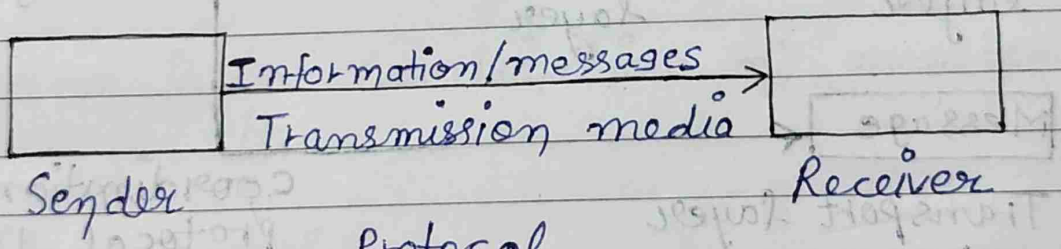
Date :

- 7 layers (OSI → open System interconnection) & TCP / IP

1. Application layer
2. presentation layer
3. Session layer
4. Transport layer
5. Network layer
6. Data link layer
7. Physical layer.

★ Two or more networks are Connected by link are Called internet.

- Data Communication
It is an exchange the information between two or more devices through the wires (fibre optics, twisted pair, Coaxial Cable)



★ Components

1) Sender
2) Receiver
3) information/ messages

Date :

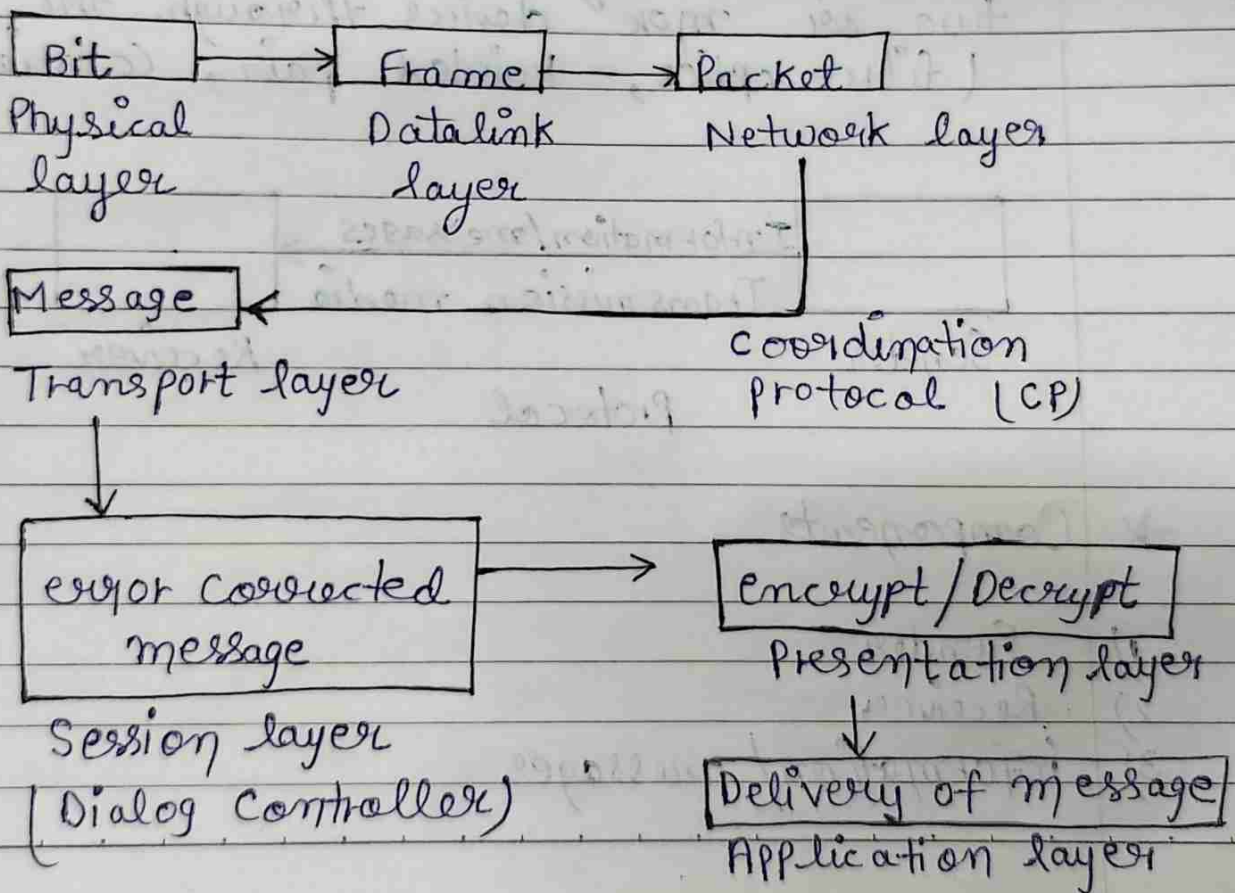
4 Transmission media
5 Protocol

★ Characteristics

1) Timely manner
2) Perfectness
3) Jitter

→ Jitter is a Variation in delay to the communication device to device

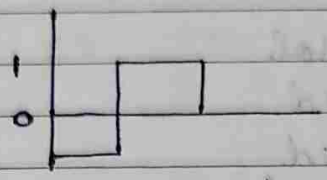
• Computer network
A Computer network is a group of networks that are connected to each other through hub, Switch, Router etc



Date :

① Physical layer

(i) Bit representation eg: [0, 1, 1, 1]



(ii) It is responsible for Transmitting the bit from one node to another node

(iii) Bit Synchronization (Bit Communication)

(iv) Security

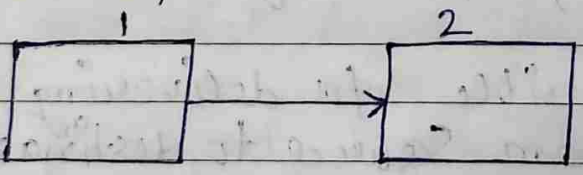
② Data link layer

(i) Frame representation

(ii) It is responsible for transmitting the frame from one node to another node

★ Frame is a combination of number of Bits

(iii) flow control



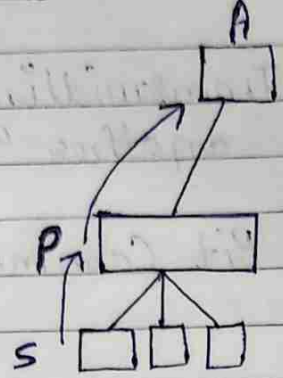
(0, 1, 1, 1, 0, 0, 0) ⟶ Same Value

flow control is a set of procedures to restrict

Date :

the amount of data when it receives by the receiver and they need acknowledgement.

4 Access Control
- Role based
- Rule based



5- error control
To control the errors
1) CRC (Cyclic redundancy check)
2) Parity check

(3) Network layer

(i) Packet representation
→ Packet is combination of number of pins

(ii) It is responsible for delivering of Packet from Source to destination

(iii) IP addressing (32 bit)
range (0-255)
Ex- 127.0.0.1, 197.1.1.1 4 octet (8)

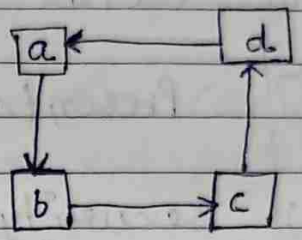
Date :

For IP address there is a 5 class

A - 0-127
B - 128-191
C - 192-223
D - 224-239
E - 240-255

(iv) Routing

Name	path
a	→ b
b	→ c
c	→ d
d	→ a



④ Transport layer

(i) Message Representation
(ii) It is responsible for the messages from one process to another process

(iii) flow control

Q- flow control is the function of datalink layer & Transport layer. Why?

→ In data link layer frame is transmitting from one node to another node. In transport layer the messages are delivering from one process to another process

Date :

(iv) Socket (It is the combination of IP address & port no.)

(5) Session layer

(i) Dialogue Controller (mistakes)
(ii) Synchronization (client → server)
(iii) error correction of messages

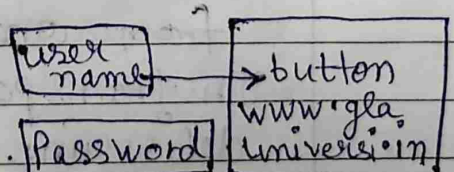
(6) Presentation layer

(i) security
(ii) encryption & Decryption
(iii) Maintain the connection (between client & server)
(iv) The format of Data
(v) No protocols are there

(7) Application layer

(i) It is responsible for services (completed message like text, audio, numerical, Video etc) from one user to another user

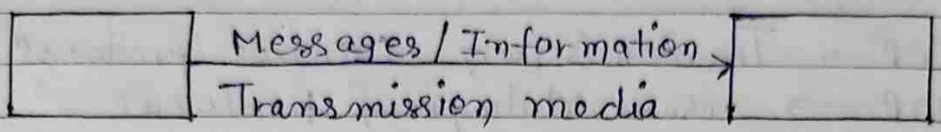
(ii) Remote login → TELNET
(iii) file transfer → FTP
(iv) use WWW → HTTP
↓ give information
↓ take information



Date :

Protocols

Protocol



(fibre optics, coaxial cable, twisted pair)

→ Protocol is a set of Rules that governs the data communication

→ Without protocols Data connection can be possible but communication not possible

layers which contain protocols

1. Physical → NIL
2. Datalink → ethernet
3. Network → Address Resolution protocol (ARP)
   → IP (Internet protocol)
   RARP → Reverse address Resolution protocol
   ICMP → Internet control message protocol
   LSRP → Link State Routing protocol
   DVRP → Distance vector Routing protocol
   RIP → Routing information protocol
   BGP → Border gateway protocol
   OSPF → open Shortest path fast

Date :

4 Transport layer

TCP → Transmission Control protocol
UDP → user datagram protocol

5 Session layer - NIL
6 Presentation layer - NIL
7 Application layer -

FTP - file transfer protocol
SMTP - Simple mail transfer protocol
DHCP - Dynamic host Configuration protocol
TELNET - Telecommunication Network
HTTP - hyper text transfer protocol
DNS - Domain name system
(DNS) - Domain name server

Firewall (that operates on Application layer)

TFTP - Trivial file transfer protocol

Ques What is difference between HTTP & WWW
HTTP getting information from WWW and WWW providing information to all

- Network Technologies Based on Scale

1) LAN - A LAN (Local area network) is a computer network that interconnects Computers within a limited area such as a residence, School, laboratory, university campus or office building

2) WAN - A WAN (Wide area network) is a type of network that spans over a large geographical area, often covering cities, countries or even continents. It is used to connect multiple smaller networks, such as Local area networks (LANs) or Metropolitan area Networks (MANs) across vast distances.

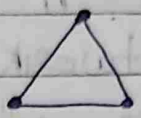
3 MAN - A MAN (Metropolitan area network) is a type of Network that spans a larger geographic area than a Local area network (LAN) but is smaller than a wide area network (WAN). Typically, a MAN covers a city or a large campus, connecting multiple LANs within that area.

4 PAN - A PAN (Personal area network) is a small network used for communication among personal devices such as computers, smartphones, tablets and wearable devices within a short range, typically within a few meters.

5 VPN - A VPN (Virtual private network) is a technology that creates a secure and encrypted connection over a less secure network such as the internet. It allows users to send and receive data as if their devices were directly connected to a private network, enhancing privacy and security.

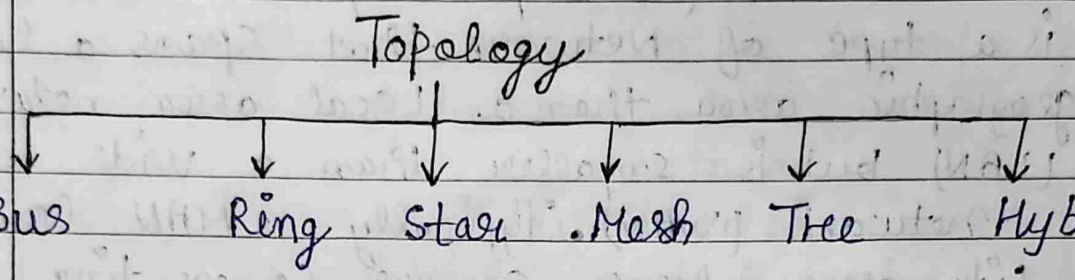
Date : _____

• Topology

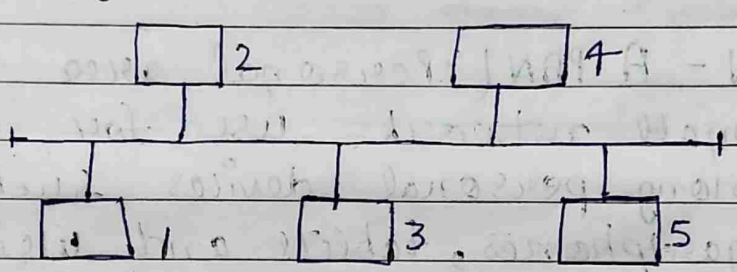


Two or more lines form a topology.

Topology is a graphical representation of nodes that the information exchanges between one node to another node.



1) Bus topology



→ It is less expensive
→ only one long cable is there
→ all devices connected to this long cable

★ All devices connected to a single long cable is called bus topology.

Advantages

1) Less expensive
2) Easy to remove / add the node
3) Required only a cable

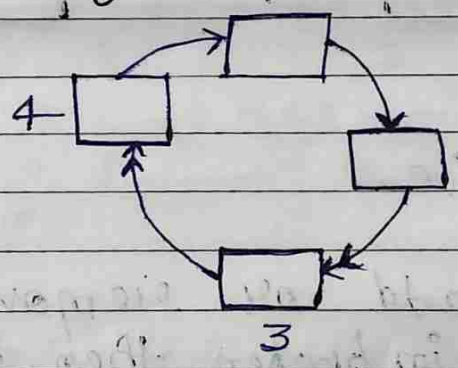
Date :

4) Broadcast messages to all the devices

Unicast → one to one Communication
Broadcast → one to many Communication
Multicast → many to many Communication

Disadvantages
1) if the cable is broken then all the devices are fail to communicate
2) Security not provided
3) length of cable is limited.

2) Ring topology



for solution
Dual ring

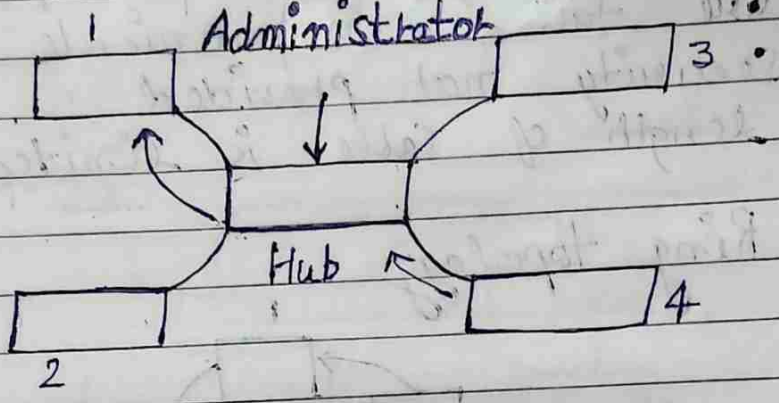
Advantages
1) less cabling
2) It forms a strong network
3) Broadcast messages
4) Transmission rate of Data is very fast (data fast transfer)
5) Dedicated point to point link.

Date :

Disadvantages

1) Security protection
2) if the link is broken then all the devices are failed to communicate
   Solution → dual ring
3) very difficult to installation
4) It is very difficult to add or remove the node.

3) Star topology



Advantage

1) less expensive
2) Security
3) easy to add or remove
4) if the link is broken then no effect all other devices they can easily transmission to each other.

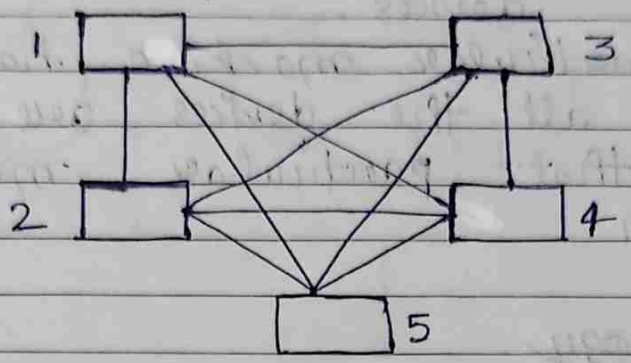
Disadvantage

1) To require the hub
2) if hub is failed then stops all the transmission.

Date :

3) if one device communicate to other device then first communicate to hub so it takes more time

4) Mesh topology



Ques Suppose you are the LLA student you want to find the link if no. of computers in your labs are 63 find the link.

$$= \frac{n(n-1)}{2} = \frac{63(63-1)}{2}$$

$$= \frac{63 \times 62^{31}}{2_1} = 1953$$

Advantage

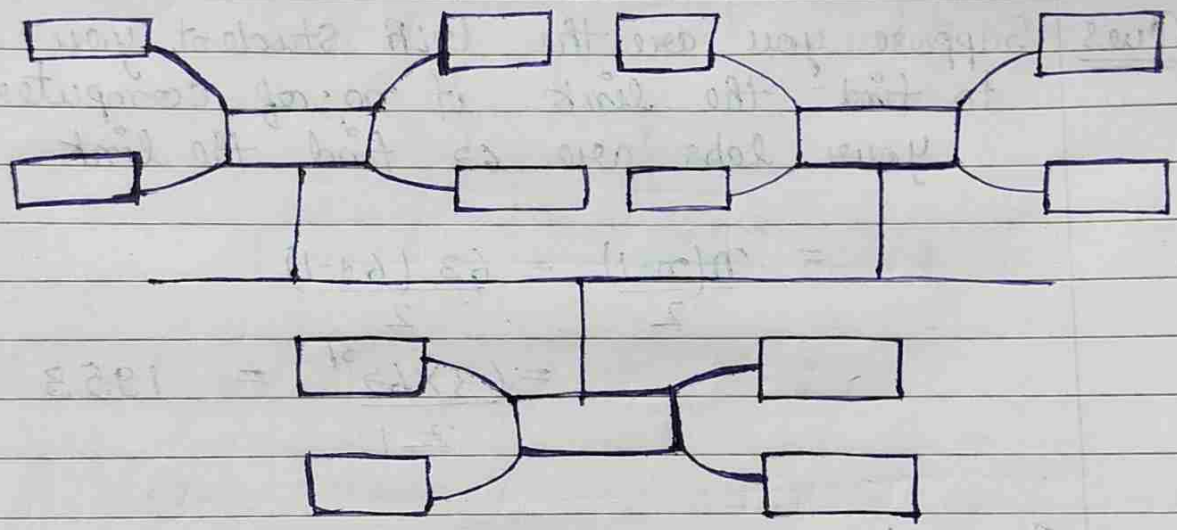
1) It has dedicated point to point links so, it creates strong network
2) Provide security
3) Multiple devices can send the data simultaneously
4) if the link is failed, then no effect to all other devices.

Date :

disadvantage

1) Very expensive because no. of wires more Required.
2) It is difficult to add or remove the devices.
3) if a particular machine has a problem, then all the devices are not knowing about that particular machine.

5) Tree topology



→ it is the combination of bus and star topology.

