IP | Segm] — Network layer

Frame
[Sou Mac | Dest Mac | Packet | FCS] — Data Link layer

0 | 0 | — Bits

It defined electrical and physical spec. for devices.

Convert to Signal and transfer to Media

Signal
↓
Media

$2^{\log n}$

$g \quad 2^{\log n} \log_2$

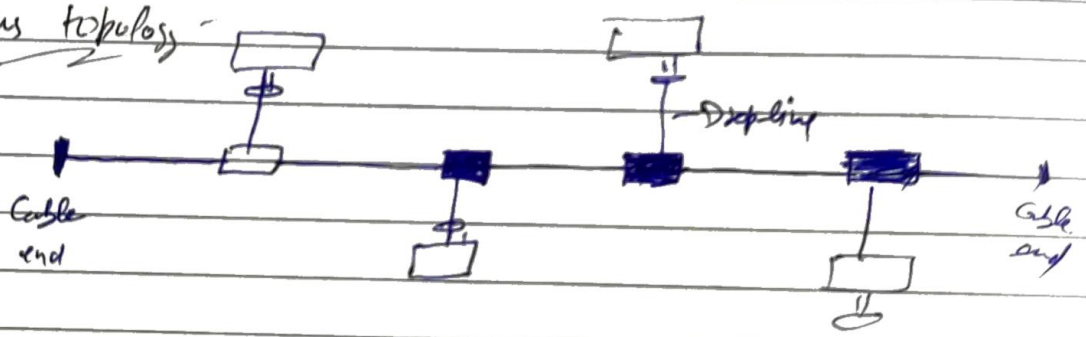
PAGE NO.:
DATE: / /

Lecture - 1

Network topology :- Network topology is the arrangement of the elements of a communication network.
Network topology can be used to define or describe the arrangement of various type of telecommunication networks.

types -

Bus topology -



One long cable act as a single communication channel & all the devices are connected to this cable

Adv - (1) Easy to add / Remove node in N/w.
(2) Req. only cable
(3) It is less expensive.
4) It broadcast the msg to each device which one connected through the Hub
5) It is easy to Maintain
6) In case of computer failure, there will be no effect on other devices.

PAGE NO.:
DATE: / /

Disadv - ① If cable is fail, entire n/w will be fail.

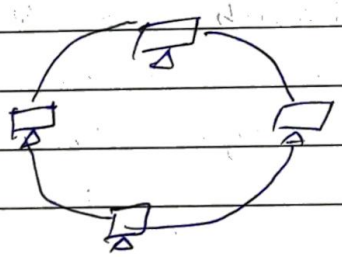
② It broadcast the msg, we can't send private msg.

3) take more time to pass one place to another.

4) the length of cable is limited.

5) data transmitted in one dir^{n}.

③ Ring topology :-



It is called ring topology because, it form a ring. In which each node is strongly connected with its adjacent node.

Adv - It forms a strong n/w

② Each an every node can share data with another node connected through a ring topology.

③ transmission rate of data is very speed.

④ data send through ring topology will be broadcast.

disadv - ① It is very difficult task to add some new comp.

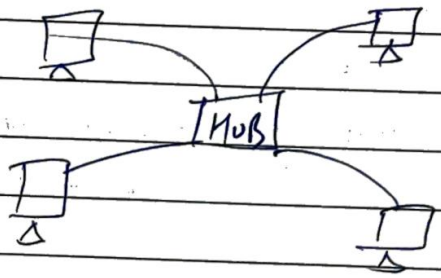
② If we send data from a source to destination machine then data will un-necessary passed to all nodes.

PAGE NO.:
DATE: / /

7. Single point of failure, entire n/w will be down
8. It is very difficult to recover the ring topology if any particular machine is not working properly.
9. We can't send private messages.

3) Star topology -

In which, all the nodes are connected with a central device called Hub. And the sharing of data is only possible through Hub.



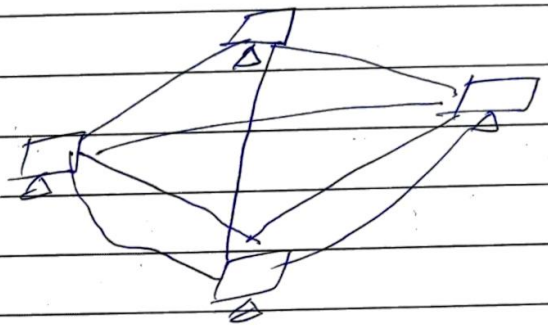
adv - ① It broadcast the messages.
② It is less expensive due to less cable.
③ Easy to connect new node without affecting other nodes.
④ If one node failed, entire n/w will not fail.

disadv

① We must buy network device like Hub, switch etc.
② If two nodes want to share data, sharing is only possible through HUB.
③ If Hub is failed the entire N/w will be failed.
④ We can't send private data.

PAGE NO.:
DATE: / /

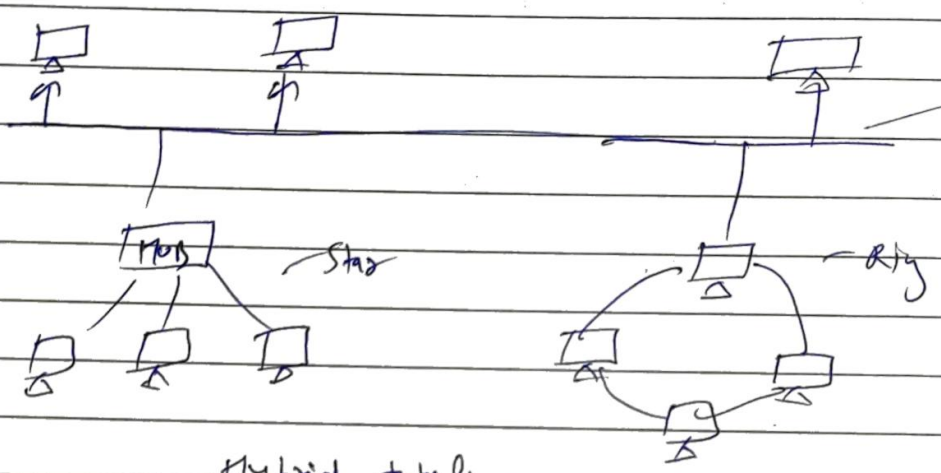
9. MESH Topology : Each an every comp. is directly connected with each other. So we can directly send the data to the dest^n machine without going to intermediate machine.



Adv: ① It is very good topology to send private msg.
② All nodes are directly associated with another node so provide point to point connection.
③ If one comp. is fail, entire N/w will not down.
④ Multiple device can send and Receive data simultaneously.

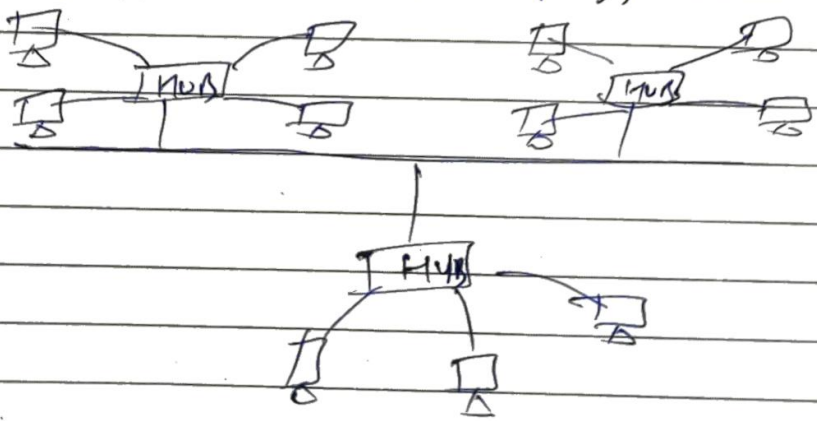
Disadv: ① Very difficult to add some new node because each an every computer directly connected with another one.
② If a particular machine not working then, we can't send data or Receive from failure machine.

5) Hybrid topology : Combination of diff" topology is called Hybrid topology.



Hybrid topology

6) Tree topology : In which all the nodes are connected like a branches of tree. The combination of Bus & Star topology is called tree topology



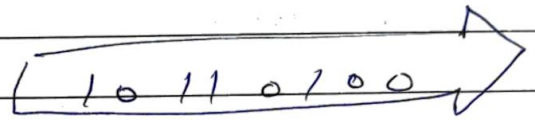
* Hierarchical n/w is a type of n/w topology in which central "root" node is connected to one of more other nodes that are one level down in the hierarchy with point to point link b/w each of the second level node and top level central.

PAGE NO.:
DATE: / /

Lecture - 5

Serial data transmission

In serial data transmission the data bits are transmitted serially over a common communication line one after the other.



Classification of serial data transmission

- Synchronous data transmission
- Asynchronous " "

1. Synchronous transmission :- In which, data flows in a full duplex mode in the form of blocks or frames.

2. For synchronization external clock is used.

It is effective, dependable for transmitting large amount of data. It offer real-time communication b/w linked devices.

Eg :- Chatrooms
- Video conferencing
- Telephone conversation
- Face to Face interaction

- data transfer rate is quicker, the possibility of errors occuring. over time, clocks will get out of sync, and the target device would have incorrect time, so some bytes are damaged, to resolve this issue, re-synchronise the clocks, as well as to make use of check digits to ensure that bytes are correctly received and translated.

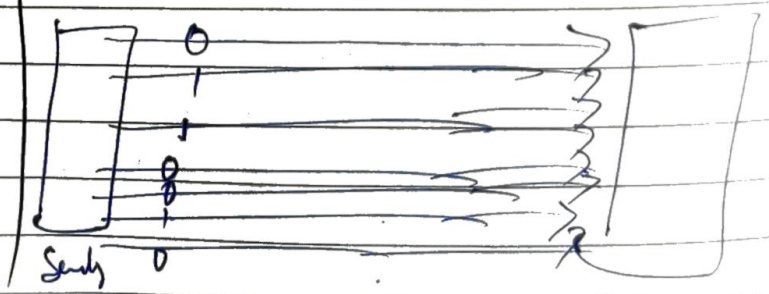
Asynchronous: In which data transfers in half duplex mode, 1 byte or 1 character at a time. Size of characters is 8 bit and 2 bit added both side at beg. and end. making total of 10 bits.

- It doesn't need a clock for interpreting bytes, it uses Parity bits to tell receiver how to translate data

- It is straightforward, quick, cost-effective, and doesn't need 2 way communication

eg- - emails
- Forums
- Letters
- Radios
- Television

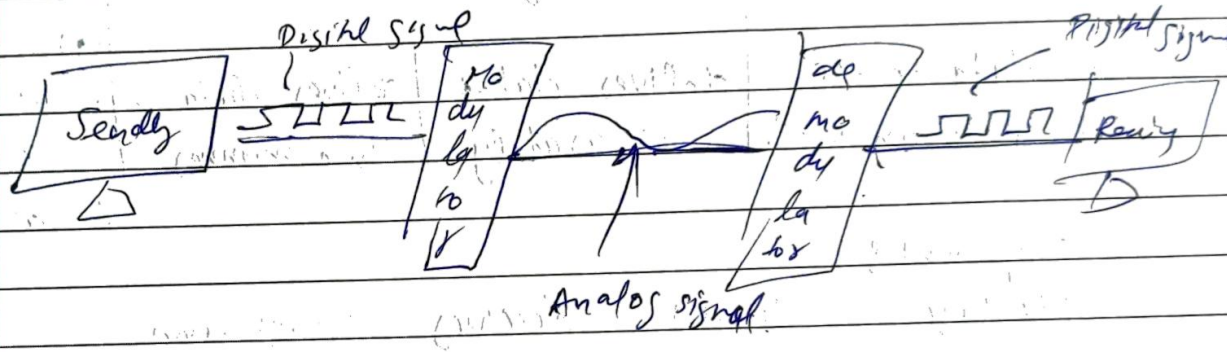
Parallel transmission: By grouping 0's and 1's, we can send data in bits at a time instead of 1.



PAGE NO.:
DATE: / /

Modem – It stands for modulator & demodulator. It is network device that is placed b/w the computer system and telephone line.