Advantage

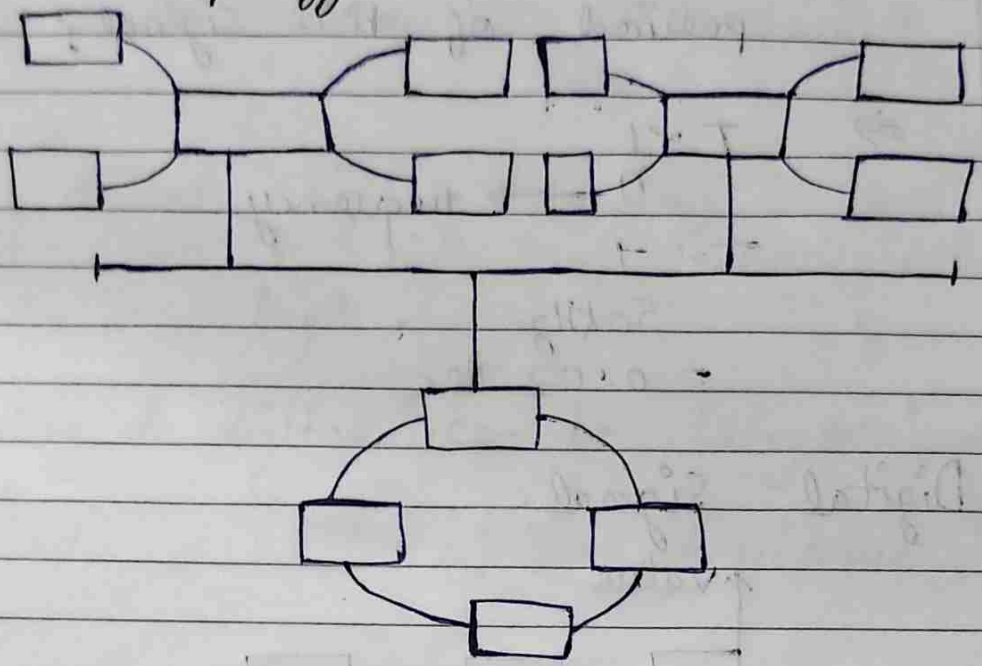
1) Performance is high
2) More Security

Date :

disadvantage

1) More expensive
2) Difficult to reconfiguration

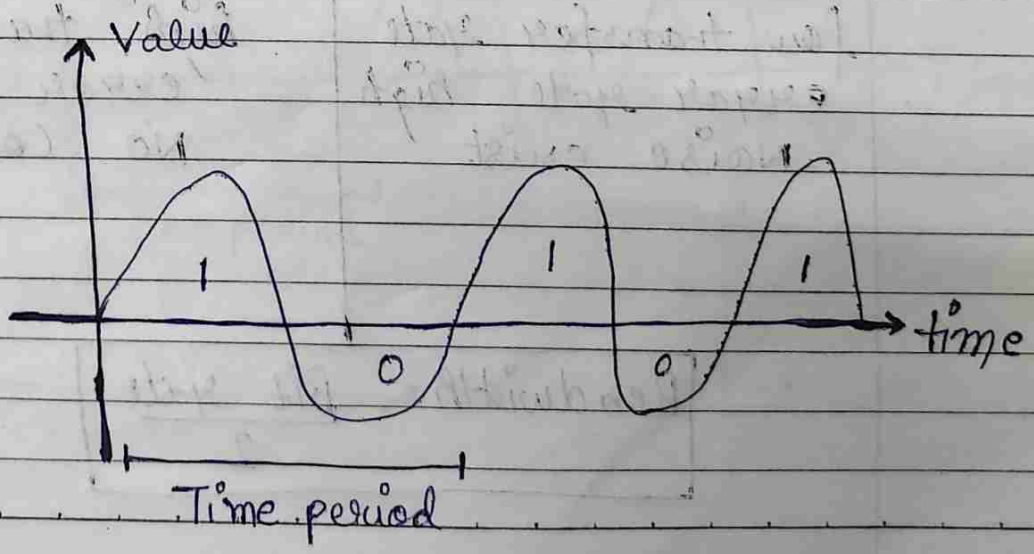
6) Hybrid topology



→ It is Combination of bus, star, Ring topology.

- Analog Signal

It is a signal where we communicate from 0 to ∞



Date :

When two cycle completed the process is called time period.

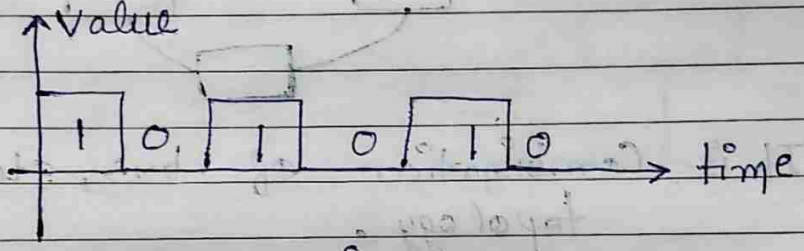
Ques Suppose 50 kHz signal sends from Sender to receiver then what is the time period of this signal?

$\Rightarrow T \propto \frac{1}{n}$ → frequency

$T = \frac{1}{50\text{kHz}}$

$= 0.02$ sec

- Digital Signal



Range from 0 to 1

Analog	Digital
low Bandwidth	high Bandwidth
low transfer rate	high transfer rate
error rate high	error rate low
Noise exist	No concept of noise

$$\text{Bandwidth} = \frac{\text{Bit rate}}{2}$$

Date :

Bit rate → No. of Bit per second

Bit rate $\propto \frac{1}{n}$ → Frequency

★ In analog signal frequency is more then Bit rate slow so, Bendwidth also low.

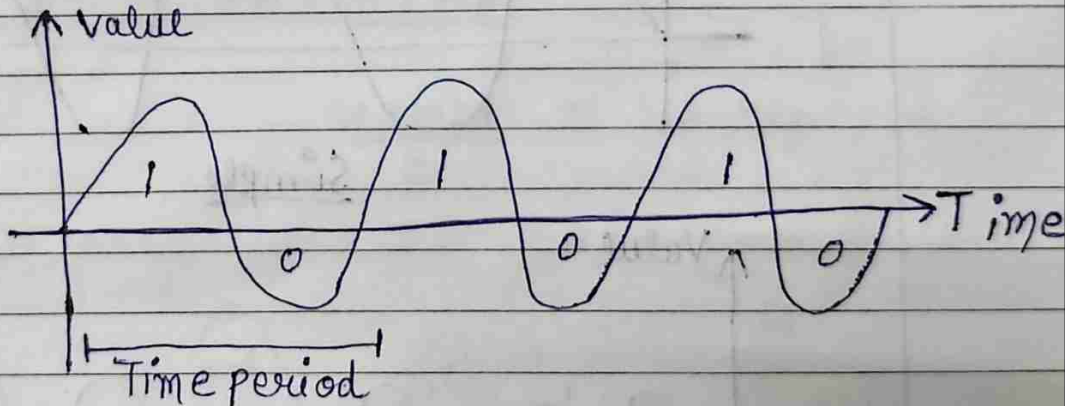
★ In digital Signal Frequency is less then Bit rate is high so, Bendwidth also high.

• Analog & digital Signal can be Categorized-

1) Periodic 2) Non-Periodic

Periodic

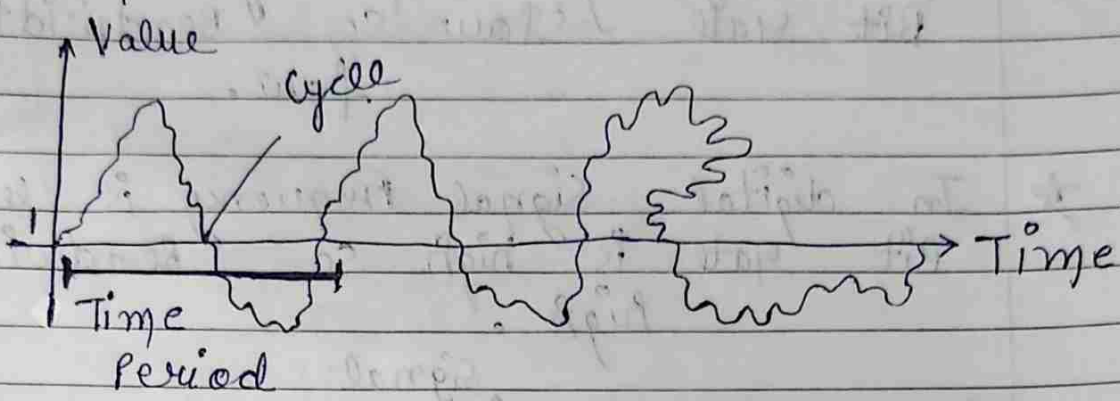
1) Complete time period
2) Repeated Pattern



Date :

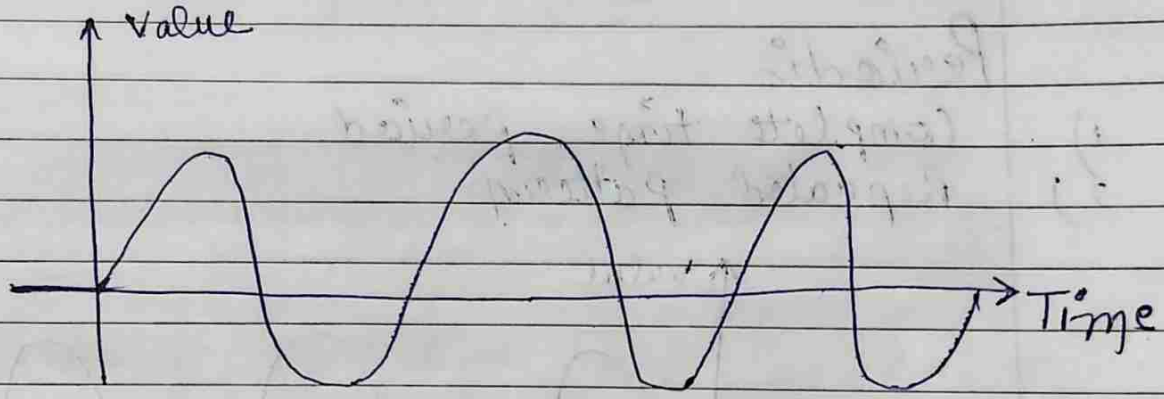
Non - periodic

1) Completed the time period
2) Non Repeat the signal from one period to another

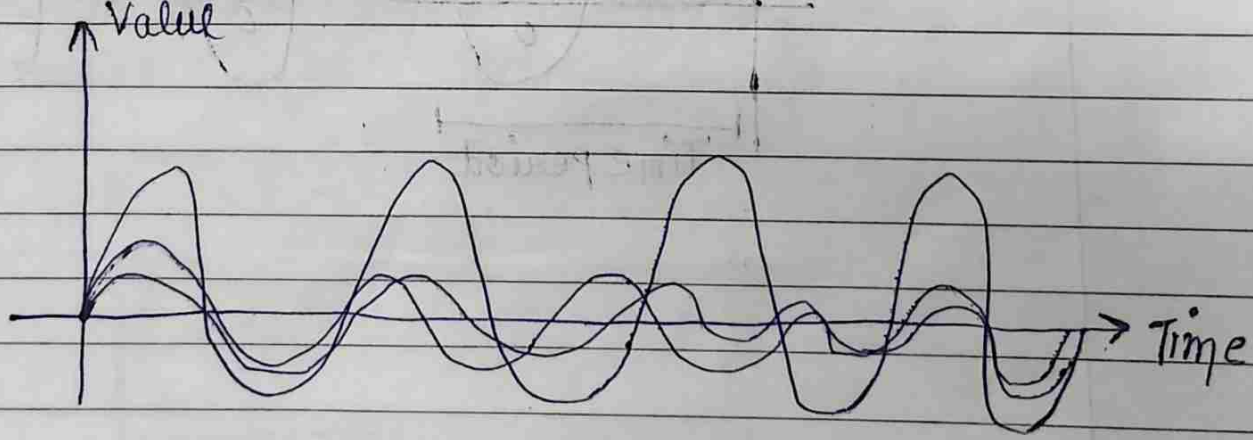


Periodic and Non - periodic have two parts -

→ Simple
→ Composite



Simple



Composite → Combination of sine Wave
Noise will be created in Composite

Ques why Composite Signal required?

→ A single frequency sine wave is not useful in data communication. We need to send a composite signal, a signal made of many simple sine waves because that implies that we are repeating the same word or words with exactly the same tone.

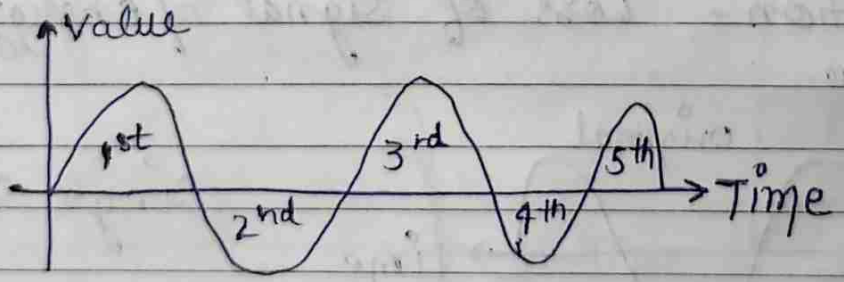
Ques What is the Required bandwidth of fourfast channel if we need to send 1 Mbps by using Baseband transmission.

1 Mbps = 1024 Kilobyte

1st Cycle

$$\text{Bandwidth} = \frac{\text{Bit rate}}{2}$$

$$= \frac{1 \times 1024}{2} = 512 \text{ KHz}$$



Date :

3rd Cycle

$$\text{Bandwidth} = \frac{\text{Bit rate}}{2}$$

$$= \frac{3 \times 1024}{2}$$

$$= 1536 \text{ KHz}$$

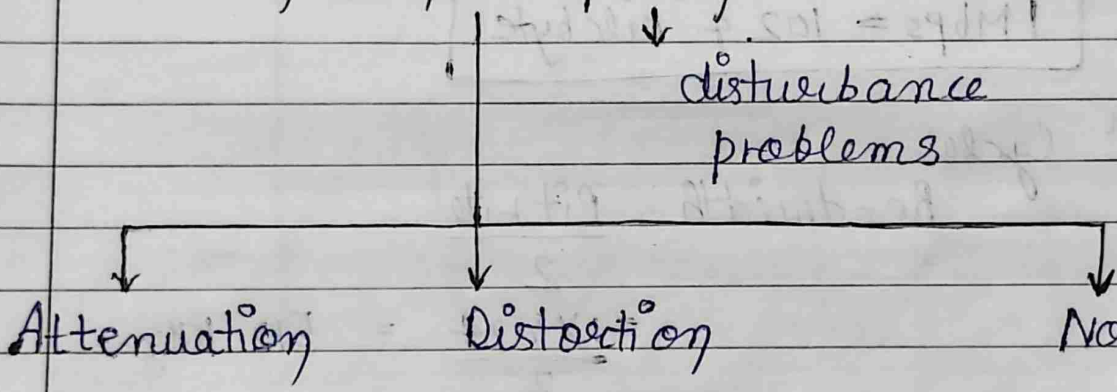
5th Cycle

$$\text{Bandwidth} = \frac{\text{Bit rate}}{2}$$

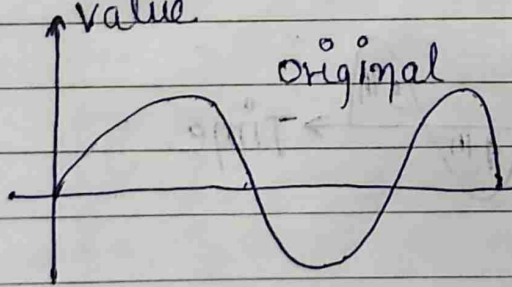
$$= \frac{5 \times 1024}{2}$$

$$= 2560 \text{ KHz}$$

- Transmission Impairment



1) Attenuation - Loss of signal / energy



Date :

3rd cycle

$$\text{Bandwidth} = \frac{\text{Bit rate}}{2}$$

$$= \frac{3 \times 1024}{2}$$

$$= 1536 \text{ KHz}$$

5th cycle

$$\text{Bandwidth} = \frac{\text{Bit rate}}{2}$$

$$= \frac{5 \times 1024}{2}$$

$$= 2560 \text{ KHz}$$

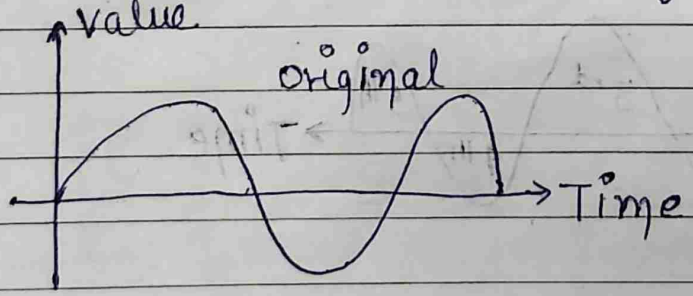
- Transmission Impairment

↓

disturbance problems

Attenuation | Distortion | Noise

1) Attenuation - Loss of signal / energy



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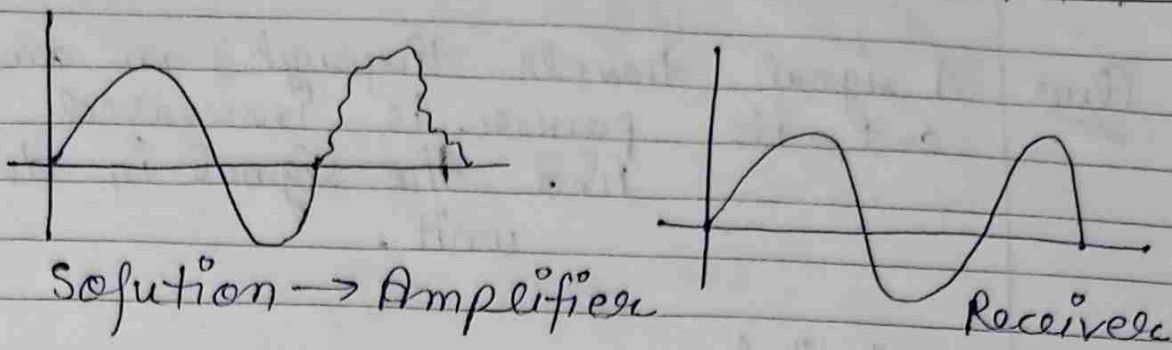
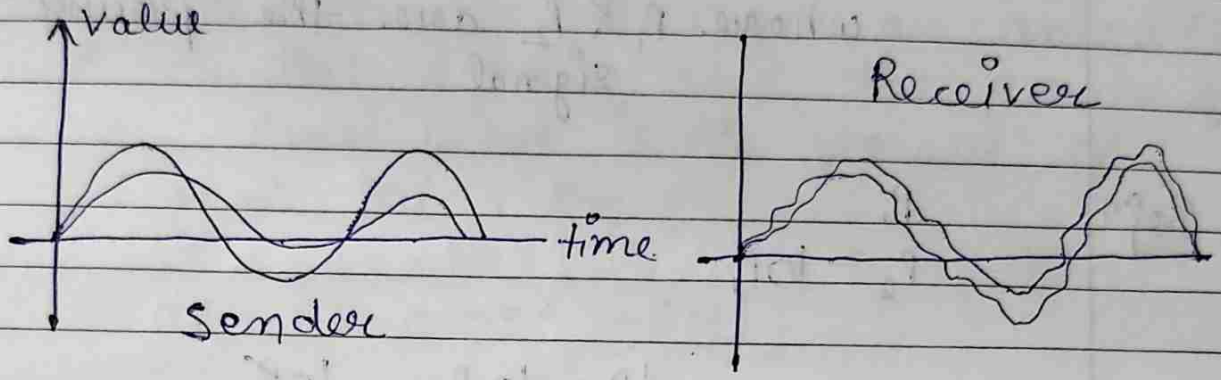


Solution → Amplifier

Receiver

2) Distortion - The signal changes from its original shape or form.

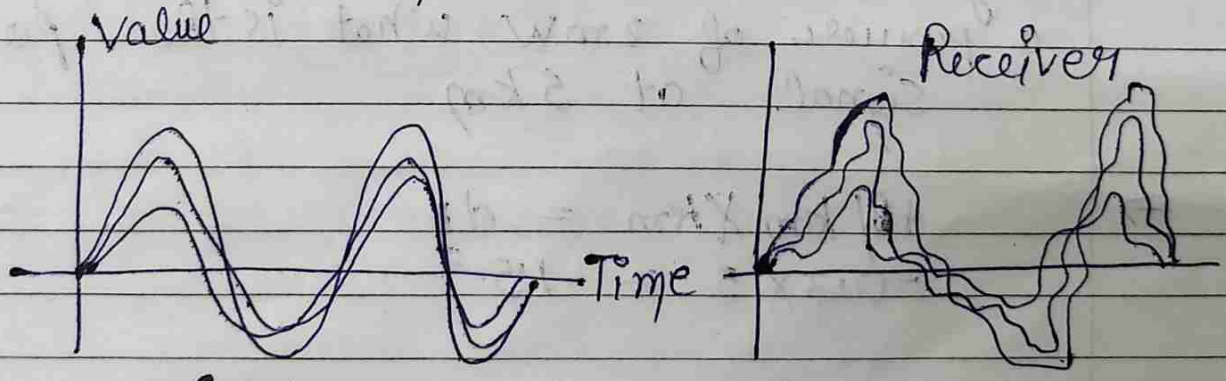


Composite signal
(2 signal)

No solution

3) Noise

It is also another cause of impairment so it changes from original shape to another form



More than 2 Signals
Composite signal

Date :

Ques A signal travels through an amplifier and its power is increased 10 times. Find the signal in decibal unit.

decibal

$$dB = 10 \log_{10} \frac{P_2}{P_1}$$

where P_1 & P_2 are the power of signal

Soln

P_1

$P_2 = 10P_1$

$$dB = 10 \log_{10} \frac{10P_1}{P_1}$$

$\boxed{\log_{10} 10 = 1}$

$$dB = 10 \times 1$$

$$\boxed{dB = 10}$$

Ques The loss in a cable is usually define in a dB per km if the signal at the beginning of the cable with (−0.3) db/km has a power of 2mW what is the power of signal at 5 km

→

$$dB/km \times km = dB$$

$$-0.3 \times 5 = -1.5$$

$$-1.5 = 10 \log_{10} \frac{P_2}{P_1}$$

Date :

$$\log_{10}\frac{P_2}{P_1} = \frac{-1.5}{10} = -0.15$$

$$\frac{P_2}{P_1} = 10^{-0.15}$$

$$P_2 = 2 \times 10^{-0.15}$$

$$\boxed{P_2 = 1.4\ mW}$$

Ques The signal travels through an amplifier with -0.09 dB/km and the power of signal 5mW what is the power of signal at 11 km ?