It has two part modulator & demodulator. Modulator convert digital signal to analog signal where as demodulator convert analog to digital signal.



NOTE- It allows us to computer to connect internet.

Adv – original data is received by the receiver
→ transmission fast

disadv – without wire we can't send data
→ it is very slow when we send data to far.

PAGE NO.:
DATE: / /

Chapter-1

DATA Communication : are the exchange of data b/w two devices via some form of transmission Medium such as wire Cable.

Delivery	Accuracy	Timeliness	Jitter
↓			Jitter refers to the variation in the packet arrival time.
deliver data to the correct position/dest^{n}.	delivers datas accurately	delivers data in time manner	

* Components -
Message Sender Receiver Transmission Media Protocol / set of Rules

* Simplex :
In which Communication is unidirectional, as on a one-way street

=) Half duplex : each station can both transmit and receive.

=) Full duplex : both station can transmit and receive simultaneously.

* Point to point : Provides a dedicated link b/w two devices. eg- Changing T.V channels.

PAGE NO.:
DATE: / /

Multidrop

1) Multipoint- Connection is one in which more than two specific devices share a single link.

2) LAN- Connects some hosts in a building, office etc.

3) WAN- Wan has a wider geographical span, town, state, country.

4) Switching: Switch connects atleast two links together. Switch needs to forward data from a network to another network when required.

two types:

i) Circuit switching: Is always b/w the two end system
eg- Connect 4 telephones to each end.

ii) Packet switching: Communication b/w the two ends is done in block of data called Packet.
eg- Connect 4 telephones to routers in each end.

5) TCP/IP protocol suite: (a set of protocols organized in a different layers) used in Internet today. Five layers model. It is a hierarchal protocol.

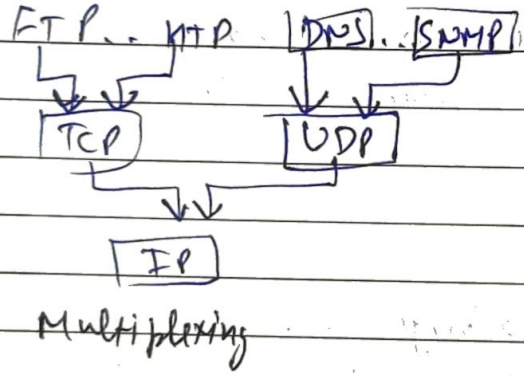
6) 1) Physical 2) Data link 3) Network 4) transport
5) Applications.

PAGE NO. :
DATE : / /

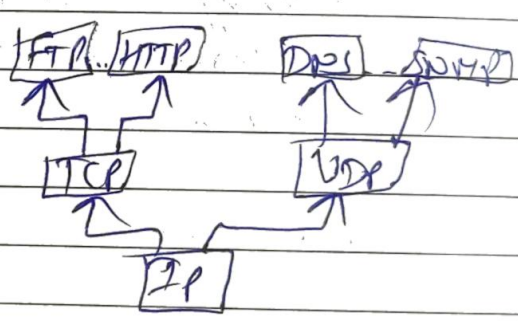
* Multiplexing and DeMultiplexing

Multiplexing means a protocol at a layer can encapsulate a packet from several next higher layer protocals.

Demultiplexing means a protocal decapsulate and deliver a packet to several next highes protocals.



Multiplexing



DeMultiplexing.

PAGE NO. :
DATE : / /

Chapter-3

Intro to Physical Layer.

* Analog and Digital Data

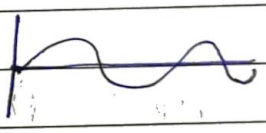
Analog - refer to information that is continuous. (normal watch)

Digital - refer that has discrete states. Data stores in Comp. in the form of (Digital watch)
0's and 1. They converted in to D.D.

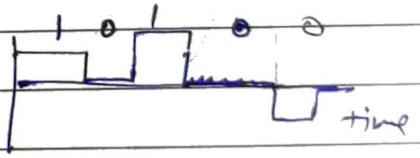
* Analog and Digital signals:

Like data, signals can be either Analog or digital.

Analog has infinitely many levels of intensity over period of time.



Digital - can have only a limited no. of defined values.



1) Periodic - It completes a pattern with in a measurable time frame.

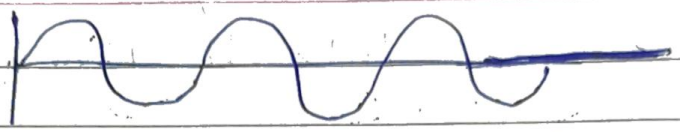
2) Non Periodic - changes without exhibiting a pattern or cycle repeats over time.

NOTE- In Data Comm^n, we use Periodic analog signal and Non Periodic Digital Signal.

PAGE NO.:
DATE: / /

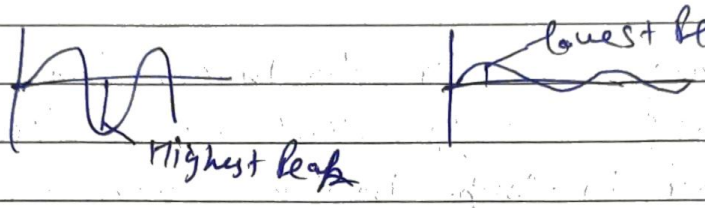
→ Periodic analog signal

* Sine Wave -



Three parameters - Peak, frequency, Phase

Peak -



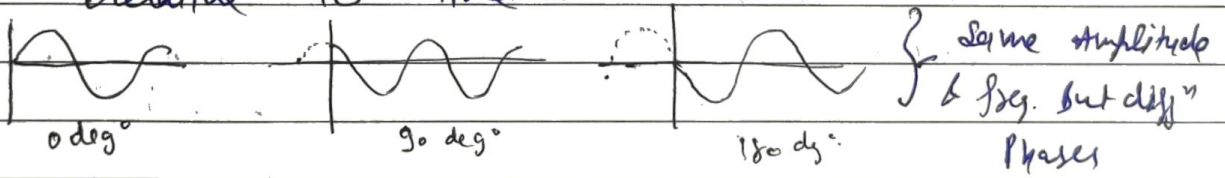
Period & freq. - → n°. of occurences of a repeating event per unit of time

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

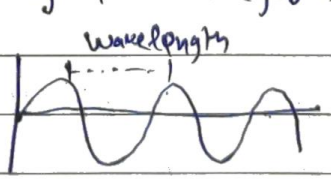
Frequency and Period are the inverse of each other.

T: Amount of time in second (Period).
F: N°. of Periods in 1 s (Frequency).

Phase: Phase describes the post^{n} of the waveform relative to time 0.



Wavelength: Wavelength is distance b/w identical pt in the adjacent cycles of a waveform signal propagated in space or wire.



→ Propagation

$W = \frac{\text{Prop. speed}}{\text{freq.}}$ ∴ $\lambda = \frac{c}{F}$

* Simple Sine wave is not useful for Data Comm" we need C.S

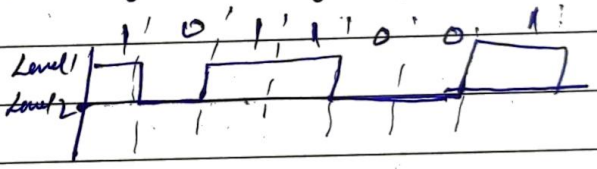
PAGE NO.:
DATE: / /

* Composite Signals: Any composite signals a combination of simple sin waves with diff" freq., Amplitude & Phases.

C.S is Periodic, Series of sine waves discrete freq.
C.S is Non " " " " Continous ".

* Bandwidth: The max. Amount of data transmitted over an internet connection in given amount of time.
Bandwidth of Composite signals = highest − lowest freq.

* Digital signals:

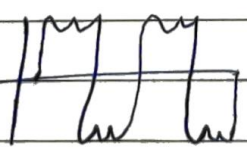


A signal that represents data as a sequence of discrete values.

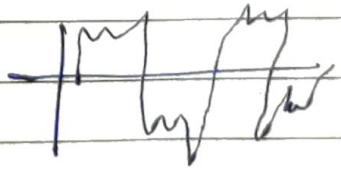
* Baseband transmission: sending a digital signal over a Channel without Changing D.S to A.S.
if we send bit faster, we need more bandwidth.

* Attenuation: Means a loss of energy. while sending data

* Distortion: Means that the signal changes its form or shape.



At sender

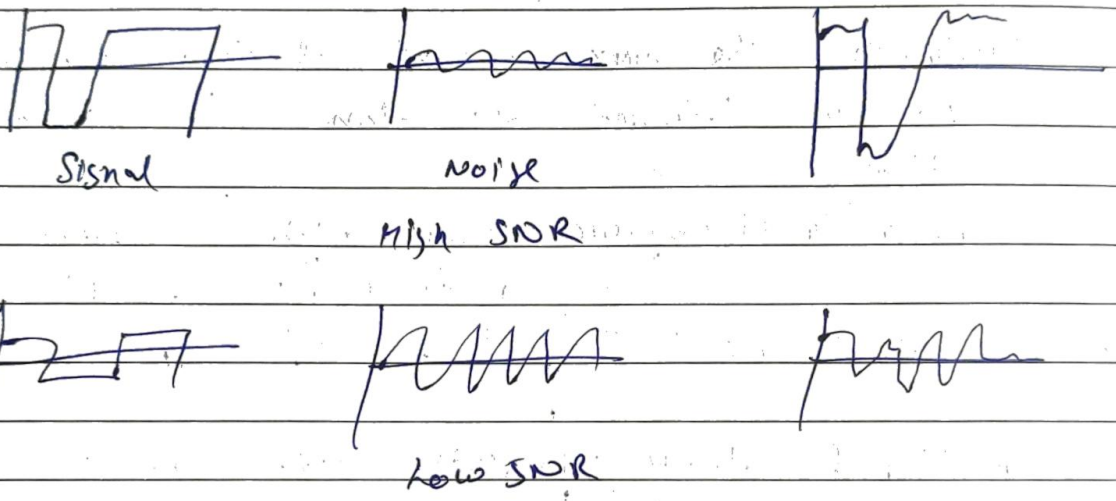


At the receiver

PAGE NO. :
DATE : / /

- Noise : may corrupt the signal. thermal noise, induced noise, crosstalk and impulse noise

- SNR (signal to noise Ratio) - $\frac{\text{avg. signal power}}{\text{avg. noise power}}$



- Throughput : is a measure how fast we can send data through a network.

- latency (Delay) : how long it takes for an entire msg to completely arrive at dest^n.

Latency = Propagation time + transmission time + queing + Processing delay.

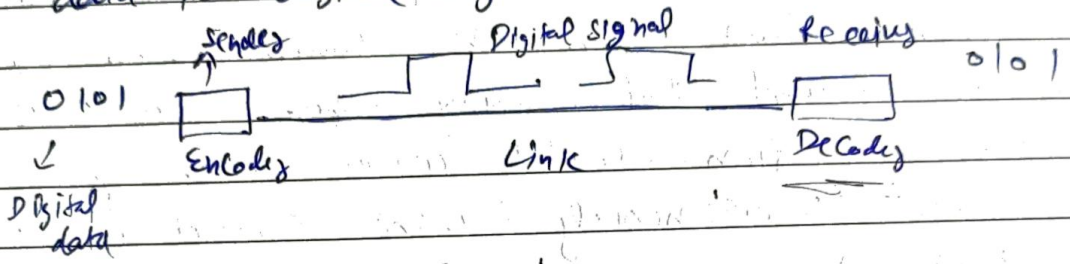
PAGE NO.:
DATE: / /

Chapter-4

Digital Transmission

Digital to Digital Conversion

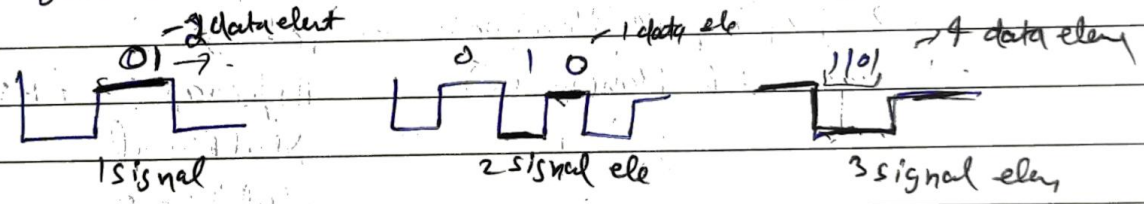
Line coding - It is the process converting digital data to digital signals



Signal vs Data elements :-

⇒ Data element is smallest entity that can represent a piece of info. A signal element carries data ele

⇒ A signal element is shortest unit of digital signal



NOTE- The Actual Bandwidth of d.s is ∞, the effective Bandwidth is finite.

⇒ **Baseline wandering** - In decoding a digital signal the receiver calculates a running avg. of the received signal power. the avg. is called baseline.

if receives clock is slow or fast, it will not correspond in the
to sender, bits not matched, receiver might misinterpret the sig.

Prob

DC Components: when the voltage level in a digital signal constant for a while, the spectrum create a low freq. which is around zero is called

Self synchronization: S.S is presented for handling synchronization Prob in communication protocols. It is found that many errors are caused by process collision, which arises when two or more processes simultaneously transmit conflicting msg.

Lack of syn.

1000 bits sent → 1001 received — 1 extra bit

Imp

* Line coding Schemes:

NRZ ← Unipolar

NRZ, RZ, biphase (Manchester and differential Manchester) ← Polar

Bipolar → AMI, pseudoternary

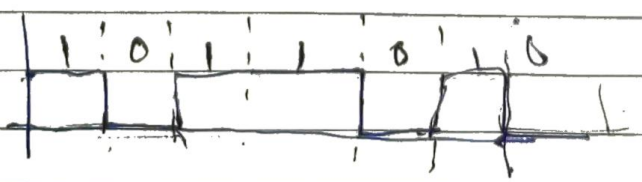
Multilevel

Multitransition → MLT-3

2B/1Q, 8B/6T, and 4D-PAM5

Unipolar:

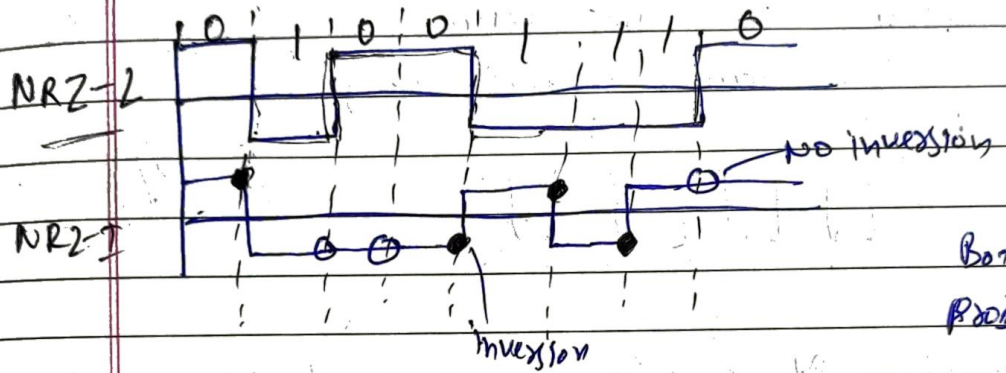
⇒ NRZ (Non Return zero): the voltage define bit 1 and the zero voltage defines bit 0.



Polar schemes:

NRZ — NRZ-L (Level) — the level of vltg. determines the value of the bit.

NRZ — NRZ-I (Invert) → If there is change the bit is 1. If no change bit is 0.



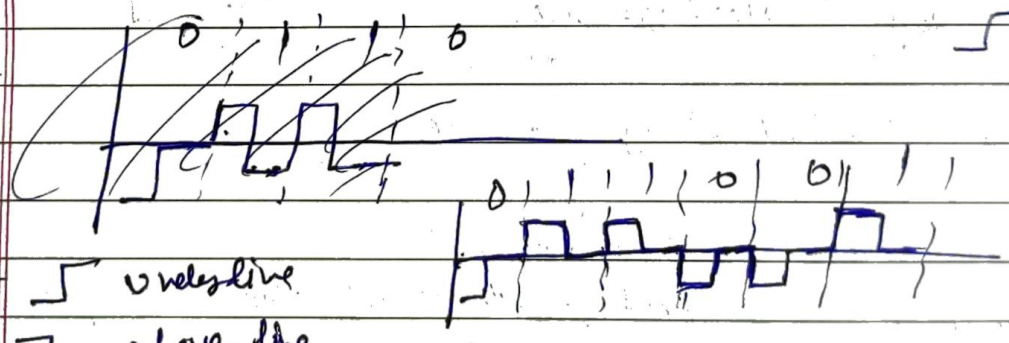
Both have avg signal rate of N/2 Bd.

Both have DC Compo-

No inversion – Next bit is 0 Inversion – next bit is 1.

R2 (Return to zero): In NR2, Receiver does not know when one bit has ended and next bit is starting, sol^n of this is R2.

which uses 3 values, Positive, Negative, zero.



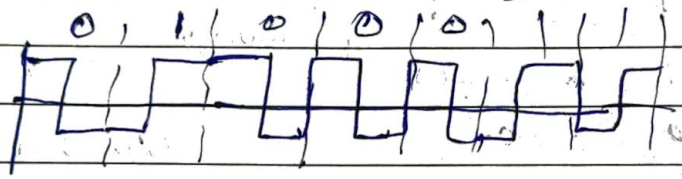
0 → ⌐ ¬ voltage line

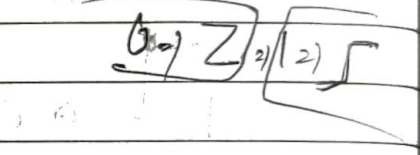
1 → ⌐ above the

the signal goes to 0 in the middle of each bit.

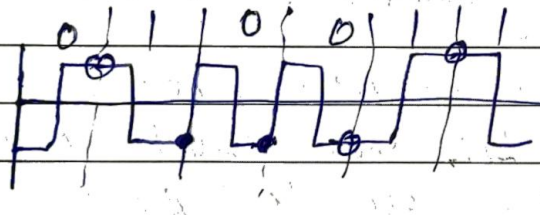
Biphase - Manchester and Differential Manchester:

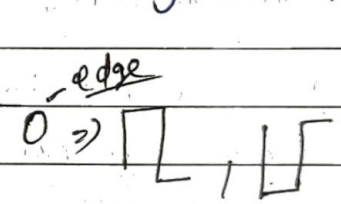
Manchester : Idea of R2 (transition in middle) and the idea of NRZ-L are combined into Manchester.
in which duration of bits divided into two halves voltage remain at one level during first half moves to other level second half.



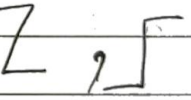


Diff^n Manchester:- It is the combination of R2 and NRI





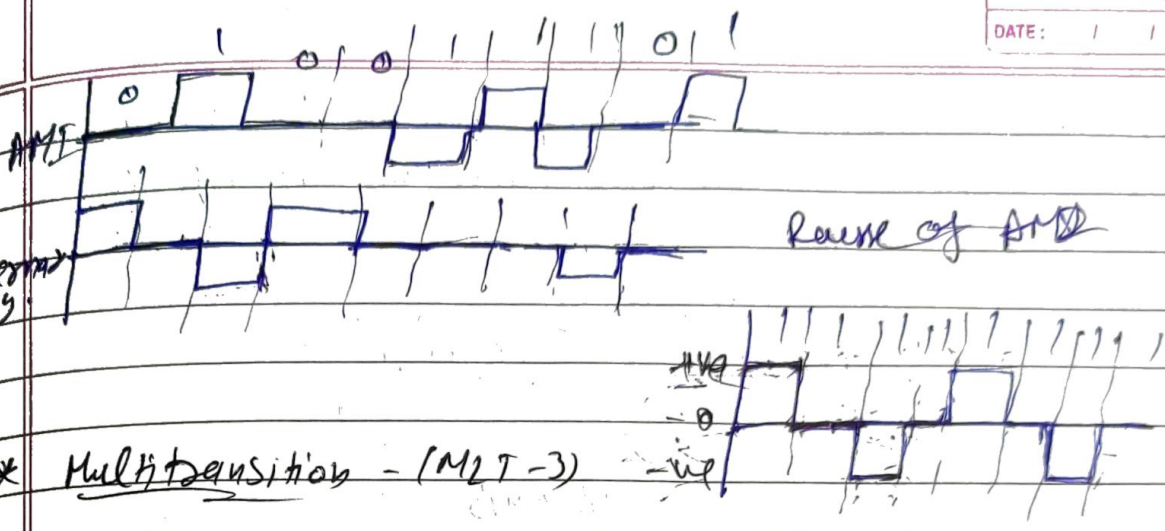
No inversion - Next bit is 1
Inversion - Next bit is 0.



=) Bipolar (Multilevel binary) - true, -ve, zero

AMI (Alternate Mark Inversion):
1 represent alternate true and -ve. 0 represent neutral.

Pseudo ternary - 1 bit encoded as zero voltage 1 bit encoded alternate true and negative

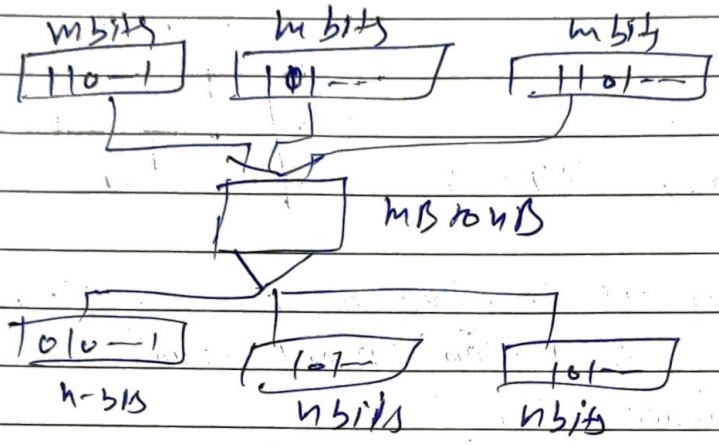


* Multitransition - (MLT-3)

- If next bit is 0, there is no transition
- " " " " 1 then current level is not zero, the next level is 0
- If next bit is 1, current level is zero, the next level is the opposite of last non zero level

Unipolar	NRZ	Costly, no self synchronization, DC
Polar	NRZ-L	No S.S, DC
	NRZ-I	No S.S, DC
	Biphase	S.S, no DC, high bandwidth
Bipolar	AMI	No S.S, DC
Multilevel	2B1Q	No S.S
	8B6T	S.S, no DC
	4D-PAM5	S.S, no DC
Multitransition	MLT-3	No S.S

Block coding is normally referred to as mB/nB coding; it replaces each m-bit group with an n-bit group.



⇒ Scrambling - the comb of block coding and NRZ line coding is not suitable for long distance.

⇒ We are looking for a soln that substitutes long zero-level pulses with a comb. of other levels to provide synchro one soln is scrambled

Analog to Digital Conversion

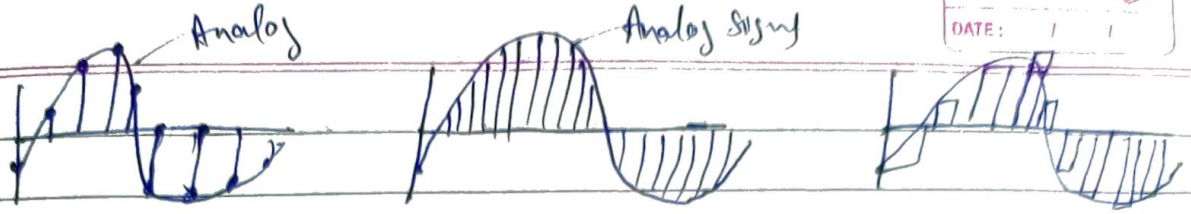
2 technique

1st technique

PCM - (Pulse Code Modulation) - A PCM encoder has 3 processes.

2.