→ $$dB = 11 \times -0.09 = -0.99$$

$$-0.99 = 10 \log_{10}\frac{P_2}{P_1}$$

$$\log_{10}\frac{P_2}{P_1} = \frac{-0.99}{10} = -0.099$$

$$\frac{P_2}{P_1} = 10^{-0.099}$$

$$P_2 = 5 \times 10^{-0.099}$$

$$\boxed{P_2 = 3.98\ mW}$$

Date :

- TCP/IP Model
  ↓ Internet protocol
  ↓
  Transmission control protocol

There are four layers in this model-

(Session, presentation, Application)	Application layer
(Transport layer)	Transport layer
(Network layer)	Internet layer
(Physical + data link)	Network interface layer

- Nyquist Bit rate (Transmission impairment)

→ To minimize the transmission impairment we can use nyquist bit rate.

$$\text{Bit rate} = 2 \times \text{Bend Width} \times \log_2 L$$

where 'L' is the signal

Ques We need to send 265 Kbps over a noiseless channel with a Bendwidth of 20 kHz. How many signal level do we need?

Date :

1 Kbps = 1000 bps
1 KHz = 1000 Hz

Bit rate = 265 Kbps X 1000 = 265 000 bps
Bandwidth = 20 KHz X 1000 = 20 000 Hz
L = ?

Bit rate = 2X Bandwidth X $\log_2 L$
$265000 = 2X\ 20000\ X \log_2 L$
$\frac{265}{40} = \log_2 L$
$6.625 = \log_2 L$
$L = 2^{6.625}$
L = 98.70 Levels

- Shannon Capacity → Bit rate (1944)

To minimize transmission impairment which is better than Nyquist bit rate

$$C = B \times \log_2 (1 + SNR)$$

C → Capacity
B → Bandwidth
SNR → signal Noise Ratio

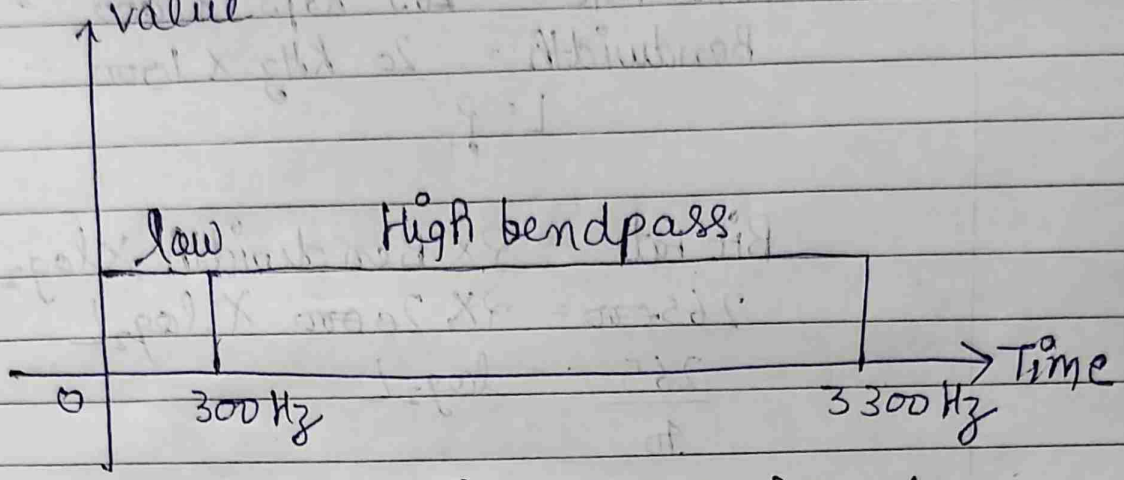
Ques find the highest Bit rate of telephone which has nominally bandwidth of 3000 Hz (300 Hz to 3300 Hz)

300 Hz → low band pass (f_1)
3300 Hz → high band pass (f_h)

Date :

$B = f_H - f_1$

assign for data communication and the SNR is 3162



$B = 3300 - 300 = 3000$ Hz

$C = B \times \log_2 (1 + SNR)$

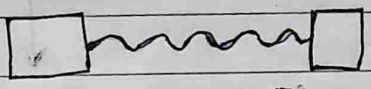
$C = 3000 \times \log_2 (1 + 3162)$

$C = 3000 \times \log_2 \times 3163$

$C = 3000 \times 11.627$

$C = 34,881$ bps

- **Through put = Bendwidth X no. of Bits**



How fast sent the data through a network from one device to another device with correctly same data

Date :

Ques A network bendwidth 10 Mbps can pass 12 000 frames / minutes with each frame Carrying 10000 bits what is throughput

→ Throughput = Bendwidth X No. of Bits

$$= \frac{10 \times 10^6 \times 12000 \times 10000}{1.60}$$

$$= 2000\,0000 \times 10^6$$

$$= 2 \times 10^{13}$$

$$= 2 \times 10^6 \times 10^7$$

$$= 2 \times 10^7 \text{ Mbps}$$

$1 \text{ Mbps} = 10^3 \text{ Kbps} = 10^6 \text{ bps}$

- propogation time

$$\text{propogation time} = \frac{\text{Distance (s)}}{\text{propogation speed (v)}}$$

- Latency

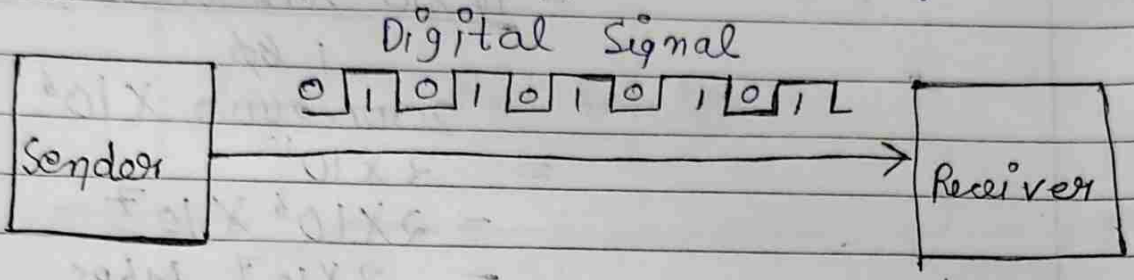
Latency = propogation time + Transmission time + queuing time + processing delay

Date :

Line Coding

[0, 1, 0, 1, 1, 1, 0, 0] → original data

Binary data ⟶ digital Signal



- Line coding is a technique Converting from binary data to digital signal if you want to get the original data you must to decode at the Receiver's side and obvious get this binary data

Line coding

→ Unipolar
→ Polar
→ Bipolar

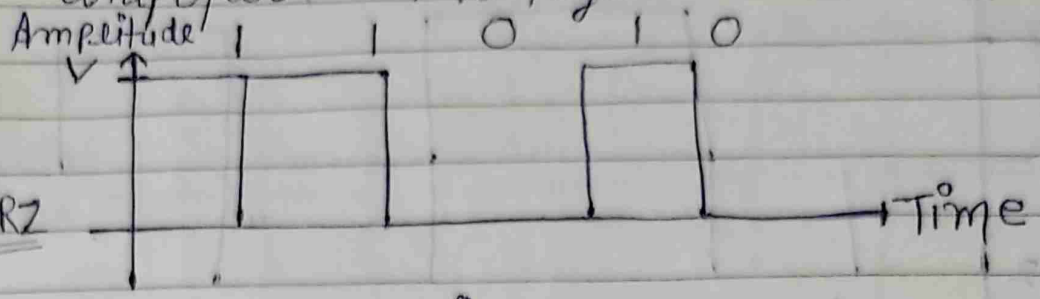
★ In unipolar → NRZ (Non-Return to zero)
→ RZ (Return to zero)

★ In polar → NRZ → NRZ-L (Level)
→ NRZ-I (Inverted)
→ RZ

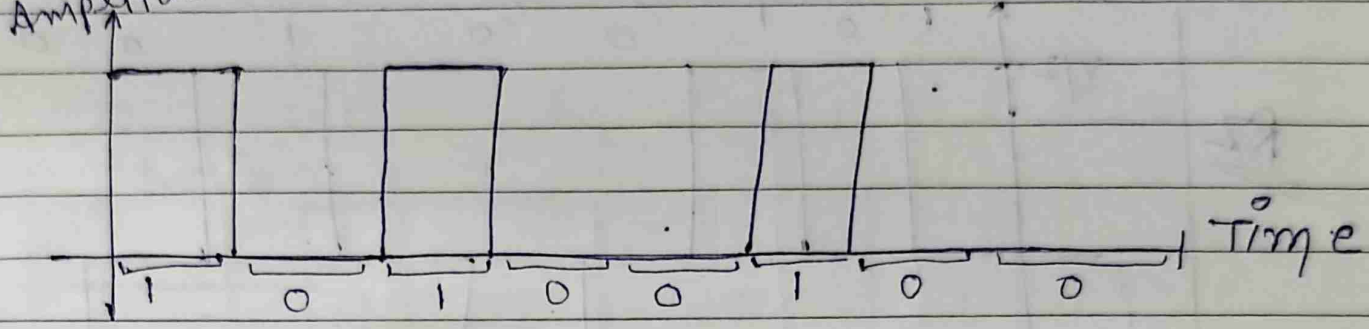
★ In Bipolar → Manchester
→ Differential Manchester
↓
not in syllabus

Date :

- Unipolar → 1 Voltage

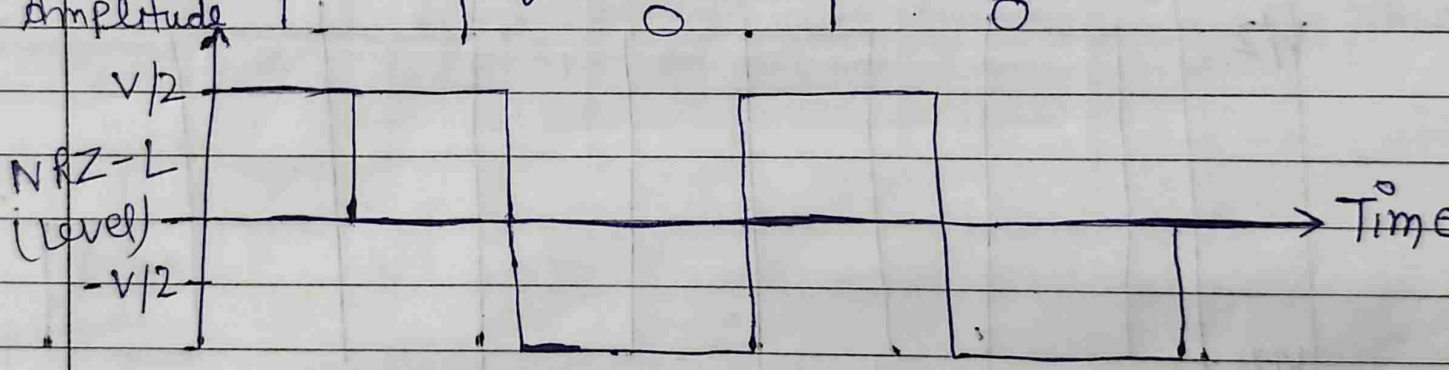


When 1 there is change when 0 there is no change in NRZ (Non Return to zero)



when simultaneously two cycle one hub is change one is same and zero as it is in RZ (Return to zero)

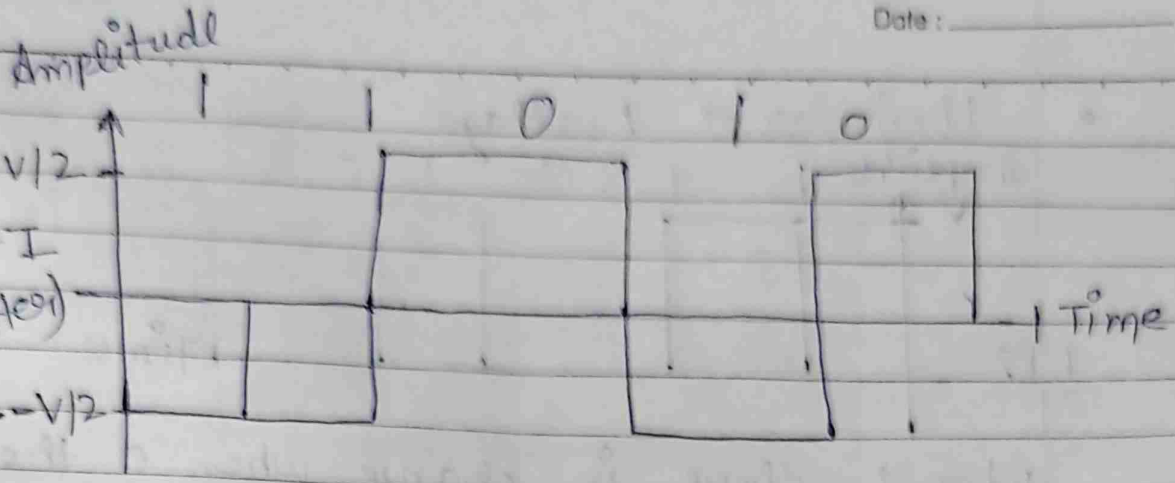
- Polar → 2 Voltage

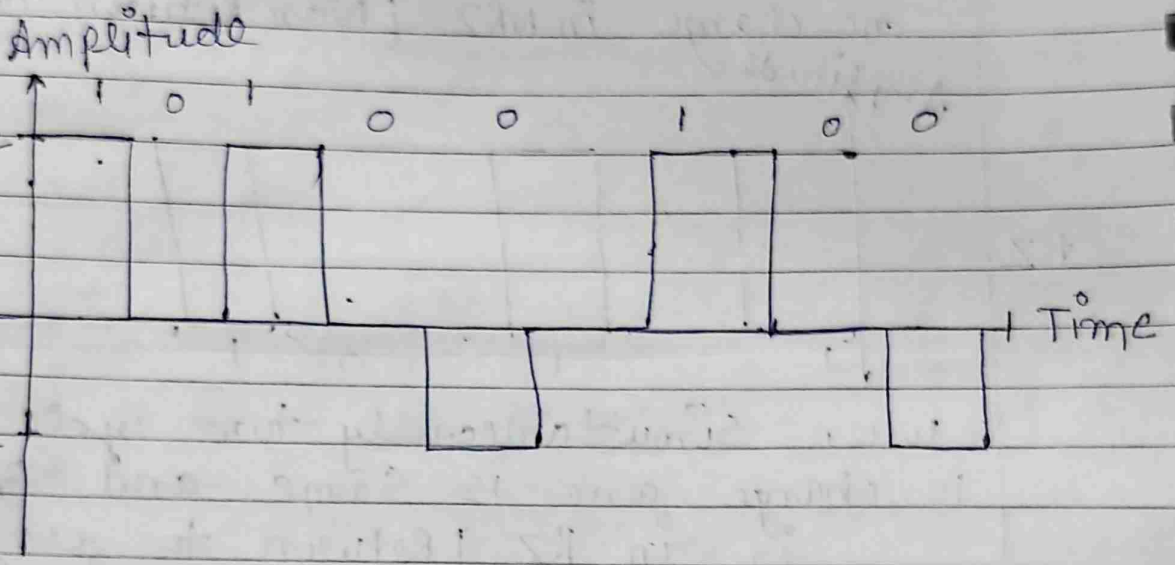


1 → +ve

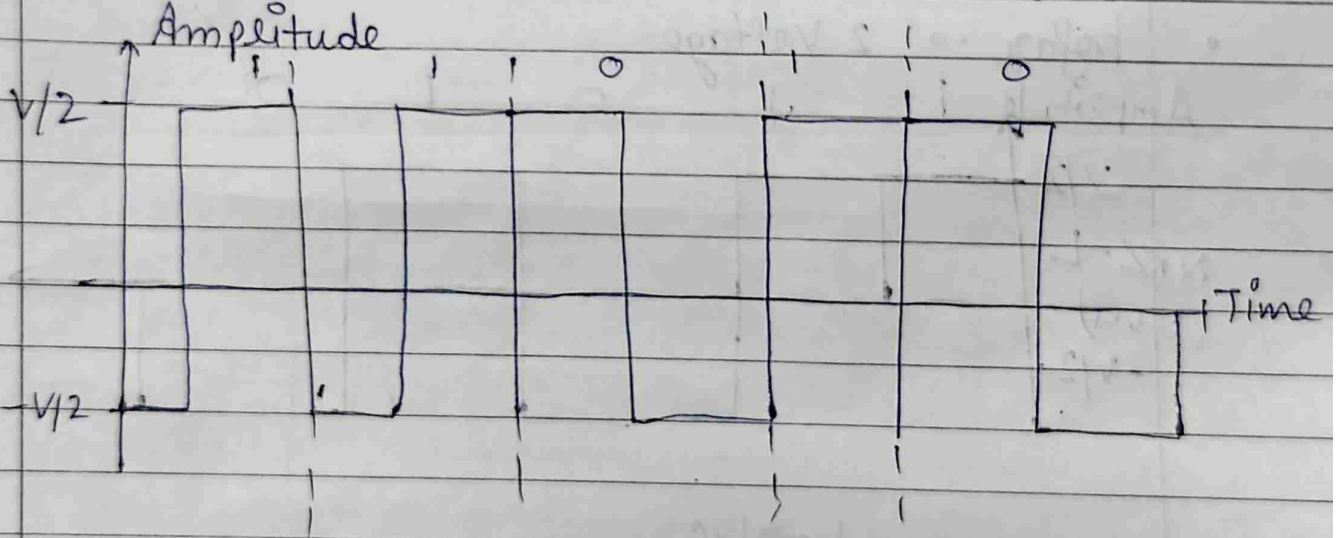
0 → -ve

Date :





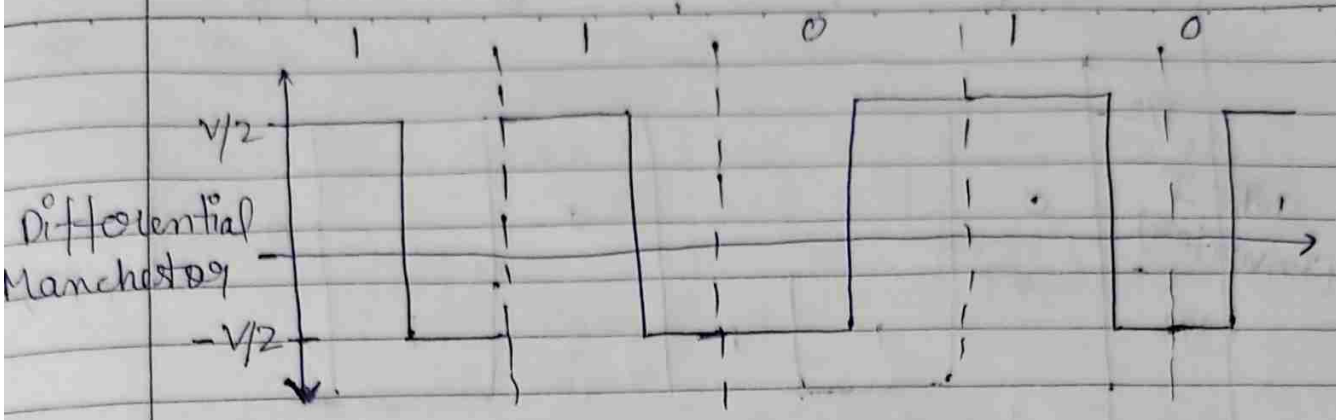
Polar → Manchester



1 → down to up

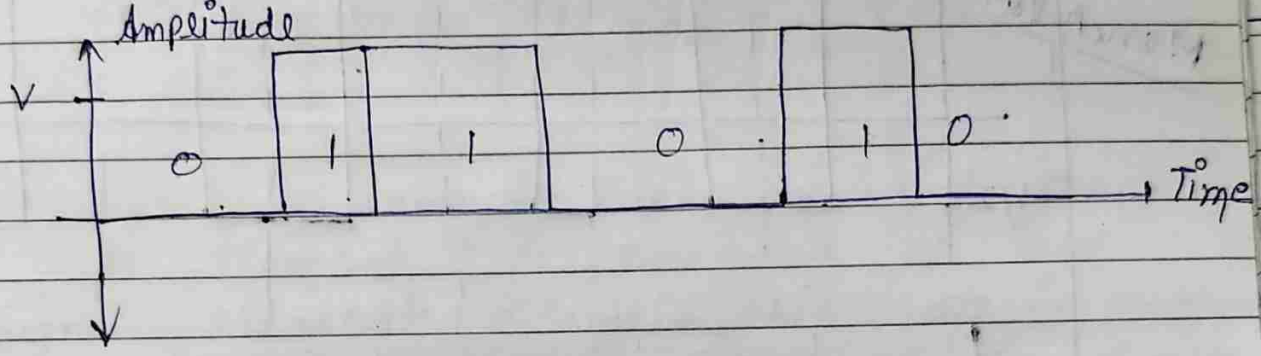
0 → up to down

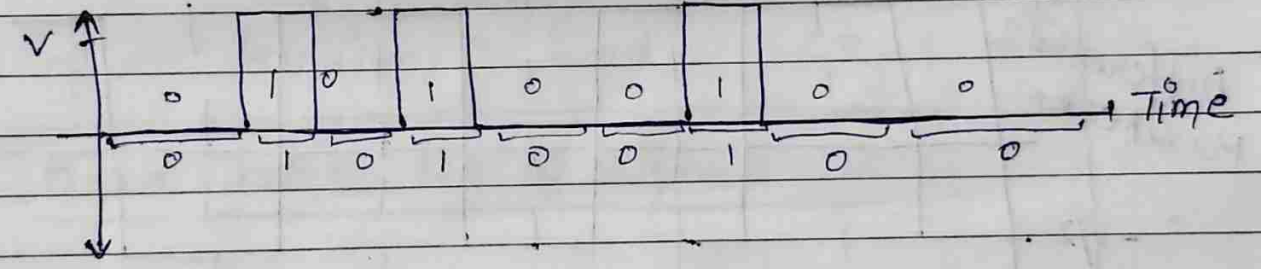
Date :



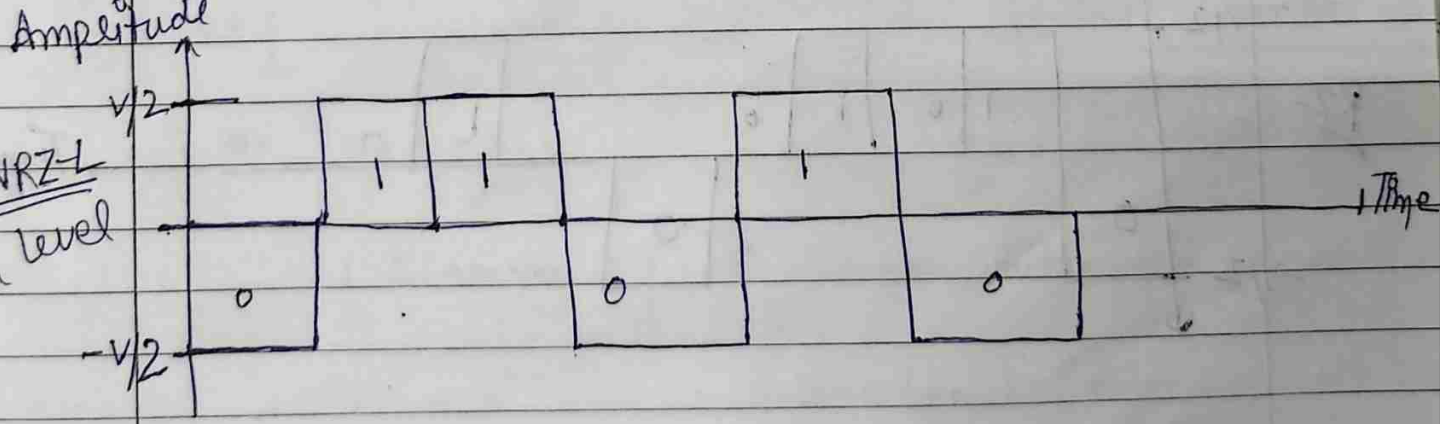
Reverse of manchester

Ques. 0 . 1 . 1 0 . 1 0

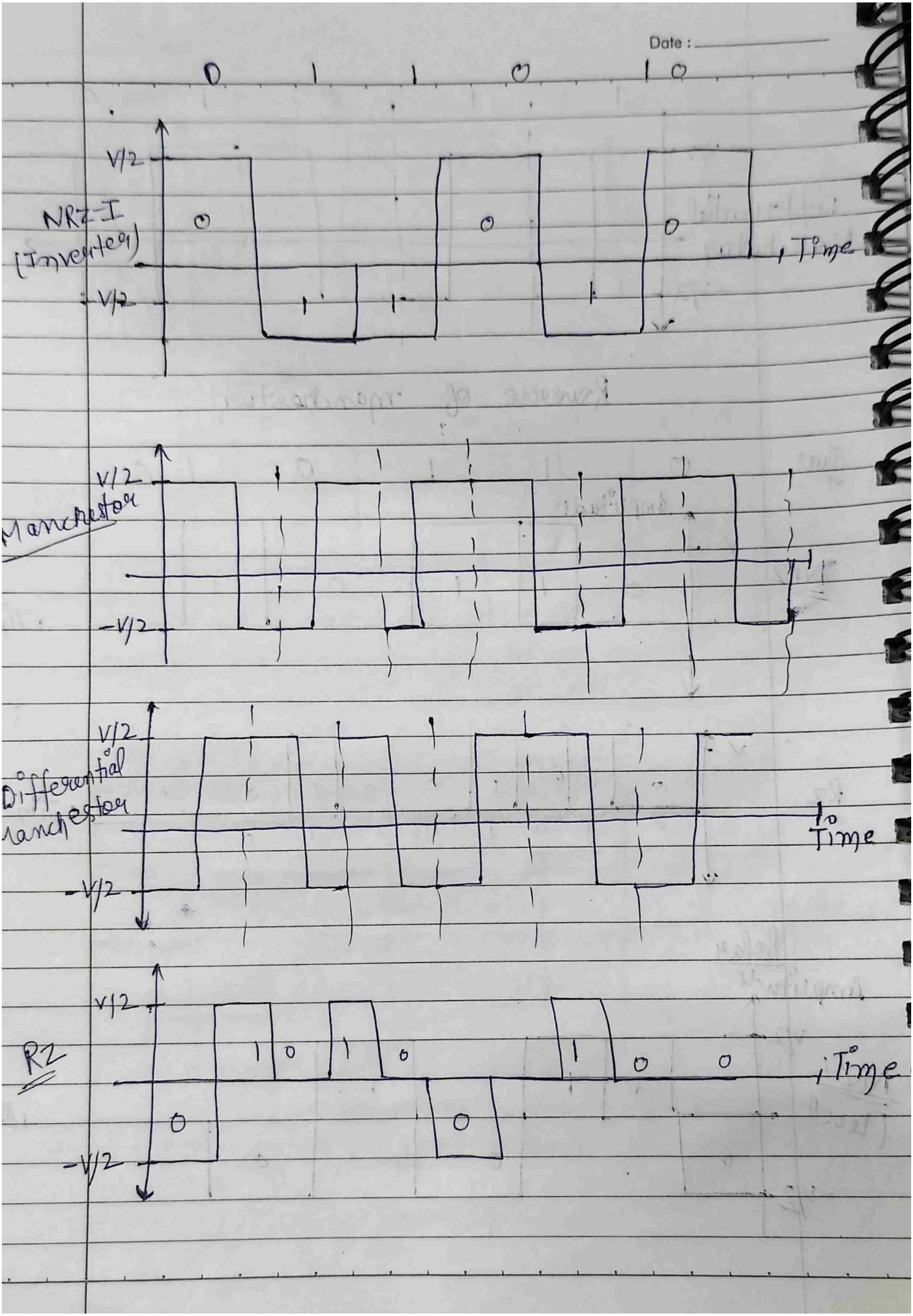




Polar



Date :


0 1 1 0 1 0
V/2
NRZ-I
(Inverted)
0
0
0
Time
-V/2
V/2
Manchester
-V/2
V/2
Differential
Manchester
-V/2
Time
V/2
RZ
1
0
1
0
1
0
0
Time
0
0
-V/2

★ Data rate Vs Signal rate

$$S = C \times N \times \frac{1}{\gamma}$$

$$B_{min} = C \times N \times \frac{1}{\gamma}$$

↓ Bendwidth

Where
C = Case factor
S = Signal
γ = Previous defined factor
N = Data rate
unit → Bit per sec

Bit rate max $(N)_{max} = \frac{1}{C} \times B \times \gamma$

Q A signal is carrying data in which one data element is encoded as one signal element ($\gamma = 1$) if bit rate is 100kbps what is the average value of Baud rate of C between 0 and 1 $C = \frac{1}{2}$ finds

Baud rate = No. of signals / Sec

Soln
$\gamma = 1$
N = 100 kbps
$C = \frac{1}{2}$

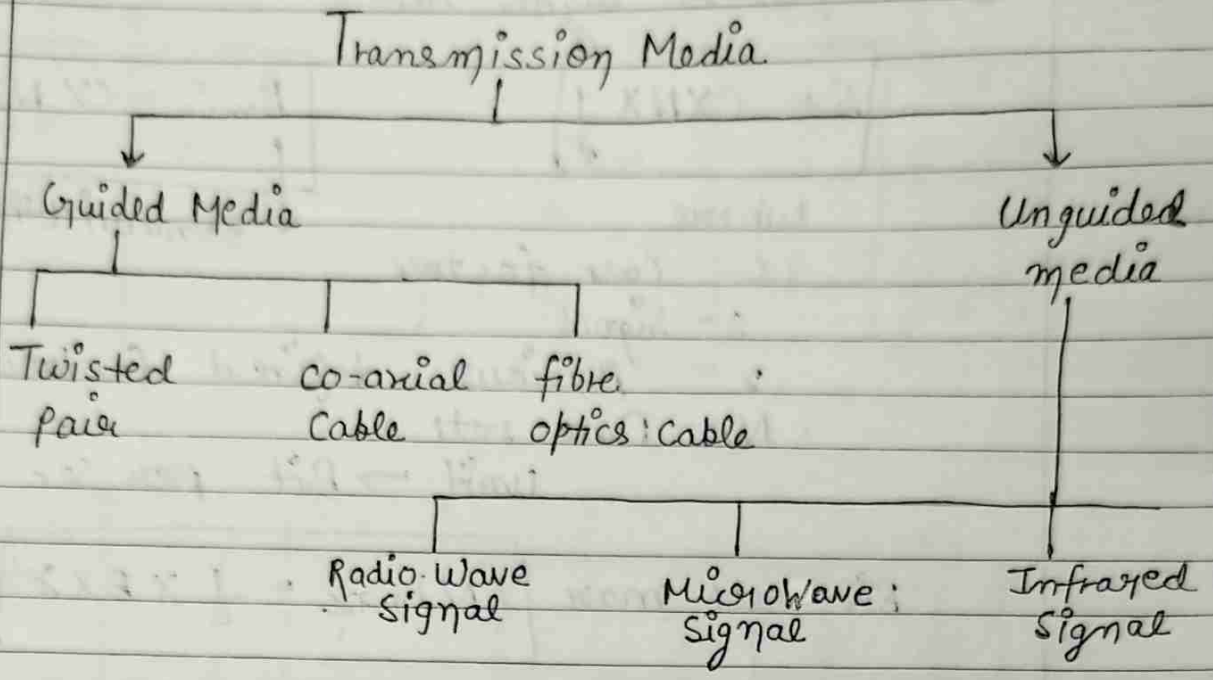
1 Kbps = 1000 bps

$$S = C \times N \times \frac{1}{\gamma}$$

$$= \frac{1}{2} \times 100000 \times \frac{1}{1} = 50000 \text{ bits}$$

$$= 50k \text{ baud}$$ Ans

Date : _____



Twisted Vs Coaxial Vs fibre optics

	Twisted	Coaxial	fibre optics
• Bandwidth	low	Moderately high	high
• Installation	easy	easy	difficult
• Cost	low	low	high
• Data rate	low	Moderately high	Very high
• Noise immunity	low	higher	highest
• Attenuation	Very high	low	very low
• external Magnetic field	More effected	less effected	Not effected at all

Date :

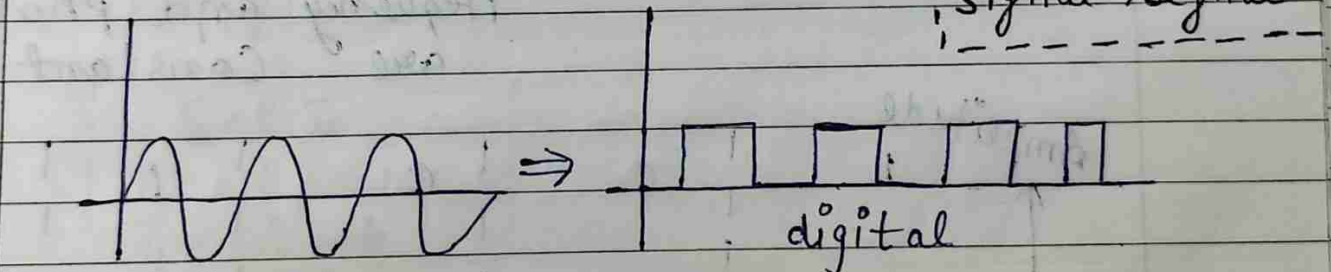
	Twisted	Coaxial	Fibre optics
• Diameter of Cable	Large	Larger/ Medium	Small
• Cause of power	powerless due to, conduction, Radiation	Powerless due to conduction	Powerless due to absorption, Scattering & bending

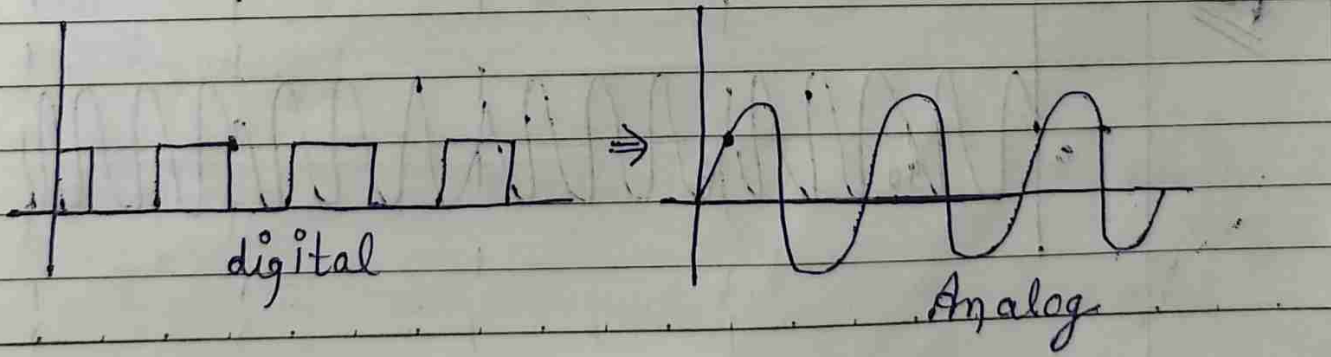
- Types - STP, UTP → shield twisted pair; unshield twisted pair
  RG59, RG6
  SMF, MMF → single mode fibre; Multi mode fibre

- Modulation

It is the technique to convert digital to analog and analog to digital signal.

Signal → Signal



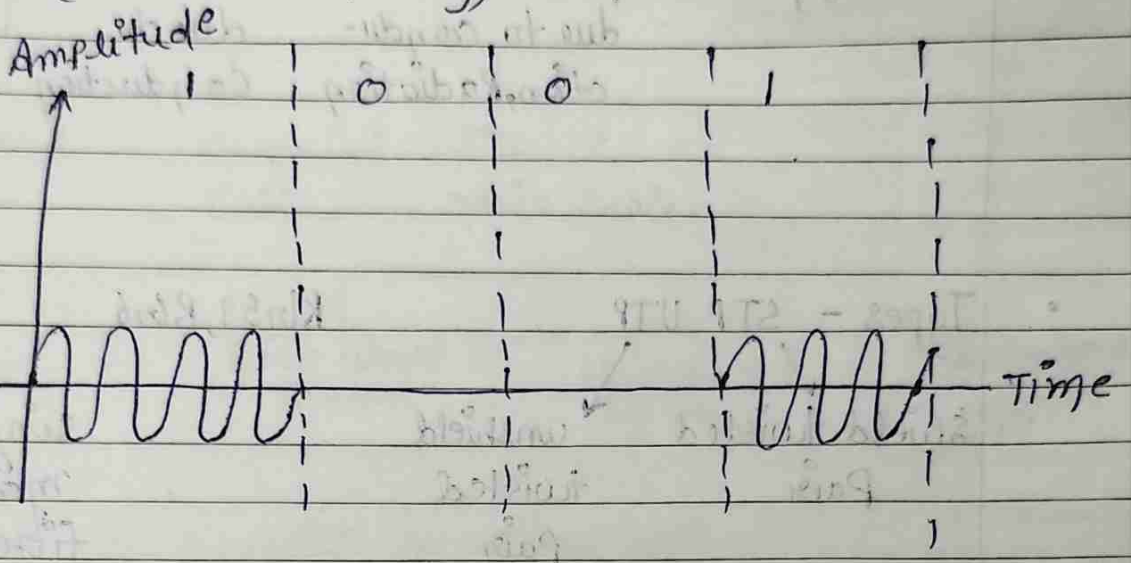


Date :

Types

1) ASK (Amplitude Shift key)
2) FSK (Frequency Shift key)
3) PSK (Phase Shift key)

ASK

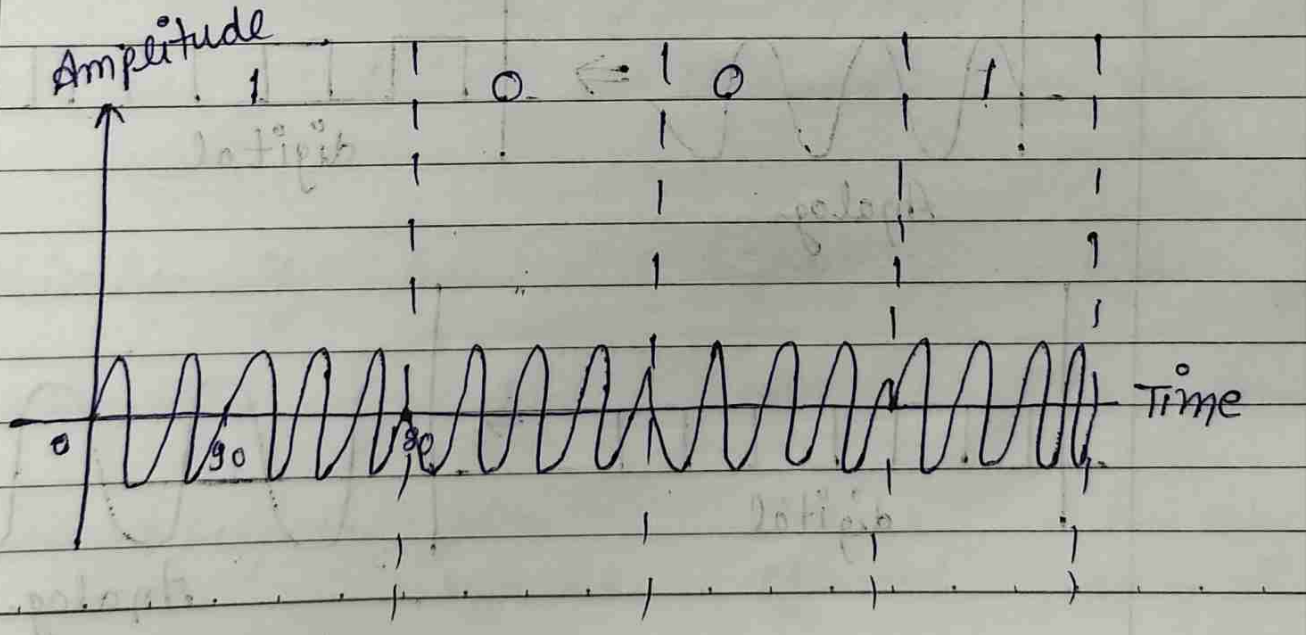


0 → unchange
1 → change (maximum Amplitude)