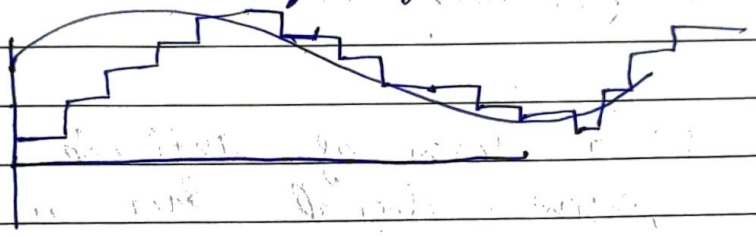
Sampling - the analog signal is sampled every T_s s, where T_s is the sample interval or period the inverse of sampling rate is called sampling rate or fs.



Sampled
- Ideal sampling — Can't be easily implemented
- Natural sampling
- Flat-top sampling.

2nd technique

* DM (Delta Modulation) - PCM is a very complex technique. DM finds PCM finds the value of the signal amplitude for each sample. DM finds the change from the previous sampl.



3 Process - Analog → Sampling → Encoding → Quantizing → Digital (1 0 ...)

- The analog signal is sampled
- The sampled signal is quantized
- The quantized values are encoded as streams of bits

1. Natural sampling - A high switch is turned on or off for only small period of time when the sampling occurs the result is seq. of samples that retain the analog signal

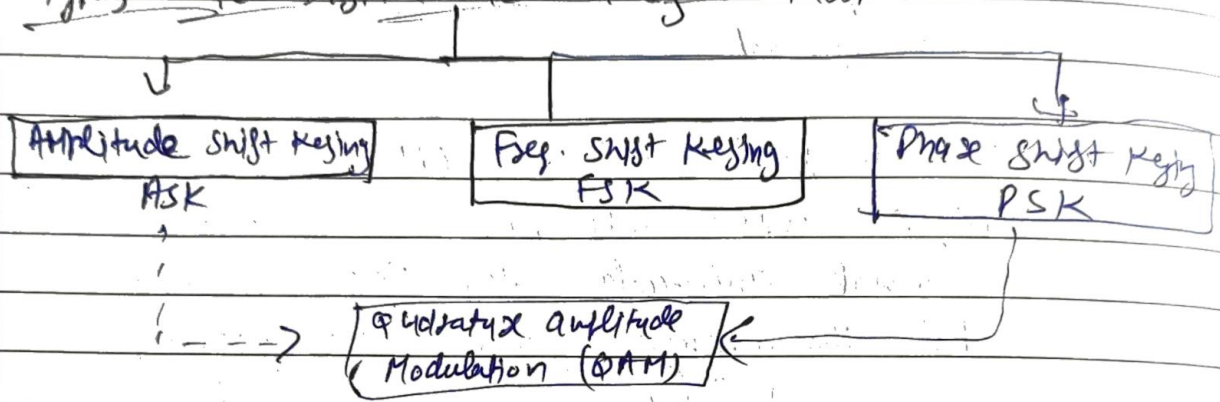
2. Flat-top - Most common method called sample and hold, however creates flat-top samples by using a circuit.

to be continued after 10th Chapter

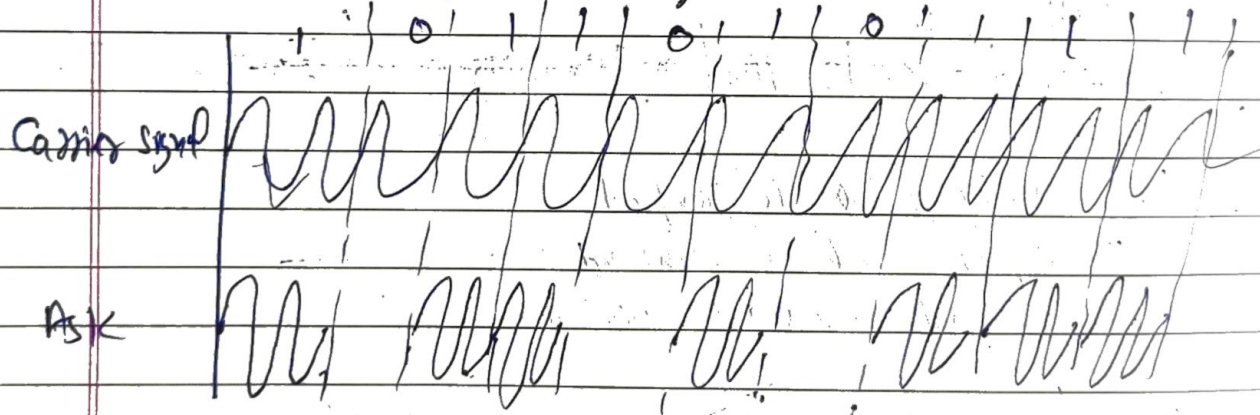
PAGE NO.:
DATE: / /

Chapter-5
Analog Transmission

Types to Digital to Analog Conversion:



=) **ASK:** is a form of amplitude modulation that represents digital data as variations in the amplitude of a Cassier wave

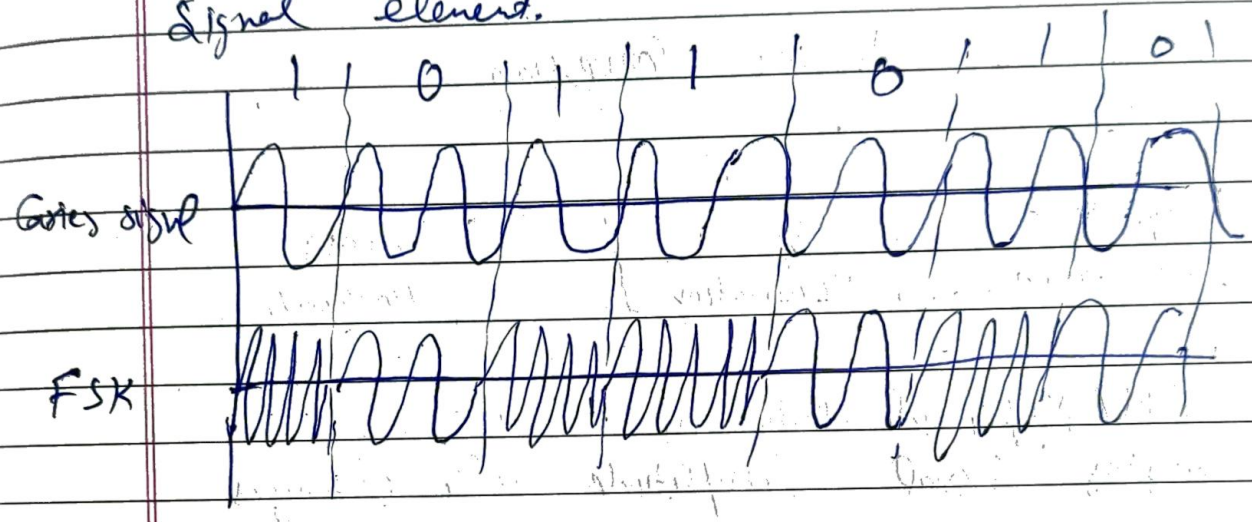


Both freq. and phase remain constant while amplitude changes

PAGE NO. :
DATE : / /

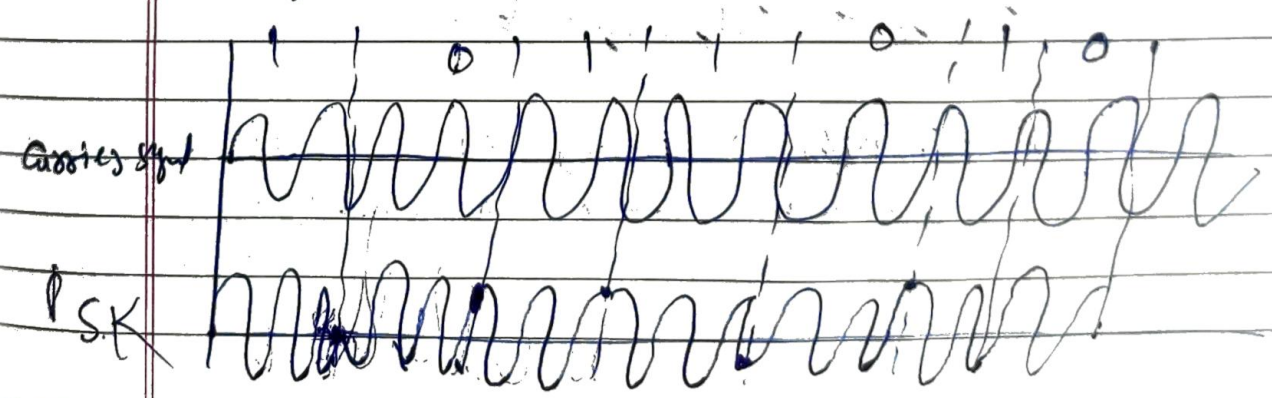
2) FSK :- Freq. of the carrier signal is varied to represent data. The freq. of modulated signal is constant for the duration of one signal element, but changes for the next signal element if the data element changes.

Both Peak and duplitud remains constant for all signal element.



1) PSK :- is represent two or more diff" signal element. Both Peak amplitude and frequency remains constant as phase changes

Today PSK is more common than ASK or FSK



PAGE NO.:
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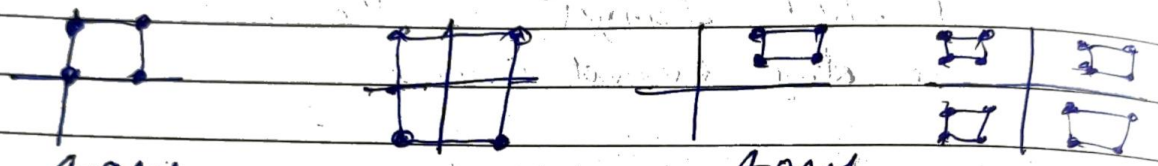
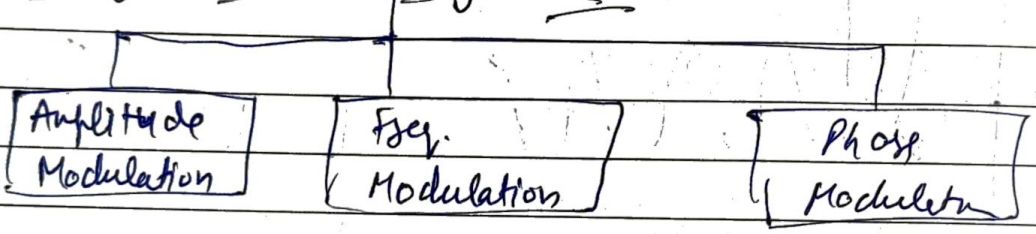
* QAM (Quadrature Amplitude Modulation)

It is combination of ASK and PSK



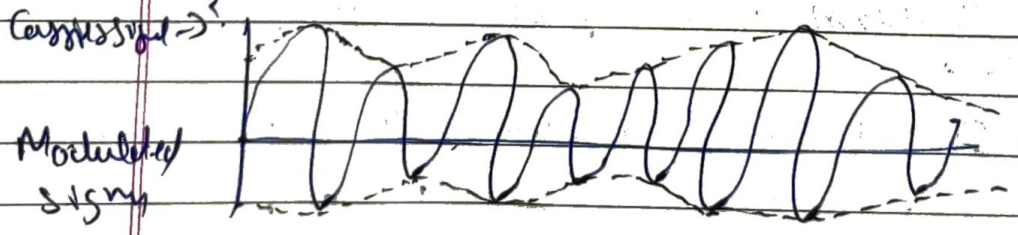
* Analog to Analog conversion



* AM (Amplitude Modulation)

While carrier signal, amplitude also changes changing

Freq. and phase remain same only amplitude changes follow variation in the info.

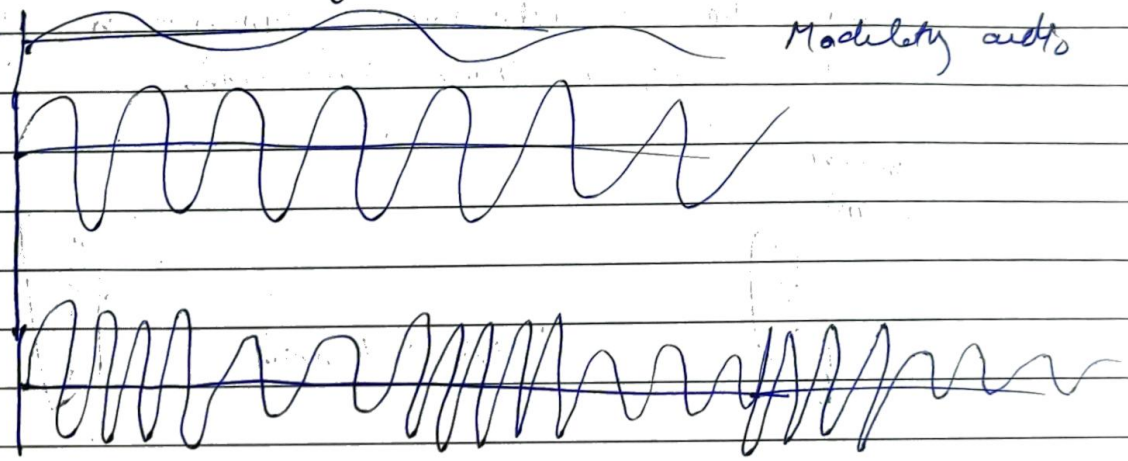


The total bandwidth req. for AM can be determined from the bandwidth of the audio signal

BAM = 2B

PAGE NO.:
DATE: / /

* FM (Freq Modulation) : in which voltage level of carrier signal is changing. Peak amplitude and phase of the carrier signal remains constant but the freq of the carrier changes correspondingly.



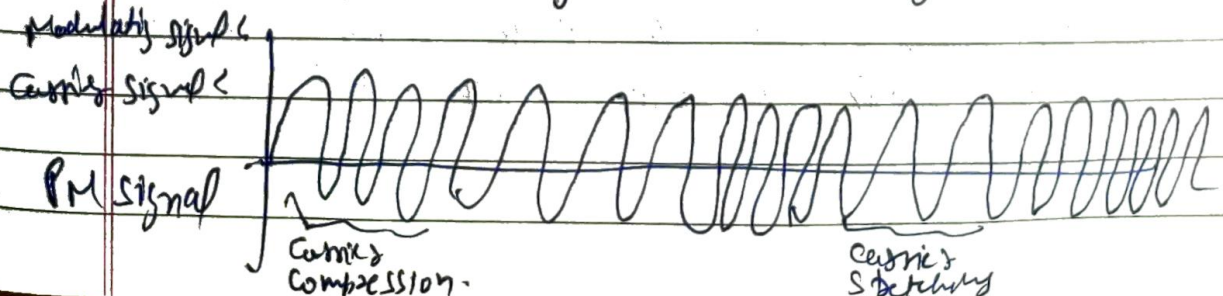
The total Bandwidth req. for FM can be determined from the bandwidth of the audio signal

$B_{FM} = 2(1 \times \beta)B$.

* Phase Modulation (PM) :-

PM is also same as FM with one difference, in FM, instantaneous change in the carrier freq. is ∝ to amplitude of modulated signal.

But in PM, it is proportional to derivative of amplitude of modulated signal.

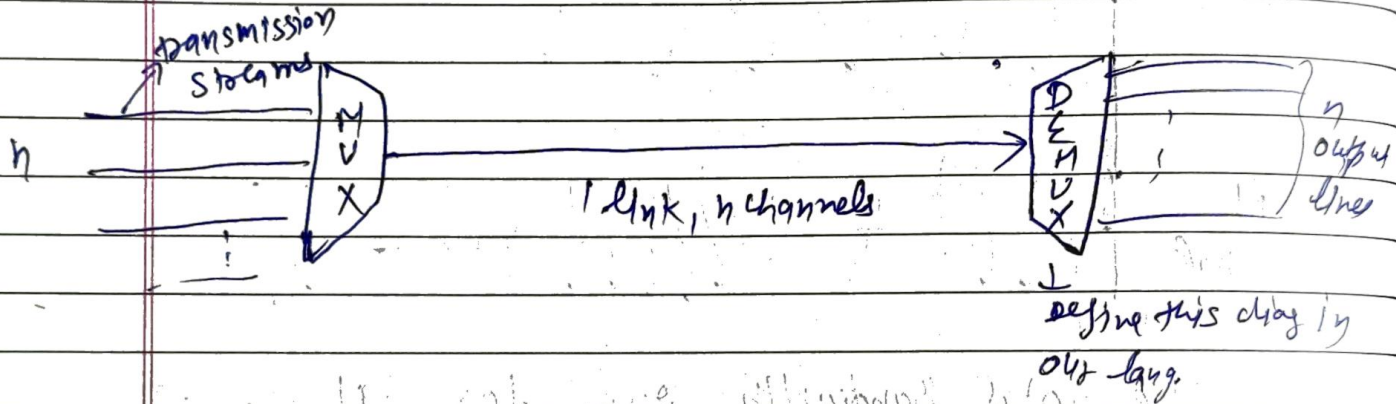


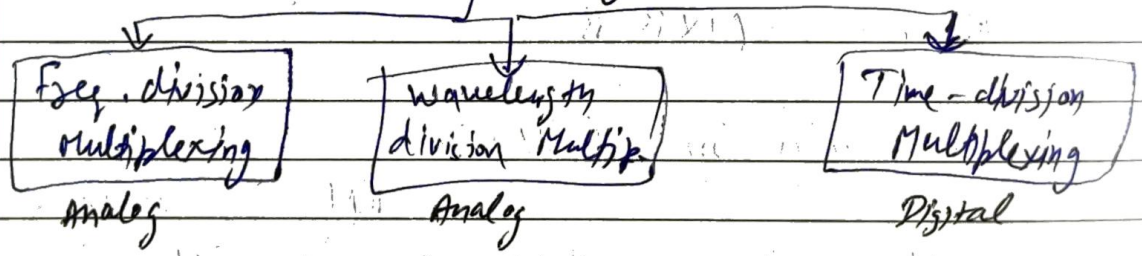
PAGE NO. :
DATE : / /

Chapter - 6

Bandwidth utilization : Multiplexing and Spectrum spreading

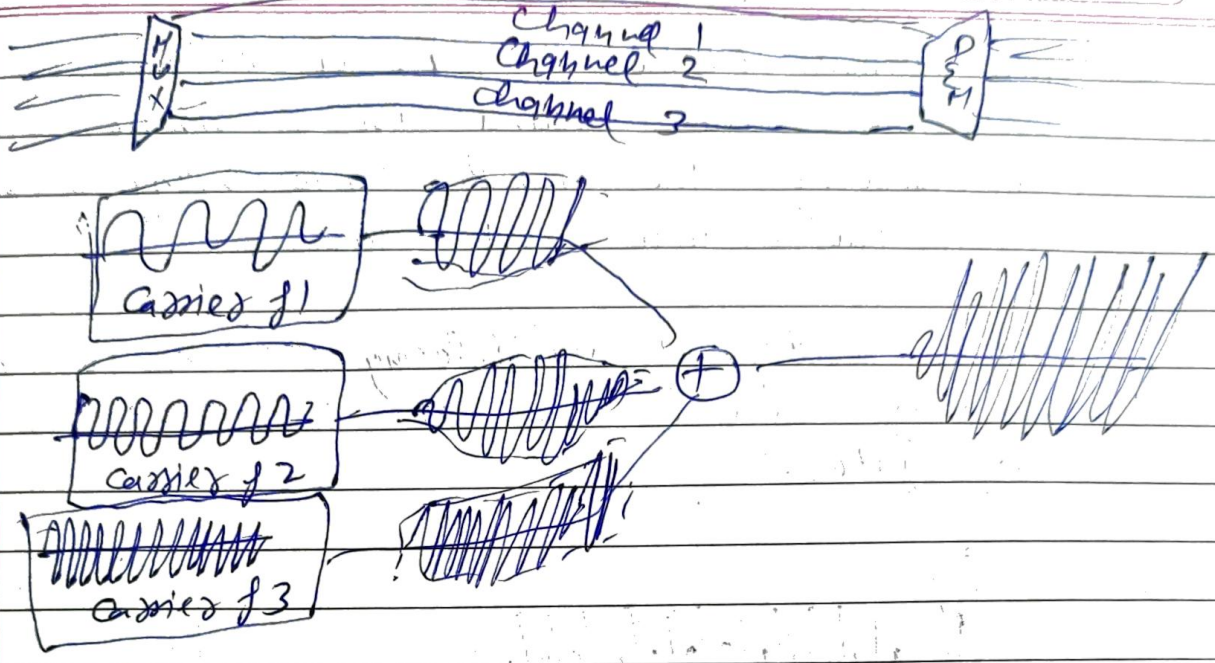
MULTIPLEXING : It is a set of technique that allows the simultaneous transmission of multiple signals across a single data link.





* **Frequency division Multiplexing :** FDM is an analog multiplexing technique that combines analog signals

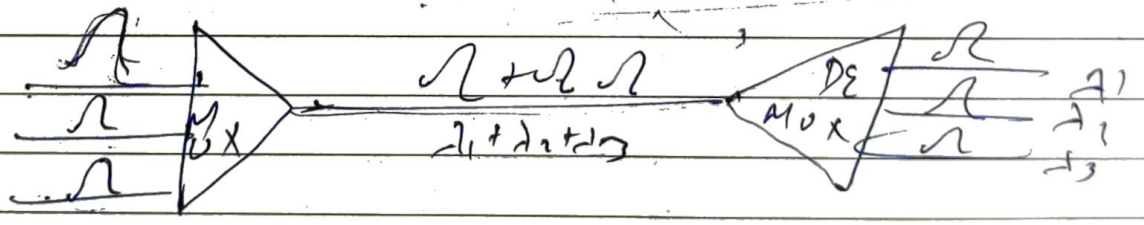
In FDM, signal generated by each sending device modulate different carrier frequencies these signal are combined in to a single composite signal that can be transported by link.



Wavelength - Division Multiplexing.

WDM is an analog multiplexing technique to combine optical signals.

- WDM is same as FDM, But in WDM Multiplexing and Demultiplexing involve optical signal transmitted through fibre-optic channels.

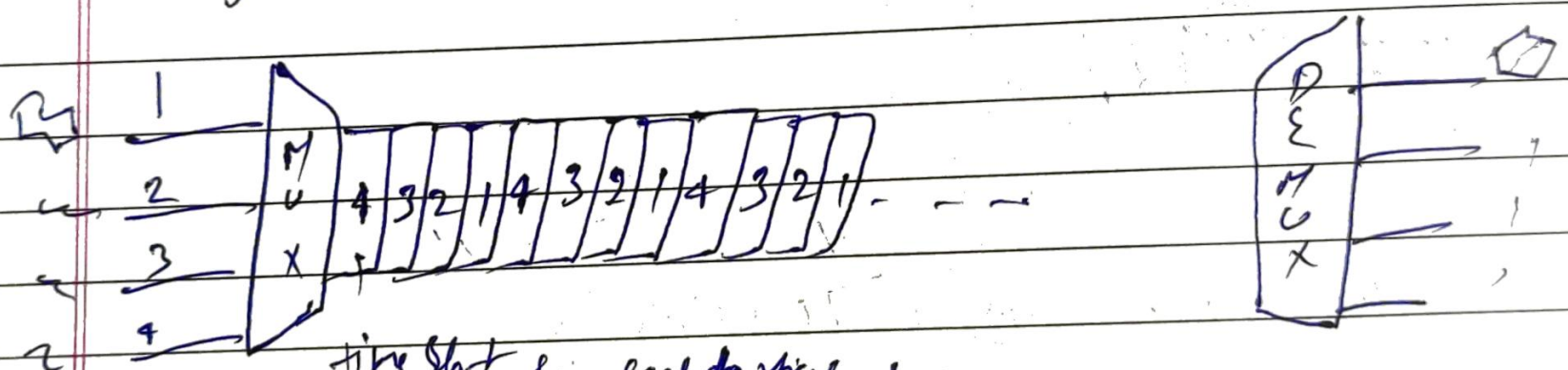


Guard-bands - to prevent signal from overlapping

PAGE NO.:
DATE: / /

* Time division Multiplexing: is a method of putting multiple data streams in a single signal by separating the signal into many segment, each having very short duration.