ON / OFF Technique

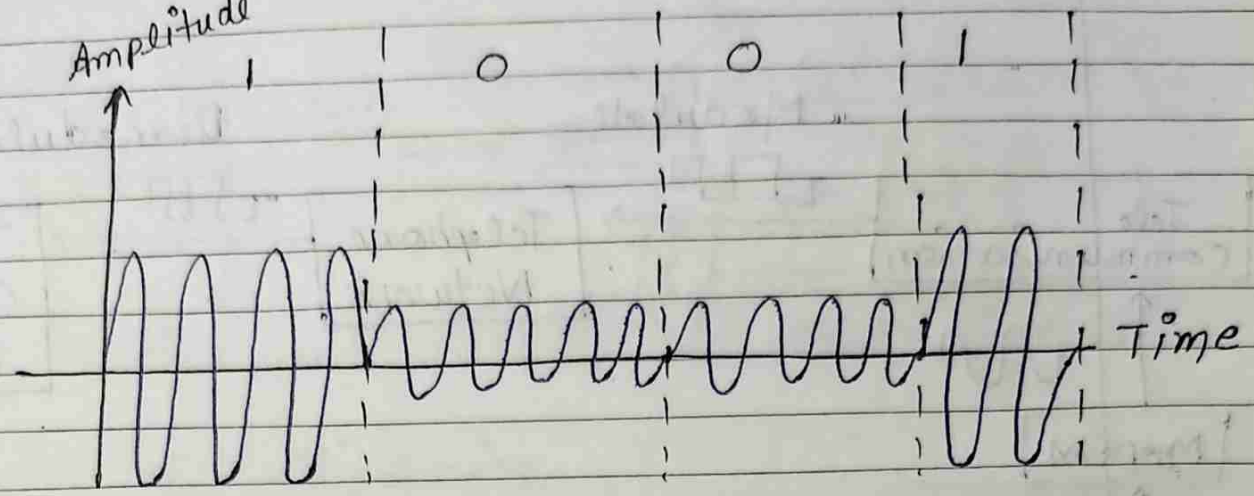
1 0

Frequency and phase are Constant



Date :

1 → start from up side
0 → start from down side



FSK

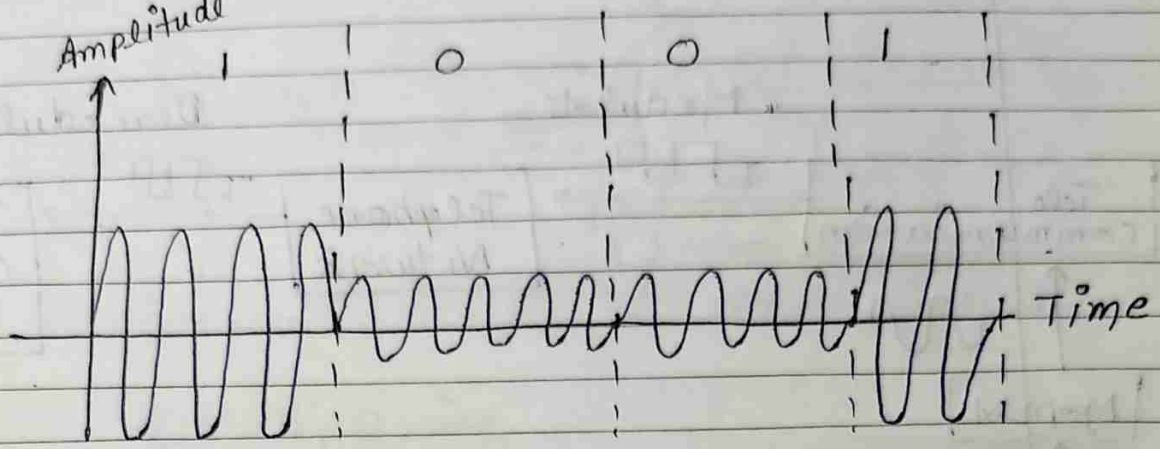
0 → less frequency
1 → high frequency

- ASK Vs FSK Vs PSK

	ASK	FSK	PSK
Distance-d)	$\sqrt{E_b}$ (min) (bit energy)	$2\sqrt{E_b}$ (max)	$2\sqrt{E_b}$ (max)
	$E_b = P_b \cdot T_b$ P_b = Bit power T_b = Bit rate		
Bandwidth	$2f_b$ (bit frequency)	$4f_b$ (Max)	$2f_b$
Probability of error	Maximum $P_e = \frac{1}{2} e^{-We\sqrt{\frac{E_s}{4\eta}}}$	$P_e = \frac{1}{2} e^{-fe\sqrt{\frac{E_s}{4\eta}}}$ (min)	$P_e = \frac{1}{2} e^{-fe\sqrt{\frac{E_s}{4\eta}}}$ (min)

Date :

1 → start from up side
0 → start from down side



FSK

0 → less frequency
1 → high frequency

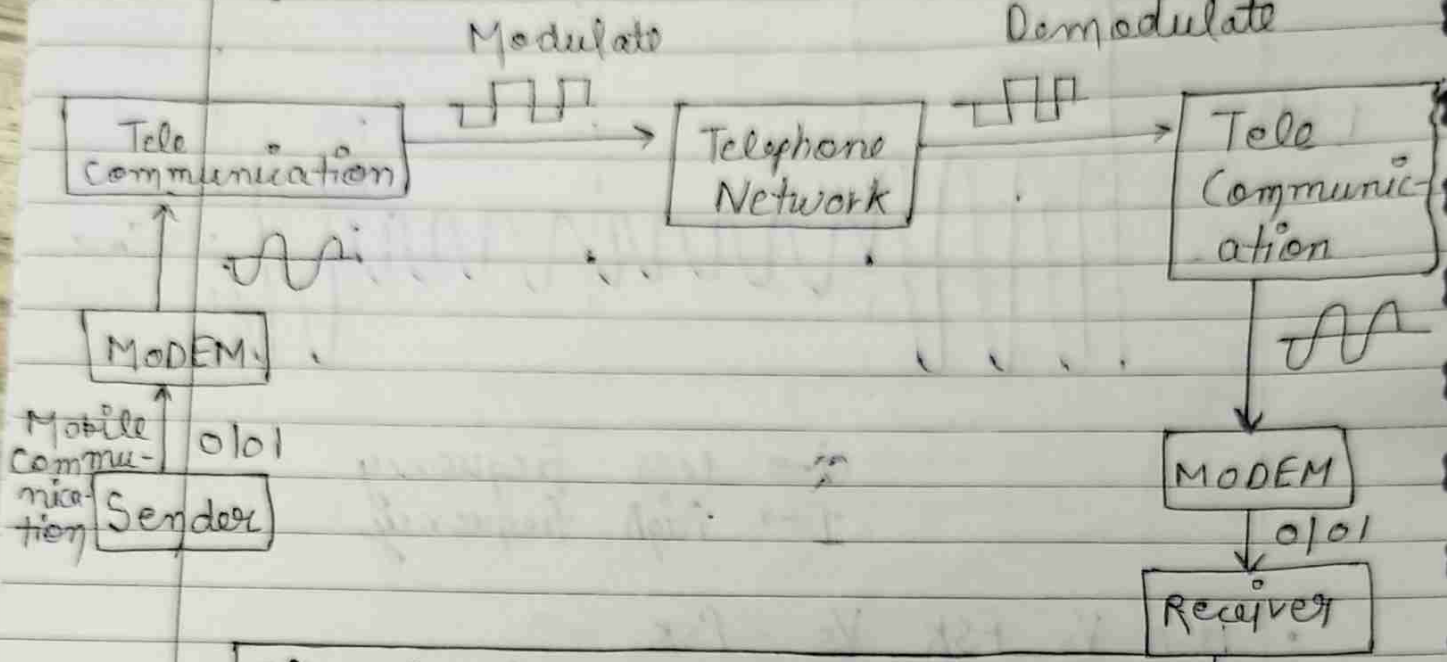
- ASK Vs FSK Vs PSK

	ASK	FSK	PSK
Distance (d)	$\sqrt{E_b}$ (min) (bit energy)	$2\sqrt{E_b}$ (max)	$2\sqrt{E_b}$ (max)
Band Width	$2f_b$ (bit frequency)	$4f_b$ (Max)	$2f_b$
Probability of error	Maximum $P_e = \frac{1}{2} e^{We\sqrt{\frac{E_s}{4\eta}}}$	$P_e = \frac{1}{2} erfc\sqrt{\frac{E_s}{4\eta}}$ (min)	$P_e = \frac{1}{2} efc\sqrt{\frac{E_s}{4\eta}}$ (min)

$E_b = P_b \cdot T_b$
P_b = Bit power
T_b = Bit rate

Date :

- Modem ÷ Modulator/Demodulator



Bit rate = Baud rate X No. of signal/unit

Ques The Bit rate of a signal is 3000 if each signal carries 6 bits find the Baud rate.

Soln Bit rate = Baud rate X No. of signal/unit

No. of Bits in each signal = 6

Bit rate = 3000

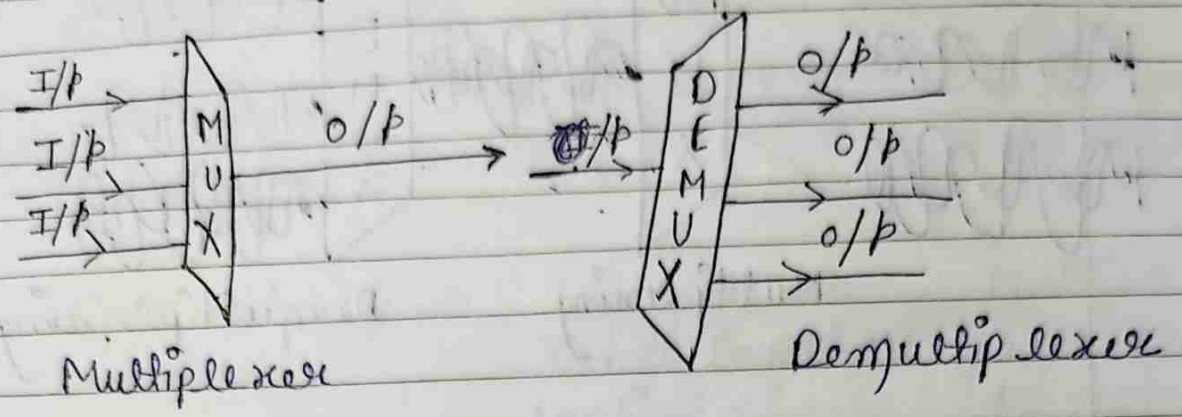
$3000 = \text{Baud rate} \times 6$

$\frac{3000}{6} = \text{Baud rate}$

500 Bauds/Sec = Baud rate

Date :

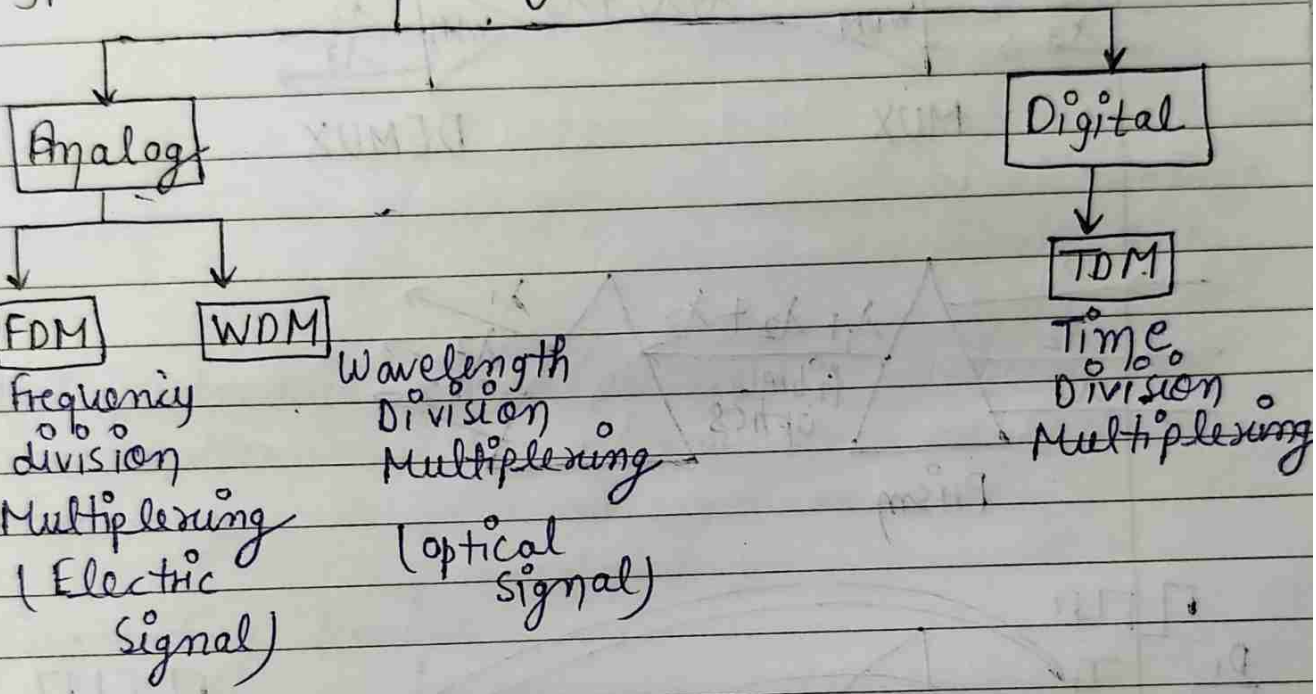
Multiplexing



Multiplexer

Demultiplexer

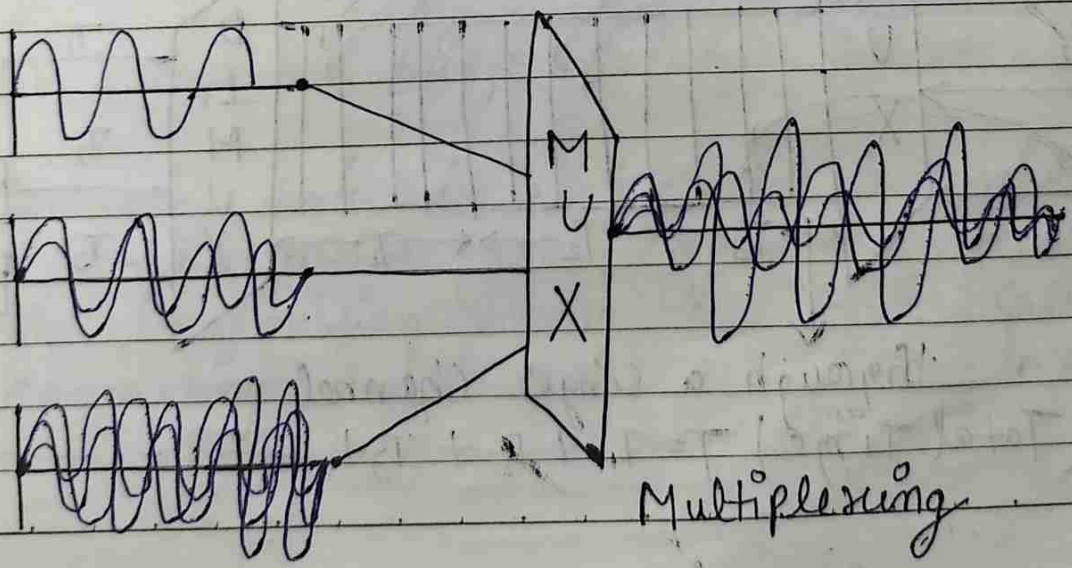
- Types of Multiplexing



Frequency division Multiplexing (Electric Signal)

Wavelength Division Multiplexing (optical signal)

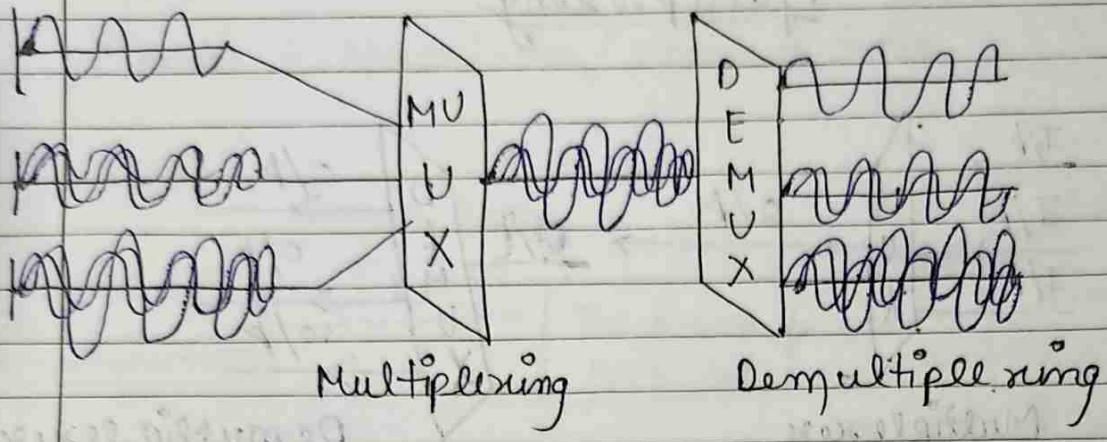
Time Division Multiplexing



Multiplexing

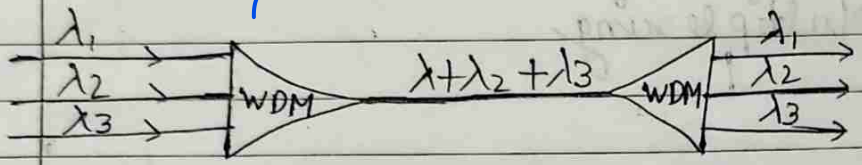
FDM

Date :

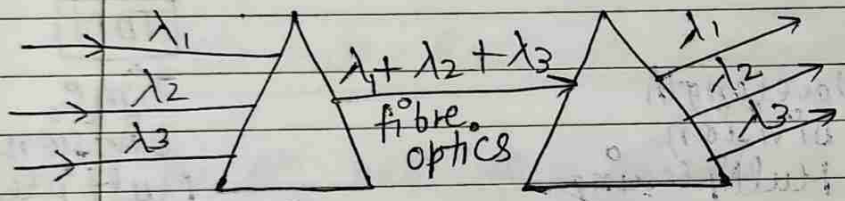


Multiplexing Demultiplexing

WDM

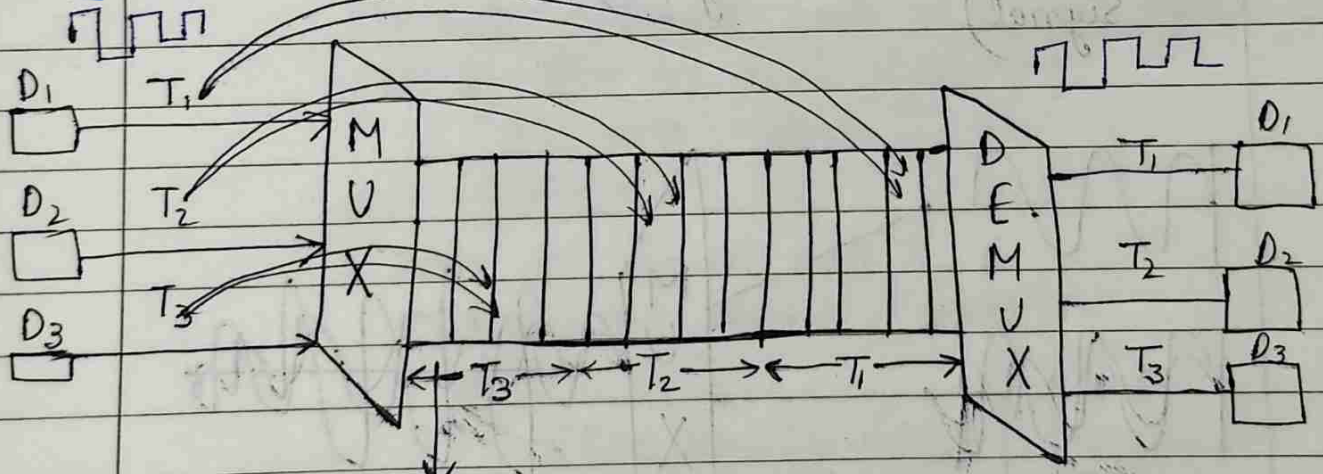


MUX DEMUX



Prism

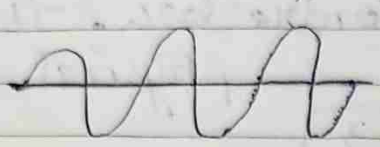
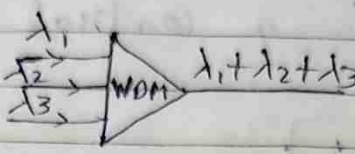
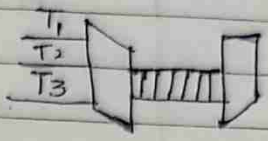
TDM



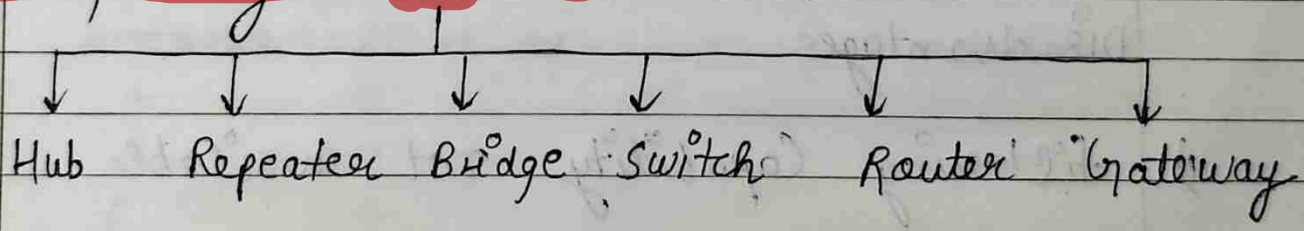
through a single channel

(Total Time) $T = T_1 + T_2 + T_3 + \cdots$

Date :

	FDM	WDM	TDM
1)	It uses Analog signal (electric signal)	optical signals	Digital signals
2)			
3)	Multiple data signals combined	Multiple Wave-length Combined (optical signals also)	Multiple user sends the Multiple digital signals to Send over a common channel by allocating fixed size time slot fixed time slot
4)	Multiple bandwidth into Smaller frequency	Multiple light beam	

- Connecting Devices

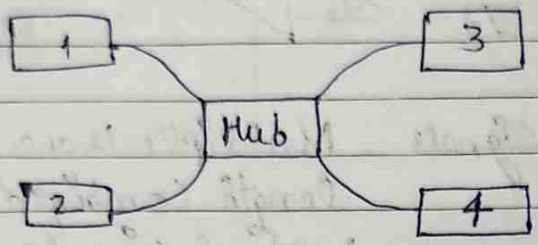


- Connecting device is a technique in which two or more devices are connected through the transmission media then it is called a connecting devices.