TDM is a digital multiplexing technique for combining several low rate channel into one high rate.

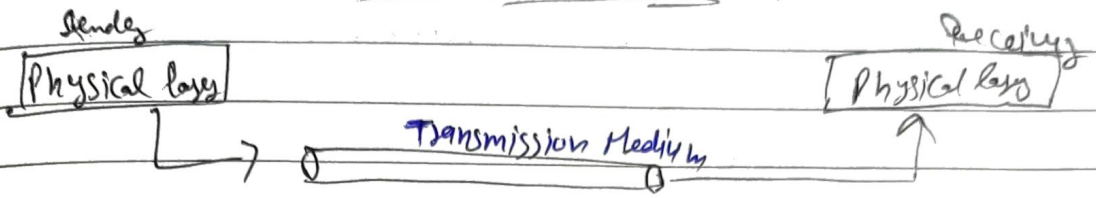


time slot for each individual device

PAGE NO. :
DATE : / /

Chapter-7

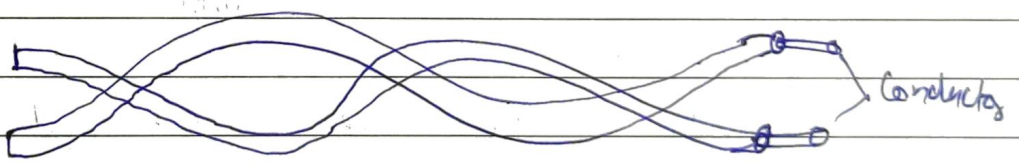
Transmission Medium



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

* **Guided Media** : which are those provide a pipeline from one device to another. Include twisted-pair cable, Coaxial cable and fibre optic cable

Twisted pair Cable : A twisted pair consist of two conductors, each with its plastic insulation, twisted together



one of wire is used to carry signals to receiver, other is used only as a ground reference

two type - UTP (↓ Unshield) STP (Shield Twisted pair ↓ Prevent noise)

Connector - UTP Connector is RJ-45 Connector. (↓ Registered Jack)

Application :

- twisted pair cables are used in telephone lines to provide voice and data channels.

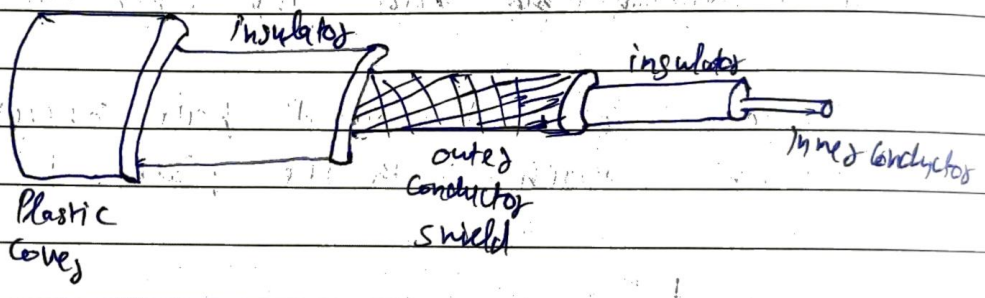
Performance: Can pass wide range of frequencies.
Per Km / above 100 KHz freq.

PAGE NO.:
DATE: / /

- The DSL lines used by telephone companies to provide high data rate connections.

2. ✗ Coaxial cable:

Coaxial Cable carries signals of higher frequency ranges than those in twisted pair Cable. Instead of two wire, Coaxial has a centre Cox Conductor of solid wire (copper enclosed in sheath which is turn, encased in an other Conductor of metal foil.



Standard Coaxial Cable ax Catagorized by their Radio Govt. (RG) rating.

Catagory	Impendence	Use
RG-59	75 Ω	Cable TV
RG-58	50 Ω	thin ethernet
RG-11	50 Ω	thick ethernet

Connector: To connect Coaxial Cable to devices, we need coaxial connector. BNC (Bayonet Neill - Concelman) Connector use to connect Coaxial.

PAGE NO. :
DATE : / /

Performance: Coaxial cable has a much higher bandwidth, the signal weakens rapidly and requires the frequent use of repeaters

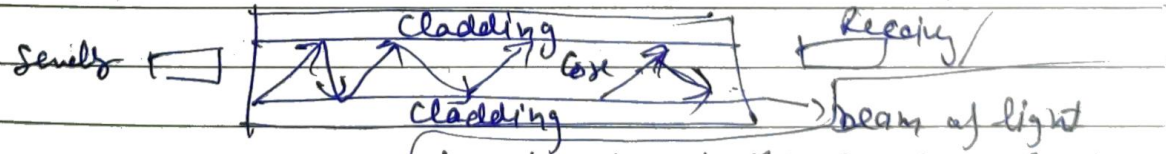
Application: Coaxial cable was widely used in analog telephone networks whereas a single coaxial network could carry 10,000 voice signals

→ Coaxial cable in telephone n/w has largely been replaced today with fibre optic cable.

3. Fibre Optic Cable:

A fibre optic cable is made of glass or plastic and transmit signals in the form of light.

Optical fibres use reflection to guide light through a channel. A glass or plastic core is surrounded by Cladding of less dense glass or plastic.



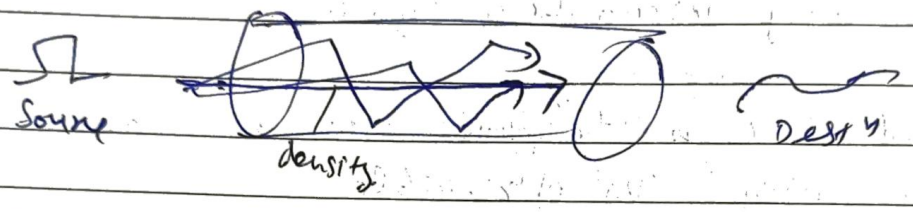
Propagation Mode

Mode
- Multimode
  - Step index
  - Graded index
- Single mode

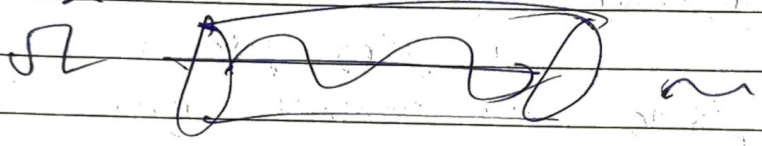
PAGE NO.:
DATE: / /

Multimode :- Multimode is so named because multiple beams from a light source move through the core in diff^{n} path.

Step index fibre :- the density of the core remains constant from the center to the edges.



Graded - decreases the distortion of signal through the cable.



→ Single mode - Smaller diameter than Multimode fibre, lower density, uses Step index fibre.

- Connectors SC (Subscriber Channel) use of TV
ST (Straight tip) used to connect n/w devices
MT-RJ - same size of RJ45

Performance - we need fewer repeaters when we use fibre-optic cable.

Applic^{n} - backbone of n/w as it is wide bandwidth is cost-effective. Today with WDM (Wavelength Division Multiplexing) we can transfer data at a rate of 1600 Gbps.

PAGE NO. :
DATE : / /

Some TV companies uses this cable.

Advantage -
- Higher bandwidth
- Less signal attenuation
- Light weight
- Creates immunity to tapping than copper cables
- Immunity to electromagnetic interference

Disadvantage
- Installation & maintainence
- Cost
- Unidirectionally light Propagation

* Unplugged Media Wireless:

1. Radiowaves : Radiowaves are the waves having the longest wavelength in the electromagnetic spectrum.

- Radio waves are usually produced by radio transmitters and can be received by radio receivers.

- Radio waves are omnidirectional. When antenna transmit radiowaves, they are propagated in all dirn.
sender can sends waves that can be received by any receiving antenna.

2) Radio waves are used for multicast communication, such as radio and television and paging system.

Application - AM and FM radio, television, Cordless phone and paging etc.

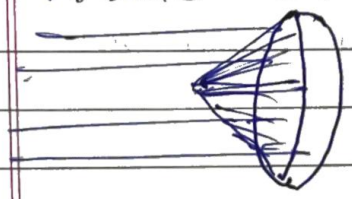
PAGE NO.:
DATE: / /

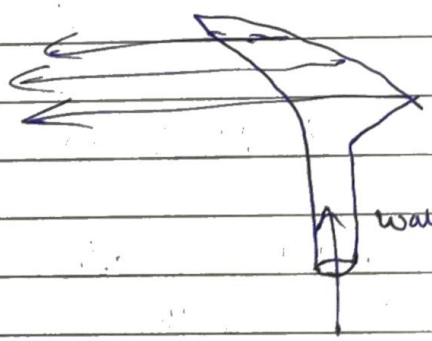
Send signal in one direction

* Microwaves: Electromagnetic waves having frequency between 1 and 300 GHz are called Microwaves.
- Microwaves are unidirectional. When antenna transmit a microwaves, then sending and receiving antennas need to be aligned.

-) Microwave can pass through glass and plastic. That is the reason why we use a plastic or glass containers in a microwave oven and not metal containers.

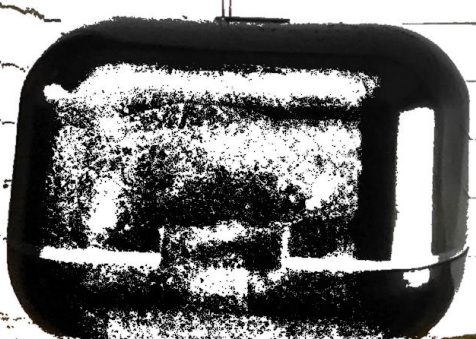
- two type of antennas are used in microwave:
1. Parabolic dish antenna
2. horn antenna





-> Microwaves are used for unicast communication such as cellular telephones, satellite networks and wireless LAN.

Application - Used in cellular phone, satellite n/w and wireless LAN.



PAGE NO. :
DATE : / /

* Infrared : It is a wireless mobile technology, used for short-range communication with freq. from 300 GHz to 400 THz

- we cannot use Infrared waves outside the building, because the Sun rays contain Infrared waves that can interfere with the communication

- useless for long range communication

Application - Infrared signals defined by IrDA transmit through line of sight, the IrDA port on the keyboard needs to point to the pc for transmission to occur. (PoA I)

→ mice, PCs and Printers

PAGE NO :
DATE : / /

Chapter - 8

Switching

Circuit | Packet | Message switching

Switching at Physical layer : Circuit switching. There is no Packet switching in Physical layer. Switches at the Physical layer allows signals to travel one path or another.

Switching at Data-Link Layer : We have packet switching in this layer. term packet in this case means frames or cells.

Switching at n/w Layer - Packet switching

Switching at App^n layer : only msg switching. Comm^n at the app^n layer occurs by exchanging msg.

* Circuit switched network : It consist of set of switches connected by physical ~~layer~~ links. A connection b/w two station is a dedicated path made of one or more links.
- each link divided in to n channels.

- In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data

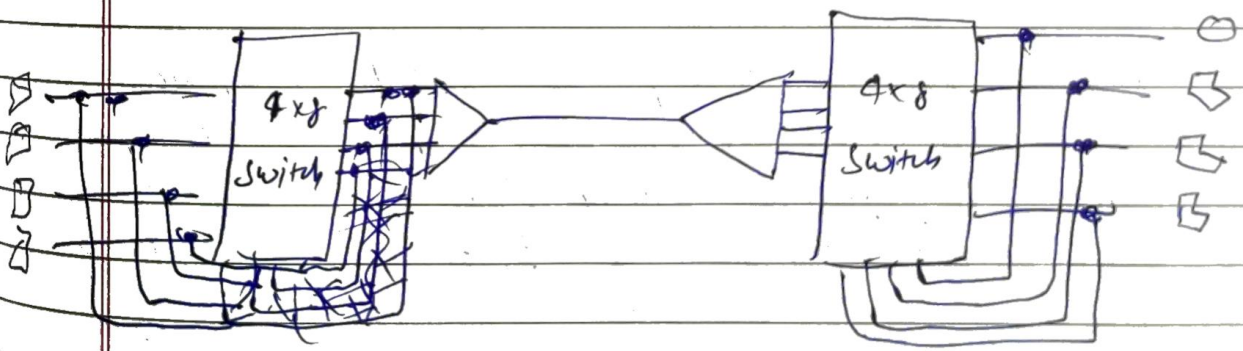
transfer until the teardown phase.

There phase

- Setup phase - Before the two parties or multiple parties can communicate, a dedicated circuit needs to be established.
The end system connected through dedicated lines to the switches, so connection setup means creating dedicated channel b/w the switches.

- Data transfer - After the establishment of dedicated circuit, two parties can transfer the data.

- Teardown phase - when one of the parties needs to disconnect, a signal is sent to each switch to release the resources.



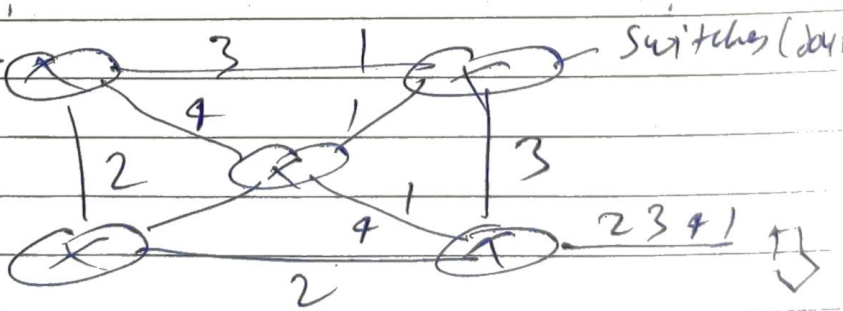
PAGE NO.:
DATE: / /

* Packet switching : the msg is going to pass through a packet-switched network, it needs to be divided in to packets of fixed. Or variable size.
- size of packet determine by the governing protocol
- there is no resource allocation for a packet. this means that no reserved bandwidth on the links, no schdule processing time for each packet.
- allocation is done basis on FCFS.
- when switch receives a packet, no matter what the source of destination is, packet must wt. if there are other packets being processed.

two type-

1) Datagram n/w : each packet treated independently of all other. Even if a packet is a part of a multipacket transmission, the n/w treats this packet alone. this approach is called datagram

2) ~~Routing~~



PAGE NO.:
DATE: / /

→ A switch in a datagram n/w uses a routing table that is based on the destination address

→ The dest^n address in the header of a packet in a datagram n/w remains the same during the entire journey of the packet

Efficiency:- datagram n/w is better than that of a circuit switched network
if there is delay for sending the packets then resources can be reallocated b/w these periods for other packets from other sources

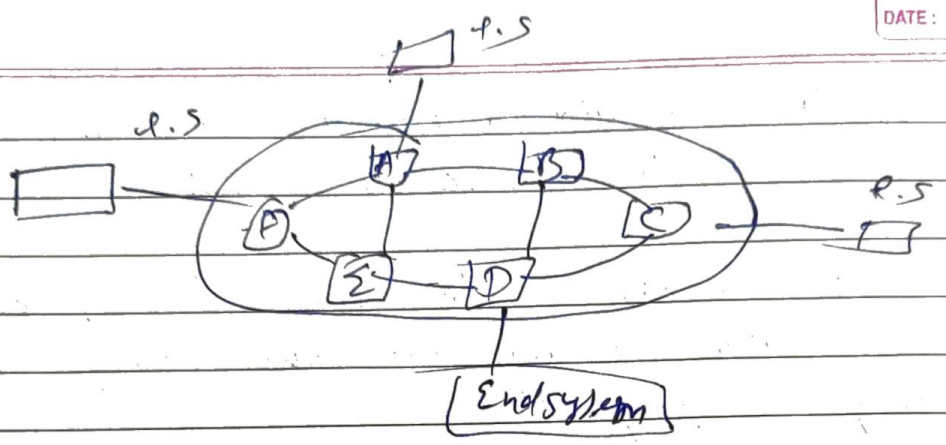
2) Virtual ~~circle~~ Circuit N/w:-

→ V.C is a cross b/w a circuit switch n/w and a datagram n/w

→ In addition data transfer phase is added
→ all packets follow same path same as circuit switch

→ V.C n/w is normally implemented in data-link layer. while circuit switch n/w is " " Physical " and datagram " " " n/w "

→ It is a connection oriented n/w
→ resources are reserve for time interval of data transm- b/w two nodes.



two type of Addressing - Global or local
↓
International level

VCI (virtual circuit identifier) - actually used for data transfer is called the VCI.

- used by a frame b/w two switches

→ data transfer phase, to transfer a frame from source to destination, all switches need to have table entry for this virtual circuit.

→ table in simplest - four columns. switch holds four pieces of info for each V.C that is already setup.

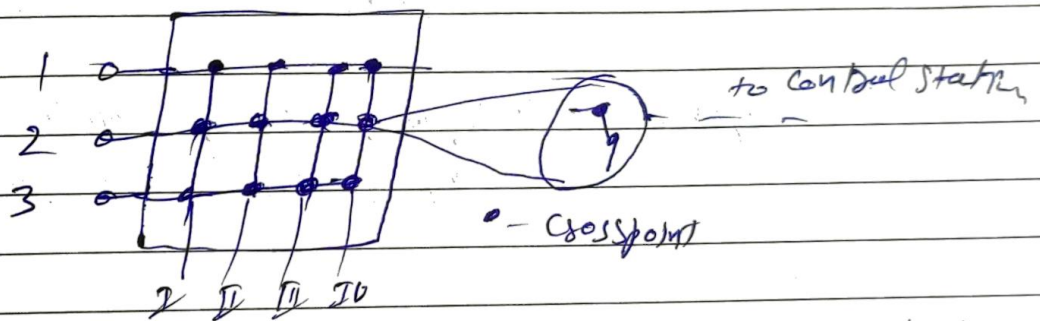
table	Incoming		outgoing	
	Port	VCI	Port	VCI
	1	14	3	22

PAGE NO.:
DATE: / /

* Structure of Switch:
We use either two technology - Space division or time division switch.

Space division switch: the path in the circuit are seperated from one another spatially.

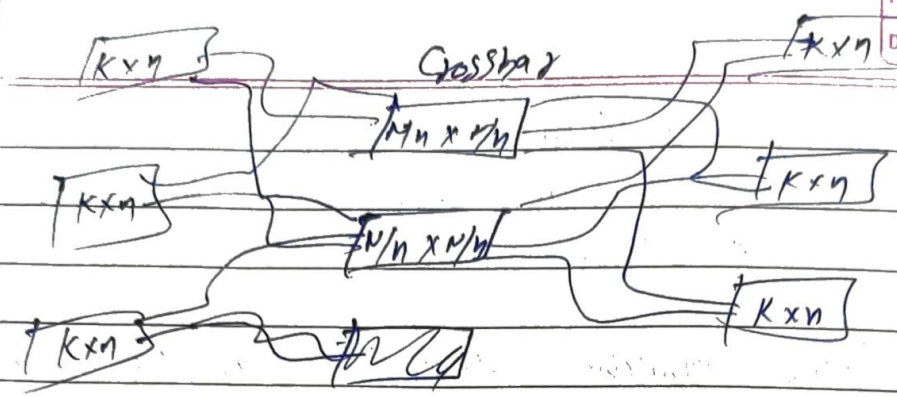
Crossbar switch: A crossbar switch connects n input to m output in a grid using electronic microswitches to each crosspoint.



disadvantage to connect 1000 input to 1000 output eg. a 1000000 switches, this is impractical. at time 25% are working rest are ideal.

Multistage switch: to solve of Crossbar switch is the Multistage switch. which combines crossbar switches in three stages.

- if we can allow multiple paths inside the switch, we can decrease the no. of crosspoint. Each crosspoint in middle stage can be accessed by multiple crosspoints in first or third stage

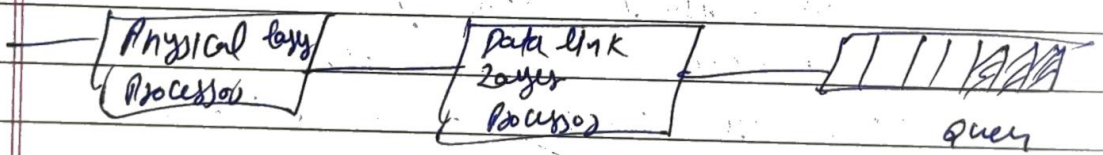


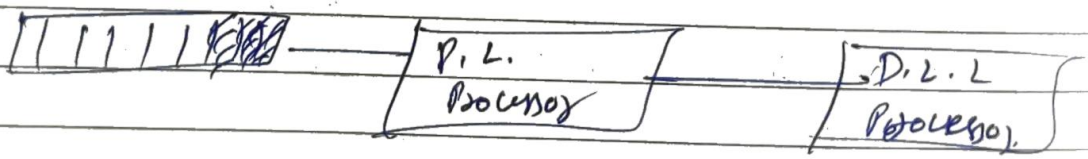
- Time division switch :- uses time-division (TDM) multiplexing inside a switch. The most popular technology is called time slot interchange (TSI)

* Structure of Packet switch

Four Component :- (1) input ports (2) output ports (3) routing processor (4) switching fabric

input Port





DBMS

PAGE NO. :
DATE : / /

* Message Switching : Msg switching is a n/w switching technique in which data is routed in its entirely from source node to destn node, one hop at a time.

- During Msg routing every intermediate switch in the n/w stores the whole msg.

→ if any of switch blocked, it stores the msg and delay the msg until resource is available for ~~act~~ effective transmission of the msg.

- Source to destn not directly connected.
- every msg include a header, which typically consist of routing info such as source, destination, ~~info~~ priority level.

PAGE NO.:
DATE: / /

Chapter-10

ERROR Detection and Correction

Types of errors

1) Single bit error: only 1 bit of given data unit is changed from 1 to 0 from 0 to 1.

2) burst error : 2 or more bits changed.

* **Redundancy** –
The central concept in detecting or correcting errors is redundancy. These redundant bits are added by the sender removed by the receiver.

1) **error detection** – we are only looking to see if any error has occured the answer is a yes or no we are not even interested in no corrupted bits

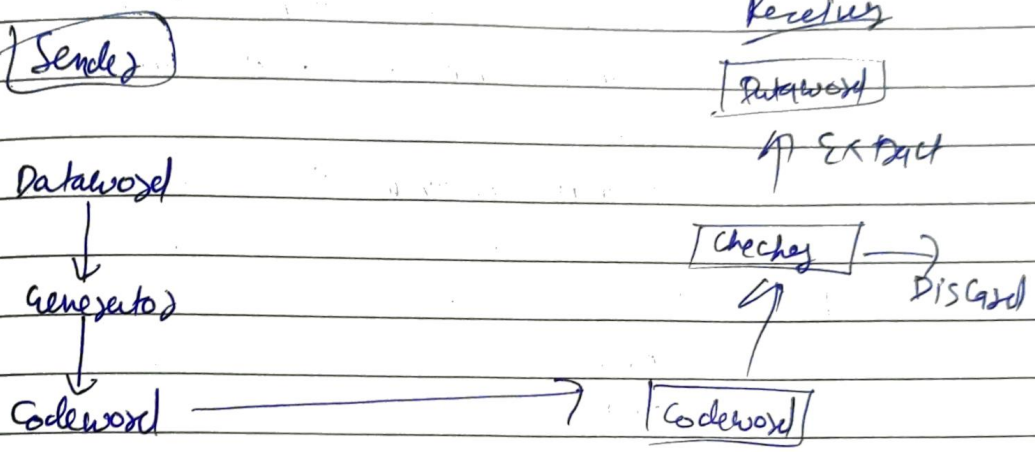
2) **error correction**: we need to know exact no. of bits that are corrupted and location in the msg. if we need to correct single error in 8 bit we need to consider 8 possible error location. You can imagine the receiver's difficulty to finding 10 errors in a data unit of 1000 bits.

error corrn" depends same as error detection but at checker it's correct not the extract and discard.

PAGE NO.:
DATE: / /

~~Block Coding~~

1) Error detection Continue:



Process of error detection in block coding

1) If no. of 1's in dataword is even then 0 added to dataword
2) If no. of 1's in dataword is odd then 1 added to dataword.