Date : _____

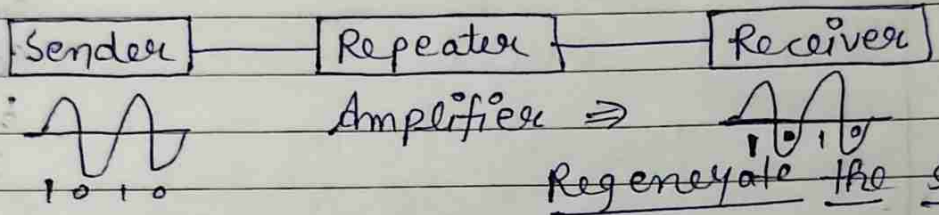
- Hub

Hub is a device to Control all the device
It is a central Controller. It works in physical layer



Don't Regenerate the signal

- Repeater



Regenerate the signal

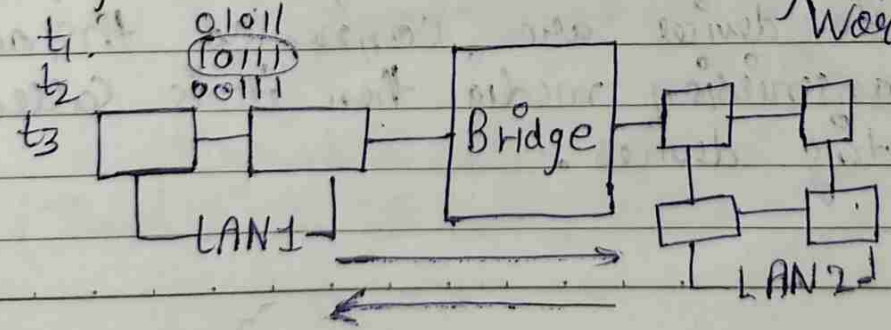
Repeater is also a device it works in physical layer as well as Network layer.
It Regenerate the signal from sender to Receiver by amplifier.

Disadvantages

1) filtering Capability not available

- Bridge

filtering Capability capable
Works at physical layer



Disadvantage

1) security

- Switch

Switch is a device it works in network layer and it forwards the packet from Source to destination without Routing Table

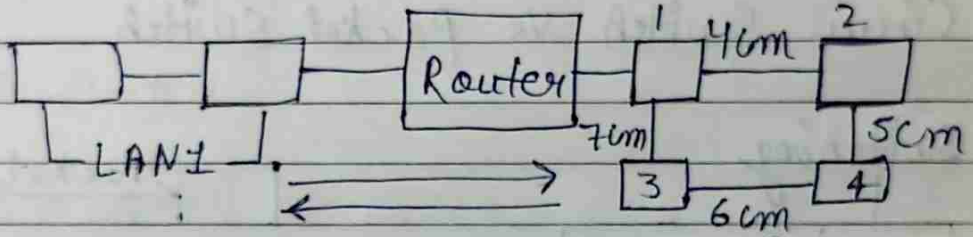
★ Advantage

Security

★ DisAdvantage

Routing Table not available

- Router



Router is the best technology for connecting devices

Routing table

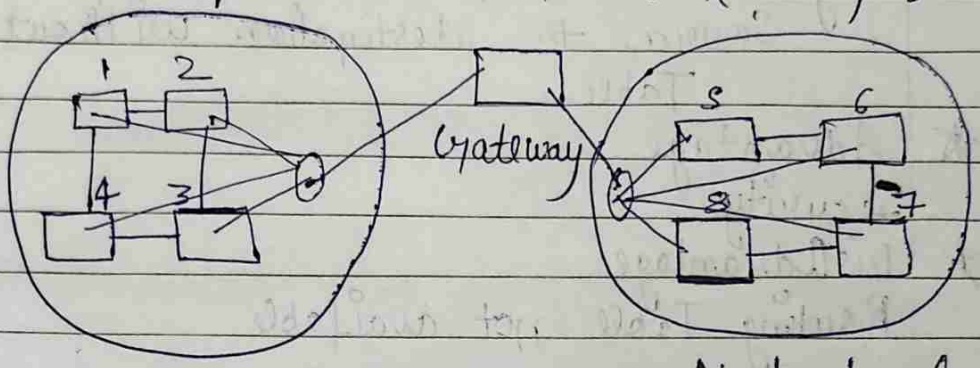
Device	Distance	Next Loop
1	4	2
2	5	3
3	6	4
4	7	1

Router is device it works at network layer it forwards the packet from Source to distination using Routing table where information of the nodes and network exists

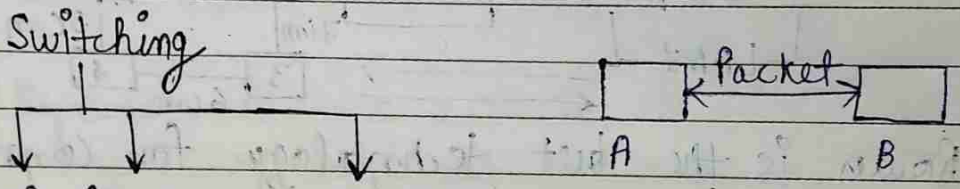
Date : _____

Gateway

Gateway is also a device it works at a Network layer it forwards the packet from one network protocol to another network protocol without Routing table

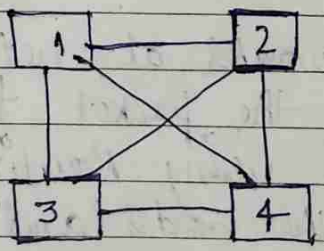


- Circuit Switch Vs Packet Switch



Switching is a technique to forwards the packet from source to destination

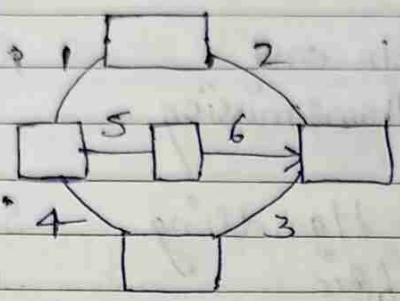
- Circuit switch



Date :

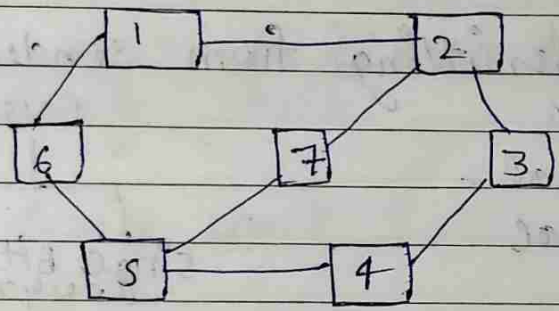
When two nodes communicate to each other over a dedicated point to point link then it is called circuit switching.

- Message Switch

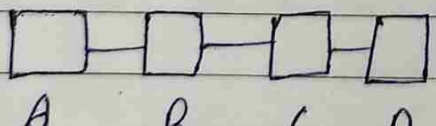


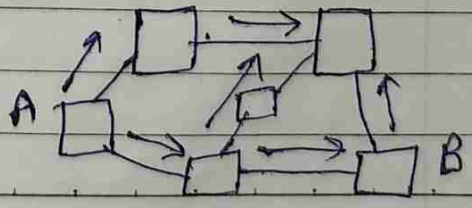
Message switch is a technique to forward the message from source to destination without point to point link.

- Packet Switch



Circuit Switch	Packet Switch
1) Physical path between Sender to Receiver	No path
2) All packets use in same path	All packets use in different path





Date :

3)	Bendwidth Wastage	Not Wastage
4)	Packets arrive in Sequence	Packets arrive not in Sequence
5)	Low Transmission capability	Maximum Transmission capability
6)	No need to end to end path for data Transmission	Required end to end path
7)	Not suitable for Handling interactive traffic	Suitable for Handling interactive traffic
8)	Noise create	No Noise create

- Datalink layer

- ✱ Framing
- ✱ Frame transmitting from sender to Receiver
- ✱ Access Control
- ✱ Error control.
- ✱ flow control

errors

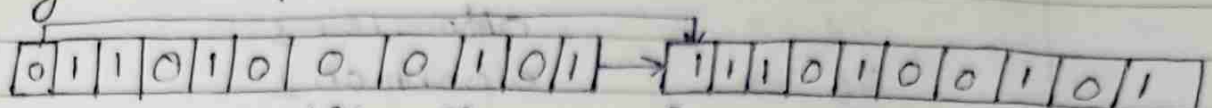
- Single Bit error
- Burst error

Error Correction and detection (technique)

- Parity Check
- Two Dimensional parity check
- Check Sum
- Redundancy check

Date :

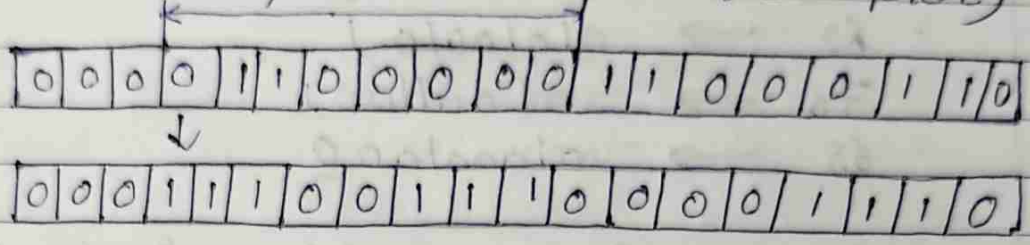
- Single Bit error



only one bit change from 0 to 1 or 1 to 0

- Burst error

(two or more than two bit error)



- Parity check.

0 1 0 1 0 0 0 ⟶ 0 1 0 1 0 0 0 [1]

When the bit is odd condition then you add 1 to make it even then it is called Parity check.

① Single Parity check

Write a program to check the parity for 'Hello World' using single parity check.

ASCII

a → 97

A → 65

H	E	L	L	O	W	O	R	L	D
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
72	69	76	76	79	87	79	82	76	68

Date :

72 → 01001000 0
69 → 01000101 1
76 → 01001100 1
76 → 01001100 1
79 → 01001111 1
87 → 01010111 1
79 → 01001111 1
82 → 01010010 1
76 → 01001100 1
68 → 01000100 0

if there is Even 1 add 0 in front of binary no. otherwise add 1 to make it even

- Two dimensional parity check

11001110 | 10111010 | 01110010 | 01010010

Q

11001110	1
10111010	1
01110010	0
01010010	1
01010100	

Q 10010101 | 01001111 | 11010000 | 11011011

Date :

10010101	0
01001111	1
11010000	1
11011011	0
11010001	

- Check Sum

steps

(1) Check Sum Generator

(i) Added all the elements with 1's Complement

(ii) Sum also complement and append it to the original data.

(2) Check Sum Checker

(i) To verify the checksum value

(ii) Added all the element as per previous instructions.

ex

10011001 $k=4$ $m:n=8$

11100010 $\frac{m}{n}=8$

00100100

10000100

1st 10011001

2nd +11100010

101111011

1

01111100

3rd 00100100

10100000

4th + 10000100

100100100

+1

00100101 Sum

→ Complement

11011010

(Check Sum)

Date :

Original data ——————→ Checksum

10011001	11100010	00100100	10000100	11011010

Check Sum checkere

10011001 k=4 m:n=8

11100010 $\frac{m}{n}=8$

00100100

10000100

1st 10011001

2nd +11100010

01111011

+1

01111100

3rd +00100100

10100000

4th +10000100

10100100

+1

00100101 Sum

Complement

Check sum = 11011010

00100101

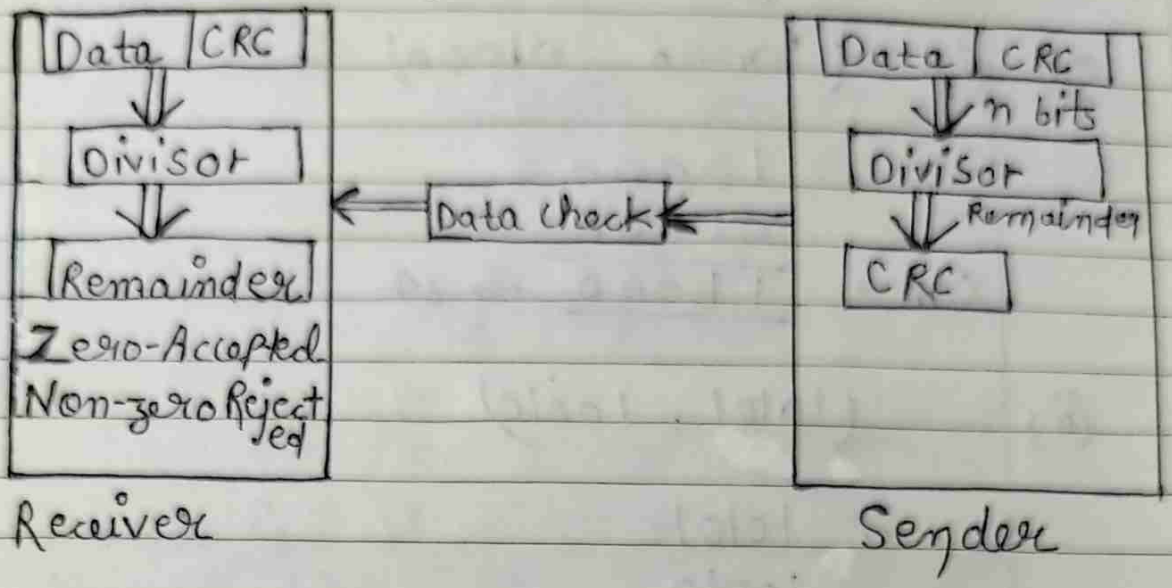
+11011010

11111111 → Complement

Check Sum = 00000000

Hence the Code Word is accepted there is no error.

Cyclic Redundancy check (CRC)



data = 11100

n bit

(n-1) = 3

```
      11111                          1001 | 11100111 | 11111
1001 | 11100000                          1001↓
       1001↓                             -------
       -------                           01110
       01110                              1001↓
        1001↓                             -------
        -------                           00111
        00111                               1001↓
          1001↓                             -------
          -------                           00011
          00110                               1001↓
            1001↓                           -------
            -------                         00010
            00011                             1001↓
              1001↓                         -------
              -------                       00001
              00010                           1001
                1001                        -------
                -------                     0000
                00011
                  1001
                  ----
                  011
```

Remainder

Condition is accepted

Date :

Hamming Code

ex (i) (10000, 01000)

```
  10000
  01000
XOR→ 11000 → 24
```

(ii) (10101, 10010)

```
  10101
  10010
  00111 → 7
```

Ques Find 15 bit Hamming Code for 11 bit data Word $[2^r \geq m+r+1]$

(i) 11001001010

(i) $2^r \geq m+r+1$; $r \rightarrow$ data redundancy
$m \rightarrow$ no. of data Bit

$2^0 \cdot (11+0+1)$
$1 < 12$ Not Satisfies eqn (i)

$2^1 \cdot (11+1+1)$
$2 < 13$ Not satisfies eqn (i)

$2^2 \cdot (11+2+1)$
$4 < 14$ Not satisfies eqn (i)

Date :

2^3 (11+3+1)

$8 < 15$ Not Satisfies eqn (i)

2^4 (11+4+1)

$16 \geq 16$ Satisfies eqn (i)

R_1	R_2	R_4	R_8
2^0	2^1	2^2	2^3
1	2	4	8

left to Right

1	2	3	4	5	6	7	8	9	10	11
R_1	R_2	1	R_4	1	0	0	R_8	1	0	0

12	13	14	15
1	0	1	0

R_1 (1, 3, 5, 7, 9, 11, 13, 15) = (1, 1, 1, 0, 1, 0, 0, 0) = R_1

R_2 (2, 3, 6, 7, 10, 11, 14, 15) = (0, 1, 0, 0, 0, 0, 1, 0) = R_2

R_4 (4, 5, 6, 7, 12, 13, 14, 15) = (1, 1, 0, 0, 1, 0, 1, 0 = R_4

R_8 (8, 9, 10, 11, 12, 13, 14, 15) = (1, 1, 0, 0, 1, 0, 1, 0) = R_8

$R_1 = 1$

$R_2 = 0$

$R_4 = 1$

$R_8 = 1$

So the Code Word is -

1011100110010

Date :

Right to left

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	1	0	0	1	0	0	R_8	1	0	1	R_4	0	R_2	R_1

$R_1 = \{1, 3, 5, 7, 9, 11, 13, 15\} = \{\underline{0}, 0, 1, 1, 0, 1, 0, 1\}$

$R_2 = \{2, 3, 6, 7, 10, 11, 14, 15\} = \{\underline{0}, 0, 0, 1, 0, 1, 1, 1\}$

$R_4 = \{4, 5, 6, 7, 12, 13, 14, 15\} = \{\underline{0}; 1, 0, 1, 0, 0; 1, 1\}$

$R_8 = \{8, 9, 10, 11, 12, 13, 14, 15\} = \{\underline{1}, 0, 0, 1, 0, 0, 1, 1\}$

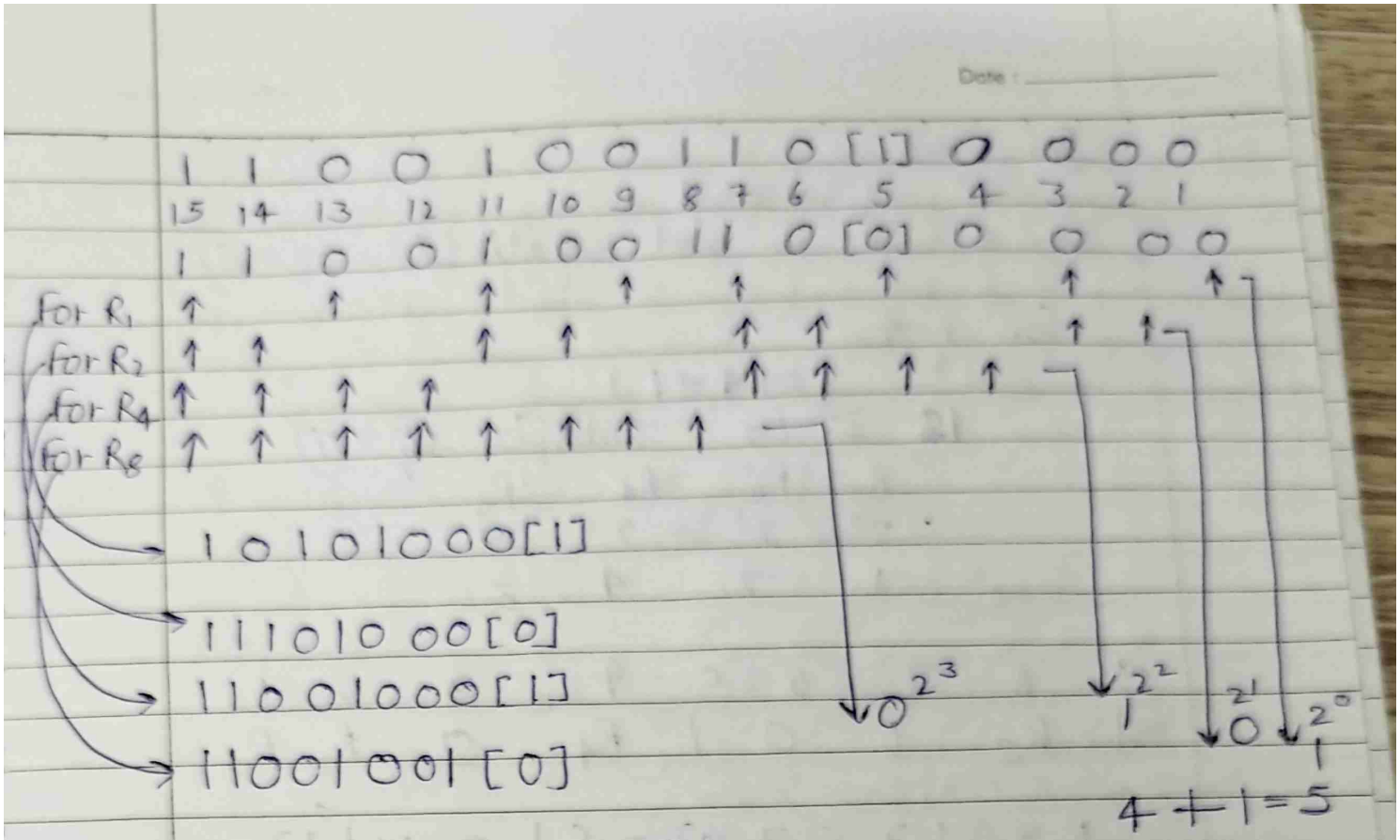
$R_1 = 0$
$R_2 = 0$
$R_4 = 0$
$R_8 = 1$

15 bit Hamming code =
1100/1001/101/0000

1100100110[1]0000 has 5th error

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	1	0	0	1	0	0	1	1	0	[0]	0	0	0	0

$R_1 = \{1, 3, 5, 7, 9, 11, 13, 15\}$
$R_2 = \{2, 3, 6, 7, 10, 11, 14, 15\}$
$R_4 = \{4, 5, 6, 7, 12, 13, 14, 15\}$
$R_8 = \{8, 9, 10, 11, 12, 13, 14, 15\}$



Ques 9 Bit hamming code for (5) bite Code 11010 using right to left.