Dataword	Codeword
00	000
01	011
10	101
11	110

receiver receive 011 it check no. of 1's in dataword and redundancy bit. if it is 1 and odd no of 1's then valid codeword.

for Detection

* Hamming Distance :- Hamming distance b/w two words is the no. of diff^n b/w corresponding bits.

⇒ Hamming distance easily found if we apply XOR op^n on the two words and count no. of 1's in the result.

⇒ Note that :- Hamming distance is a value greater than zero.

H.D d(000, 011)

```
  000
  011
 ---
  011   - no. of 1's is 2   H.D is 2
```

d(1010, 11110) ⇒

```
  1010
 11110
 -----
 01011   = H.D is 3
```

* Minimum hamming distance :-

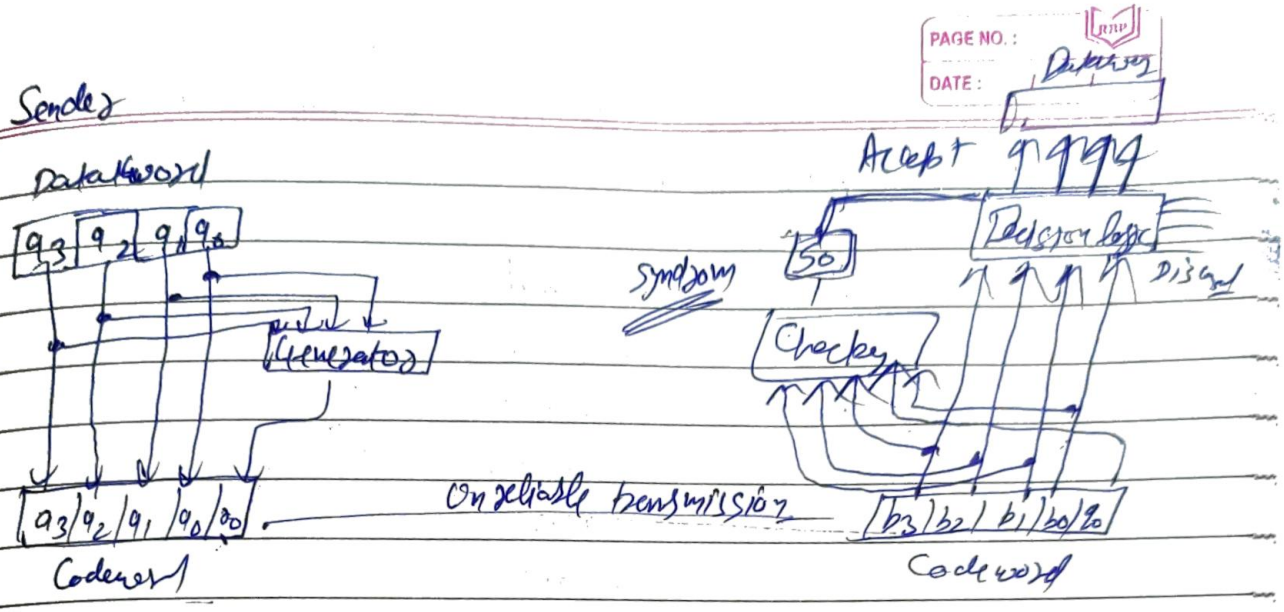
Minimum hamming distance is the smallest hamming distance b/w all possible pairs in a set of words.

Min. Ham. dis = 1 → एक bit की error detect नहीं हो पाती है।

⇒ Parity check code - same odd, even no. of 1's

⇒ Hamming Distance for correction

Min. Ham. distance is d ⇒ $\frac{(d-1)}{2}$ ⇒ कितने bits की error correct की जा सकती है।



In Senders Side Generator will Generate parity bit.

If the no of 1's is even, the result is 0, if the no of 1's is odd, the result is 1.

if syndrome value is zero, there is no detectable error, its accepted, if syndrome value is 1, there is error, its discarded.

The checker at the received does the same thing as the generator in the sender with one exception the addition is done over all 5 bit, the result is called syndrom

* CRC (Cyclic Redundancy Check) :- Use for error detection.

- Can detect all odd error, single bit, burst error of length equal to polynomial degree.

PAGE NO :
DATE : / /

total bits = (m + r) — m: no. of bits in msg, r: no. of redundant bits

Dataword	Codeword
0000	0000 000
0001	0001 011
0010	0010 110
0011	0011 101
0100	0100 111
0101	0101 100
0110	0110 001
0111	0111 010

Let Dataword = 1001 Divisor = 1011

Encode

```
        1010
1011 ) 1001 0000   <- Divident
       1011        <- r
       ----
       0100
       0000        <- leftmost bit is 0
       ----
       1000
       1011
       ----
       0011 10
       0000
       ----
        110        <- remainder
```

→ if leftmost bit is 1 simply divide by 1

→ if leftmost bit is 0 simply divide by 0

Codeword = 1001 110

parity + msg

PAGE NO. :
DATE : / /

Ready

```
        101
   ------------
1011 | 1001 | 110
       1011
       ----
        0101
        0000
        ----
        1011
        1011
        ----
        0000
        0000
        ----
        000   -> Syndrome
```

↓

Accepted

Dataword - 1001

```
        1011
   ------------
1011 | 1000 | 110
       1011
       ----
        0111
        0000
        ----
        1110
        1011
        ----
        0101   Syndrome
```

Dataword Discarded

* Polynomials :

$1\,0\,0\,0\,0\,1\,1$: 7

$x^6 + x + 1$

$1\,0\,0\,0\,0\,1\,1$

$1x^6 + 0x^5 + 0x^4 + 0x^3 + 0x^2 + 1x^1 + 1x^0$ → $x^6 + x + 1$

$1\,0\,0\,1\,1\,0\,0\,0$

$x^7 + x^4 + x^3$

$x^4 + x^3 + 1$

$1\,1\,0\,0\,1$

Dataword = 1001 divisor = 1011

1)

1001000 1011

$x^6 + x^3$ $x^3 + x + 1$

$x^3 + x$

$x^3 + x + 1$) $x^6 + x^3$

$x^6 + x^4 + x^3$

x^4

$x^4 + x^2 + x$

$x^2 + x$ → Remainder

↓

$x^6 + x^3 \mid x^2 + x$

if S(n) is zero, one or More bit Corrupted

if S(n) is zero, either

→ No bit corrupted or

→ Some bits are corrupted, but the decoder failed to detect them.

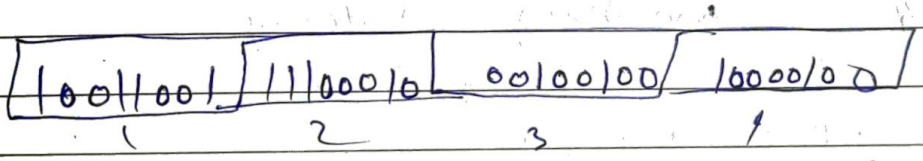
* Checksum : Checksum is an error-detecting technique that can be applied to a msg of any length.

2) In Checksum the data is divided into K segments each of m bits.

PAGE NO.:
DATE: / /

Sender	Receiver
1. The msg is divided in to 16-bit words.	1. The msg and checksum are received.
2. The value of checksum initially set to zero	2. The msg is divided in to 16 bit words
3. All words including the checksum are adding using 1's Complement.	3. All words are added using 1's complement addition
4. The sum is completed and becomes the checksum	4. The sum is completed & become the new checksum
5. The checksum is sent with the data.	5. If the value of the checksum is 0, msg accepted otherwise rejected.

Eg:-



K=4
m=8

Sender

1→ 10011001
2→ 11100010
① 01111011
→ 1
3 01111100
3→ 00100010
01000000
4→ 10000100
② 00100100
1
00101001 → sum
11010110 → checksum

All the steps are same till sum

Receiver

00100101
11010110
11111111 → 1's Comp
00000000

All values are zero of Checksum its accepted.

Chapter - 4 .. Continue here.

PAGE NO.:
DATE: /

a) Multilevel schemes - increase no of bit sent

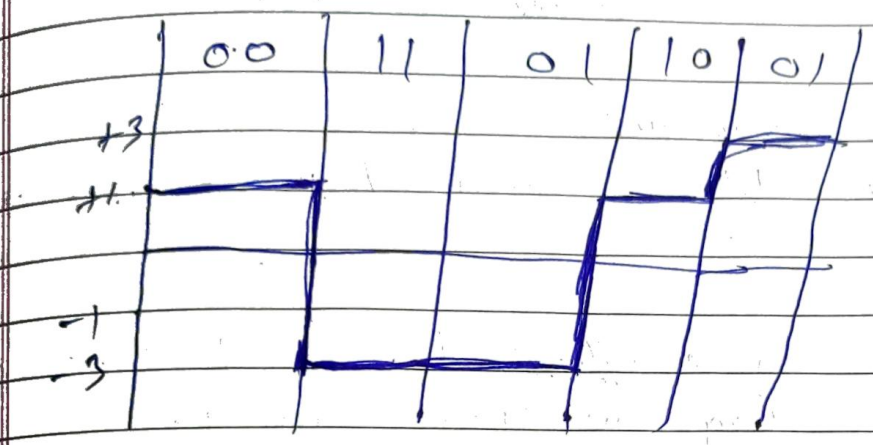
- mBnL
  - m - Length of binary pattern
  - B : Binary data
  - n - Length of signal pattern
  - L : No of levels

Letter used for number of level
- L = 2 Letter : B
- L = 3 Letter : T
- L = 4 Letter : Q

→ 2B1Q : two Binary 1 Quaternary
- 2 - Length of binary pattern
- B : Binary data
- 1 - Length of signal pattern
- Q : 4 levels.

Next bit	Next Level (Previous level +ve)	Next Level (Previous level -ve)
00	+1	-1
01	+3	-3
10	-1	+1
11	-3	+3

Data: 00|01|11|00|

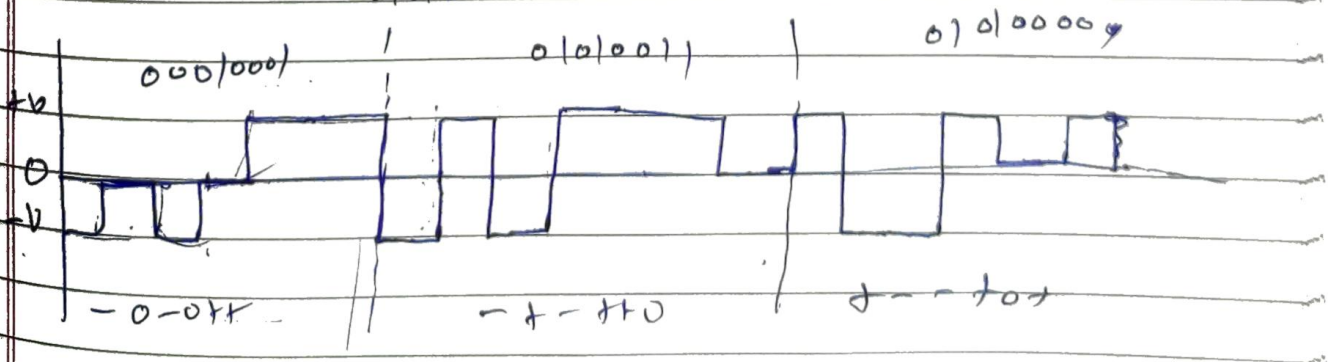


3) 8B6T (8 Binary, 6 ternary)
the idea is to encode a pattern of 8 bits (000|0001) as a pattern of 6 ternary signals (-0-0++) where the signal they have levels (-1, 0, +1).

4) Each signal pattern has a weight of 0 or +1 DC value of there is no pattern weight is -1.

Ex- Signal 1/0/0

000|0001 | -0-0++
0|0|0011 | -+-++0
0|0|0000 | +--+0+



PAGE NO. :
DATE : /

⇒ 4DPAM5 - (4 dimensional, five - level pulse amplitude modulation)

- It use 5 voltage level - -2, -1, 0, 1 and 2
- 4D means data is transmitted over four channel at same time.
- All 8 bit can be applied to channel simultaneously and sent by using one signal element.