$2^r \geq m+r+1$ —(i)

for r=0

2^0 (5+0+1)

1 < 6 not satisfies eqn(i)

for r=1

2^1 (5+1+1)

2 < 7 not satisfies eqn(i)

for r=2

2^2 (5+2+1)

4 < 8 not satisfies eqn (i)

Date :

For r = 3

$2^3 \geq (5+3+1)$

$8 < 9$ not satisfies eqn (i)

for r = 4

$2^4 \geq (5+4+1)$

$16 \geq 10$ Satisfies eqn (i)

R_1	R_2	R_4	R_8
2^0	2^1	2^2	2^3
1	2	4	8

9	8	7	6	5	4	3	2	1
1	R_8	1	0	1	R_4	0	R_2	R_1

$R_1 = \{1, 3, 5, 7, 9\} = \{\underline{1}, 0, 1, 1, 1\}$

$R_2 = \{2, 3, 6, 7\} = \{\underline{1}, 0, 0, 1\}$

$R_4 = \{4, 5, 6, 7\} = \{\underline{0}, 1, 0, 1\}$

$R_8 = \{8, 9\} = \{\underline{1}, 1\}$

$R_1 = 1$

$R_2 = 1$

$R_4 = 0$

$R_8 = 1$

9 Bit Hamming Code is

1 1 1 0 1 0 0 1 1

Ques A network has a data transmission bandwidth of 20×10^6 bit per second. It uses CSMA/CD in the MAC layer the maximum signal propogation time from one node to another node is 40 microseconds. what is the minimum size of a frame in the network in byte?

Sol^n Bandwidth = 20×10^6 bit / Sec

Maximum propogation = 40 ms

$= 40 \times 10^{-6}$ sec

We know

Minimum frame size = 2 X propogation time X Band width

$= 2 \times 40 \times 10^{-6} \times 20 \times 10^6$

$= 1600$ bits

In byte $= \frac{1600}{8} = 200$ bytes

Ques five equal size datagrams belonging to the same message leave for the destination one after another. However, they travel through different paths as shown in the following Table.

Datagram	Path length	Visited Switches
1	3200 km	1, 3, 5
2	11700 km	1, 2, 5
3	12200 km	1, 2, 3, 5
4	10200 km	1, 4, 5
5	10700 km	1, 4, 3, 5

We assume that the delay for each switch (including Waiting & processing) is 3, 10, 20, 7 & 20 ms Respectively. Assuming that the

Date :

propogation Speed is 2×10^8 m/s, find the order the datagrams arrive at the destination & the delay for each. Ignore any other delays in Transmission.

5 datagrams

We know

$$\text{propogation delay} = \frac{\text{Path length}}{\text{propogation speed}}$$

Switching delay = Sum of the delays at each Switch visited by the datagram.

Total delay = propogation delay + Switching delay

For datagram 1

length $= 32\,000 \times 10^3$ m

propogation delay $= \frac{32000 \times 10^3}{2 \times 10^8} = 0.016$ sec $= 16$ m sec

Switching delay (1, 3, 5) $= 3 + 20 + 20 = 43$ m sec

Total delay $= 16 + 43 = 59$ m sec

1 → 3
2 → 10
3 → 20
4 → 7
5 → 20

For datagram 2

length $= 11\,700$ km $= 11\,700 \times 10^3$ m

propogation delay $= \frac{11700 \times 10^3}{2 \times 10^8} = 0.0585 = 58.5$ ms

Switching delay (1, 2, 5) $= 3 + 10 + 20 = 33$ ms

Total delay $= 58.5 + 33 = 91.5$ ms

Date :

For datagram 4

Length = 10200 km = 10200×10^3 m

Propogation delay = $\frac{10200 \times 10^3}{2 \times 10^8}$ = 0.051 = 51 ms

(1,4,5) Switching delay = 3+7+20 = 30 ms

Total delay = 30+51 = 81 ms

For datagram 5

Length = 10700 km = 10700×10^3 m

Propogation delay = $\frac{10700 \times 10^3}{2 \times 10^8}$ = 0.0535 = 53.5 ms

(1,4,3,5) Switching delay = 3+7+20+20 = 50 ms

Total delay = 50+53.5 = 103.5 ms

For datagram 3

Length = 12,200 km = 12200×10^3 m

propogation delay = $\frac{122000 \times 10^3}{2 \times 10^8}$ = 0.061 = 61 ms

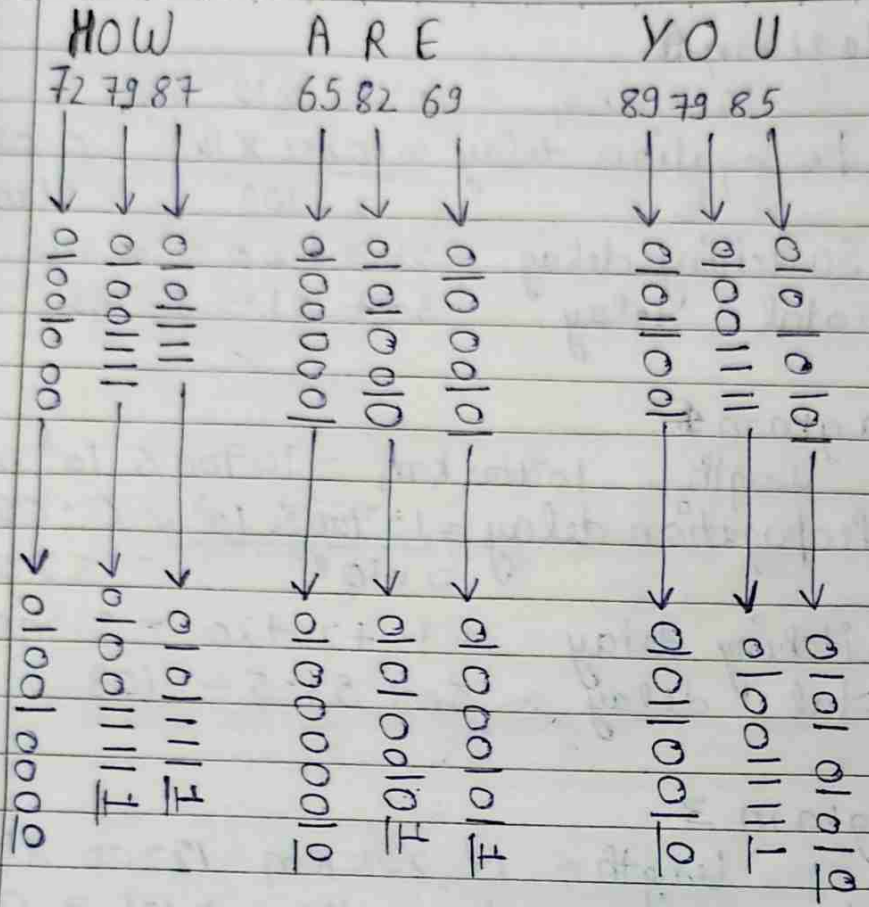
(1,2,3,5) Switching delay = 3+10+20+20 = 53 ms

Total delay = 53+61 = 114 ms

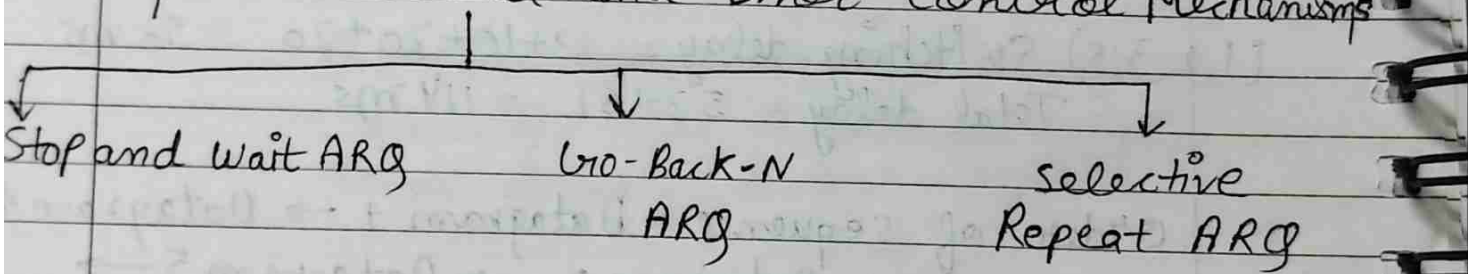
Order of sequence = Datagram 1 → Datagram 4 → Datagram 2 → Datagram 5 → Datagram 3

Ques HOW ARE YOU Parity check

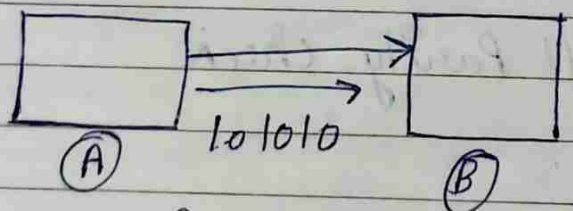
Date :



- flow Control and Error Control Mechanisms



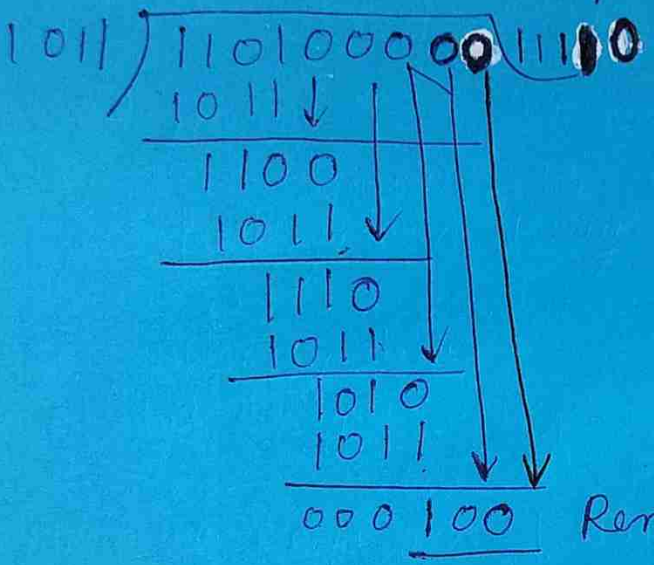
ARQ → Automatic Repeat Request

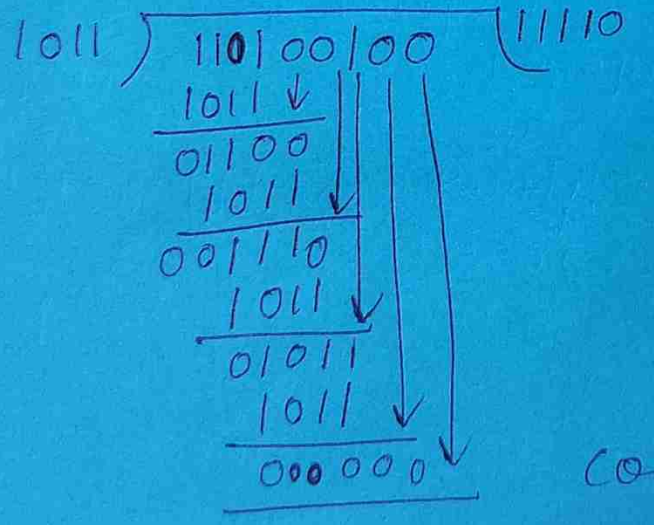


Same data transfer

- Manchester and Differential manchester
- Datagram (ques)
- XOR like 10101 (Hamming distance)
  10010 (XOR)
  00111
  $2^2 2^1 2^0 = 4+2+1 = 7$
- Assignment 2 → 13, 14, 16 (ques)
- Hamming Code 12 bit
- 11100
  polynomial equation - $x^3 + x + 1$

$2^3\ 2^2\ 2^1\ 2^0$
1 0 1 1





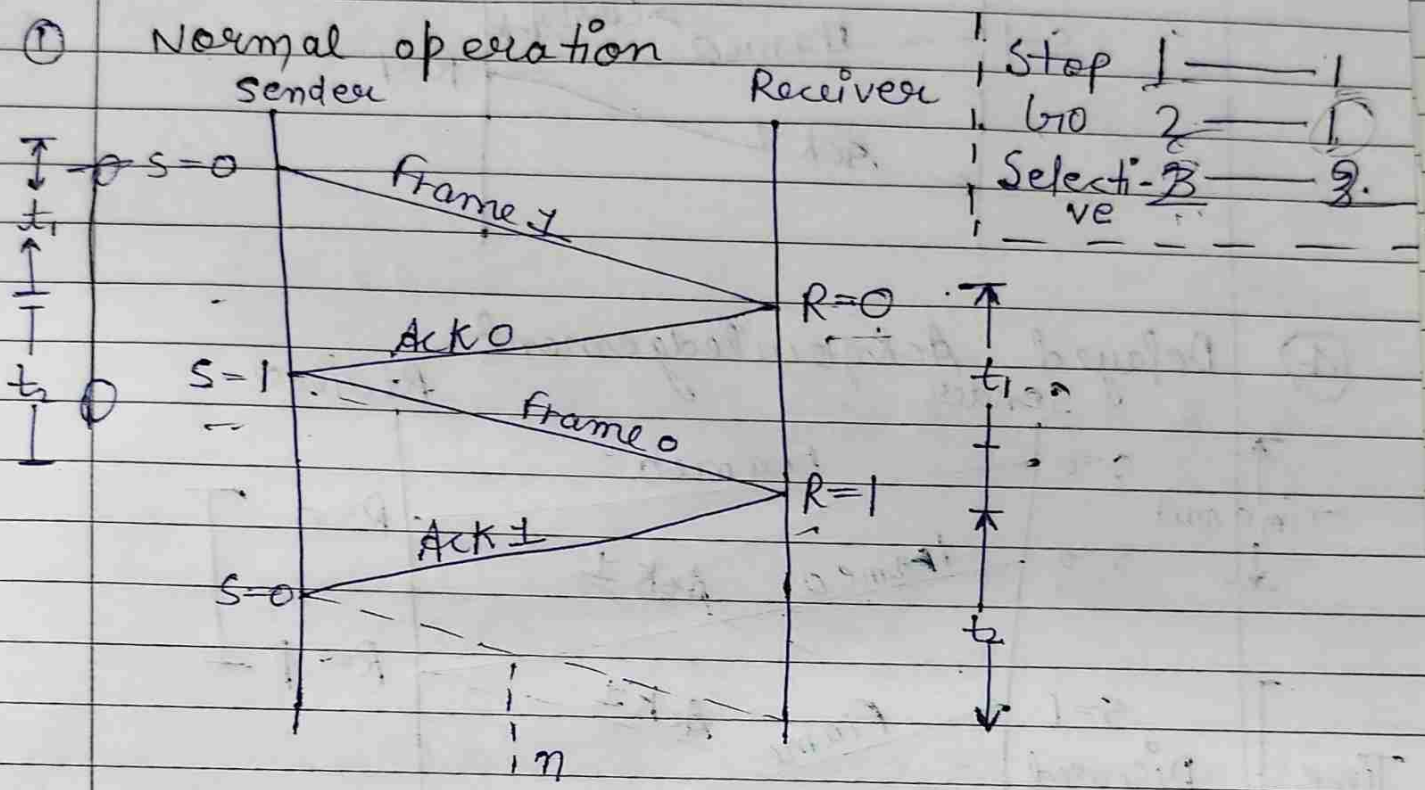
Codeword is accepted

Date :

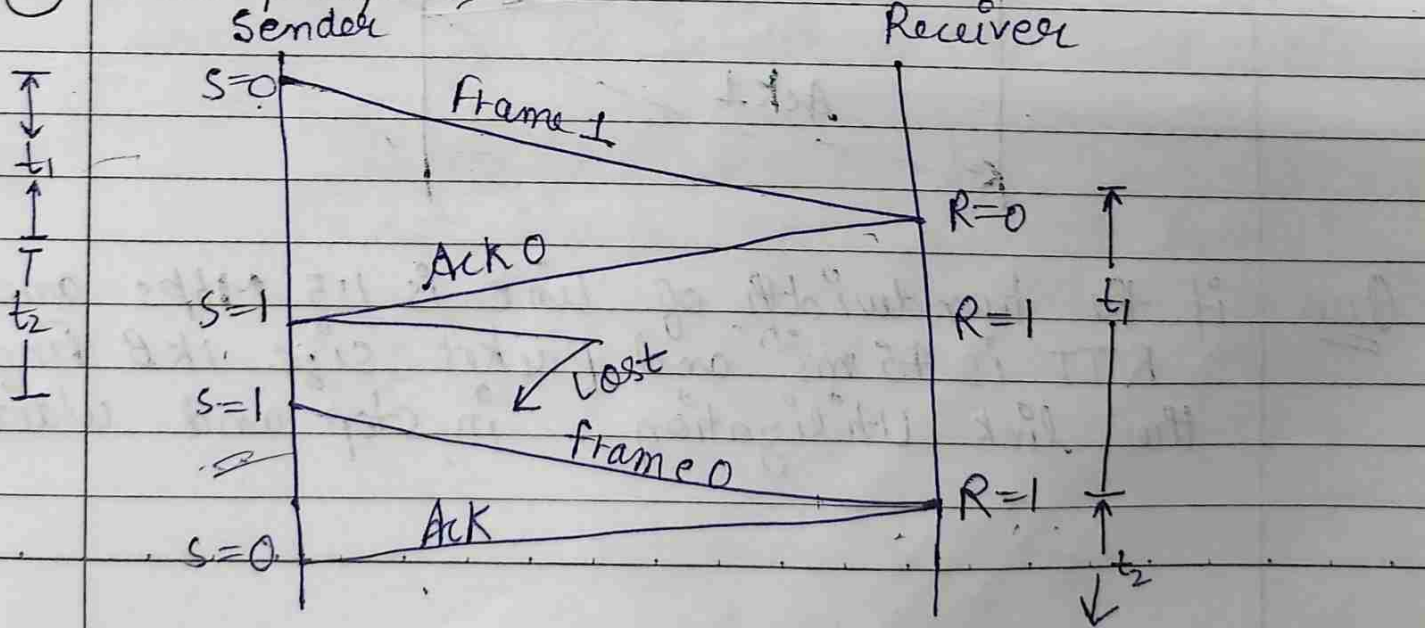
1) Stop and Wait ARQ

operation → Normal operation
→ Lost frame
→ lost acknowledgement
→ Acknowledgement delay
(delay acknowledgement)

① Normal operation

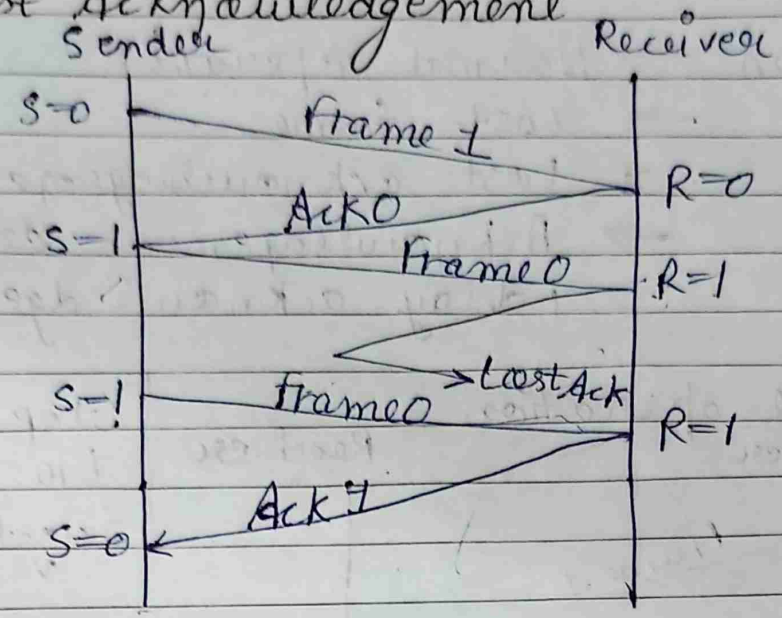


② Lost frame

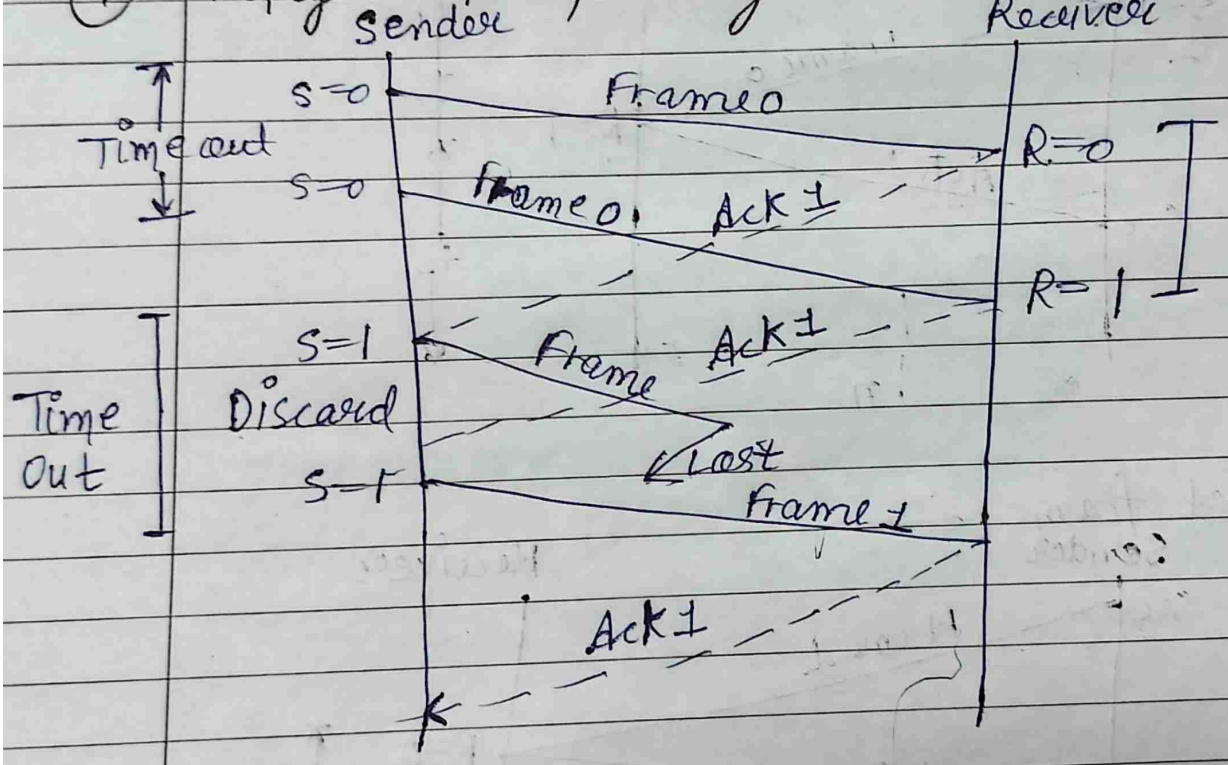


Date :

(3) Lost Acknowledgement



(4) Delayed Acknowledgement



Ques if the bandwidth of line is 1.5 Mbps and RTT is 45 ms and packet size 1KB Find the link Utilization in stop and wait

Date :

Soln In stop and wait ARQ, only one frame send at a time

$B = 1.5 Mbps = 1.5 \times 10^6$ bps

RTT (Round Trip Time) $= 45 \times 10^{-3}$ sec

Packet size $= 1 \times 1024$ byte $= 1024 \times 8$

$= 8192$ bit

(i) Transmission Time (T_{Trans}) $= \frac{\text{Packet Size}}{\text{Bandwidth}}$

$= \frac{8192}{1.5 \times 10^6} = 5.46 \times 10^{-3}$ sec

$= 5.46$ ms

(ii) Link Utilization (U) $= \frac{T_{Trans}}{T_{Trans} + RTT} = \frac{5.46}{5.46 + 45 \times 10^{-3}}$

$= 0.1082$

Link Utilization $= 10.82\%$

Ques In the packet size 1KB and propogation time 15 ms the channel capacity is 109 beat per sec. then find the Transmission time and Utilization of the Sender in stop and wait ARQ.

Soln Bandwidth, $B = 109$ bps

Packet Size $= 1KB = 1 \times 1024$ byte

$= 1024 \times 8 = 8192$ bit

propogation time $= 15$ ms

Date :

(i) Transmission Time (T_{Trans}) = $\frac{\text{Packet Size}}{\text{Bandwidth}}$

$= \frac{8192}{10^9} = 75.155\ ms$

(ii) Utilization - (U) $\Rightarrow \frac{T_{Trans}}{T_{trans} + 2 \times \text{propogation time}}$

$= \frac{75.155}{75.155 + 2 \times 15}$

$= \frac{75.155}{75.155 + 30} = \frac{75.155}{105.155}$

$= 0.7147$

Link Utilization = 71.47 %.

- Go-Back-N-ARQ and Selective Repeat ARQ

Sliding Window (Two or more than two frame must sent from sender side)

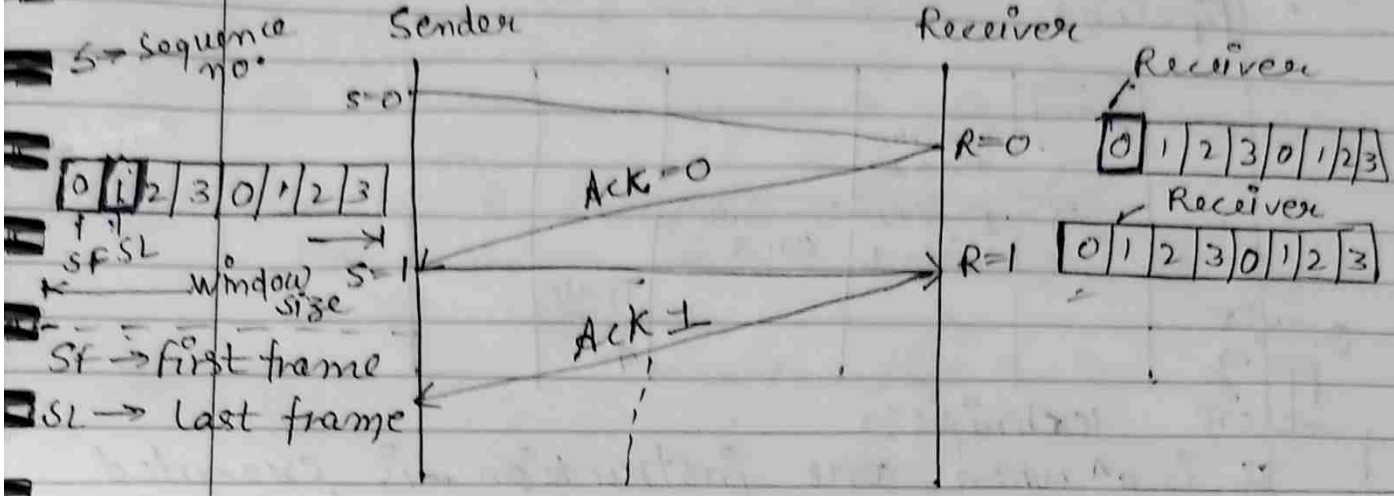
Stop & wait 1. 1 frame send → one frame Receive
Go Back N 2. more than 2 frame send → 1 Receive
Selective Repeat 3. 2 frame send → 2 Receive

Stop and wait ARQ, Go Back N ARQ, Selective Repeat

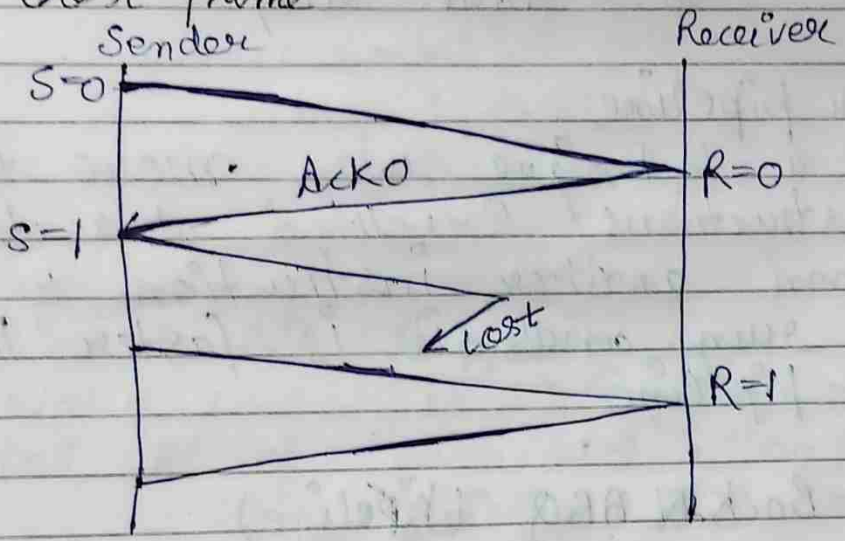
Normal operation

Date :

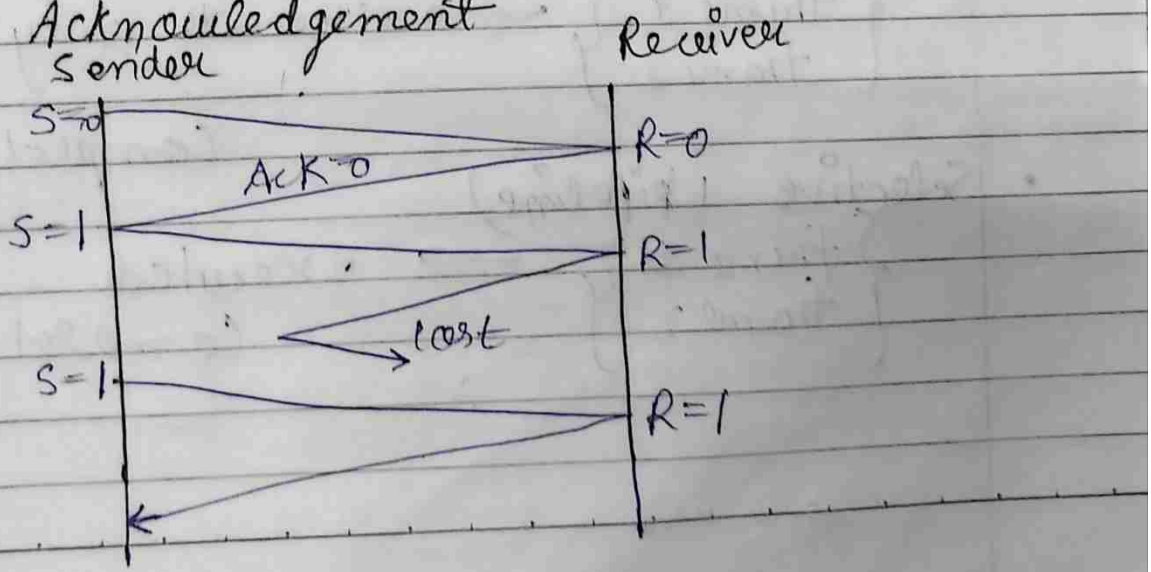
- Normal operation



- Lost frame

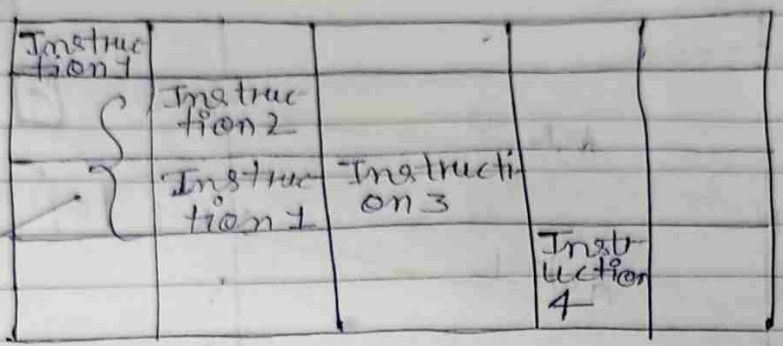


- Lost Acknowledgement



Date :

- Pipeline



technique

It is a^ when one instruction is executed completely then another instruction to start run.

- Super pipeline

It is a technique when more than instructions executed at a time then another instruction to start run and it is faster than pipeline

- Go-Back N ARQ (Pipeline)

{ frame 1, frame 2 } ⟶ execute only one frame completely

- Selective (Pipeline)

{ frame 1, frame 2 } ⟶ executed completely

Window size = $2^n - 1$

$S_t - S_f + 1 = 2^n - 1$

$S_t - S_f = 2^n - 2$

Sequence no. = $2^n - 1$

Ques In Go Back-N ARQ Window Size (W) = 15 How many bits are needed to define the sequence no.

Soln Window Size = $2^n - 1$

$15 = 2^n - 1$

$16 = 2^n$

$(2)^4 = 2^n$.

$\boxed{n = 4}$

Sequence no. = $2^4 - 1$

$= 16 - 1 = 15$

Sequence no. → 0, 1, 2, 3, 0, 1, 2, 3, 0, 1, 2, 3, 0, 1, 2

Ques Find 12 bit hamming code using Code-word 10010011 if 5th Position error in HMC,

Ques Find CRC of codeword 11001 0 using $x^3 + 1$ division. Find the original code word.

then find the original codeword

Date :

Sol^{n}

$2^r \geq m+r+1$ — i

for $r=0$

$2^0 \quad (8+0+1)$

$1 < 9$ — not satisfies eq^{n} (i)

for $r=1$

$2^1 \quad (8+1+1)$

$2 < 10$ (not satisfies eq^{n} (i)

for $r=2$

$2^2 \quad (8+2+1)$

$4 < 11$ not satisfies eq^{n} (i)

for $r=3$

$2^3 \quad (8+3+1)$

$8 < 12$ not satisfies eq^{n} (i)

for $r=4$

$2^4 \quad (8+4+1)$

$16 \geq 13$ Satisfies

R_1	R_2	R_4	R_8
2^0	2^1	2^2	2^3
1	2	4	8

11	10	9	8	7	6	5	4	3	2	1
0	0	1	R_8	0	0	1	R_4	1	R_2	R_1

$R_1 = \{1,3,5,7,9,11\} = \{1,1,1,0,1,0\}$

$R_2 = \{2,3,6,7,10,11\} = \{1,1,0,0,0,0\}$

$R_4 = \{4,5,6,7\} = \{0,1,0,0\}$

12

Date :

$R_8 = \{8, 9, 10, 11, 12\} = \{0, 1, 0, 0, 1\}$

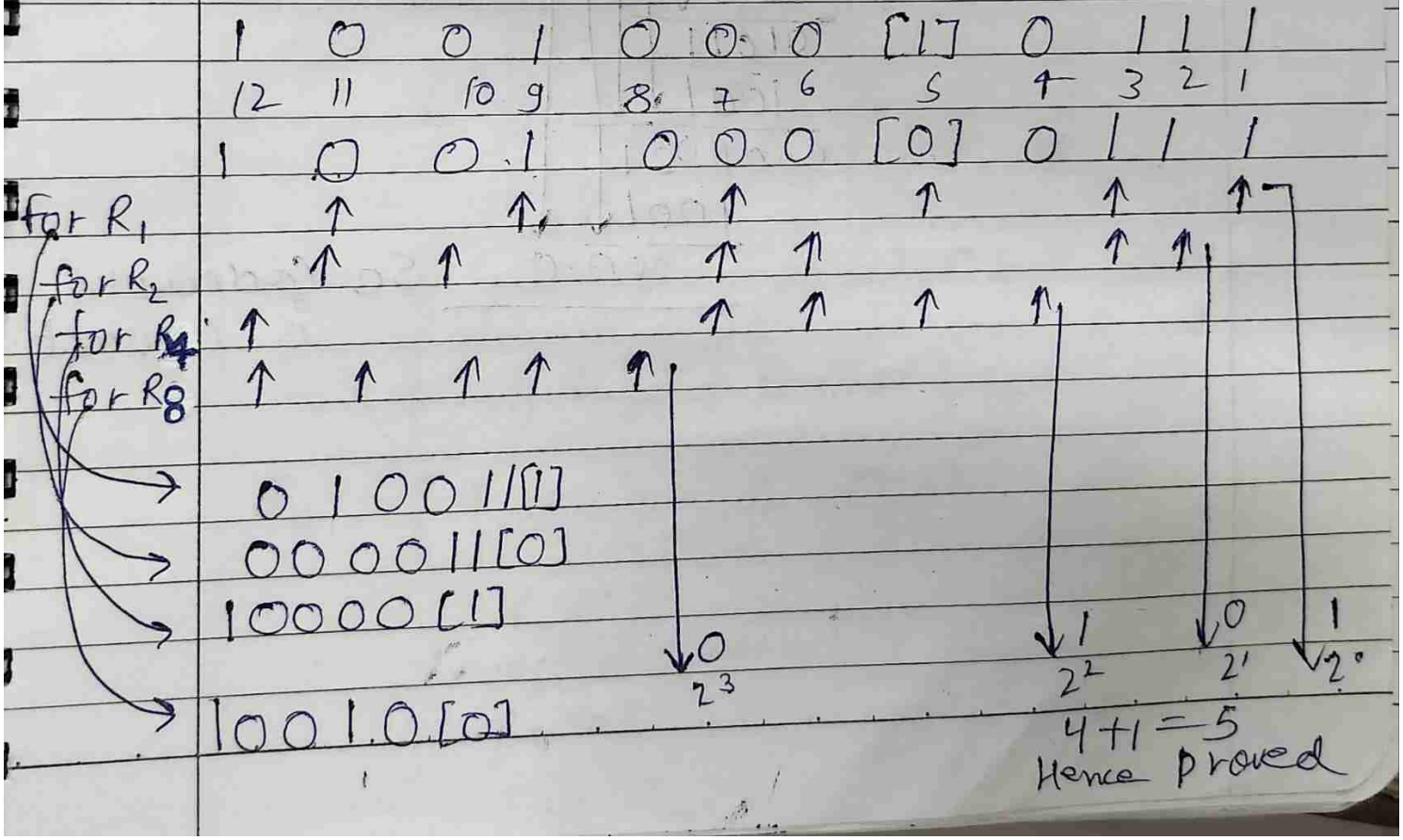
$R_1 = 1$
$R_2 = 1$
$R_4 = 0$
$R_8 = 0$

12 bit Hamming code is
1 0 0 1 0 0 0 1 0 1 1

if 5th position has error

1 0 0 1 0 0 0 [] 0 1 1 1
12 11 10 9 8 7 6 5 4 3 2 1
1 0 0 1 0 0 0 [0] 0 1 1 1

$R_1 = \{1, 3, 5, 7, 9, 11\}$
$R_2 = \{2, 3, 6, 7, 10, 11\}$
$R_4 = \{4, 5, 6, 7, 12\}$
$R_8 = \{8, 9, 10, 11, 12\}$



Date :

(2) Soln x^3+1 Polynomial equation

2^3 2^2 2^1 2^0
1 0 0 1

```
1001) 11001000 (1010
      1001
      -----
       0111
       1001
       -----
        0001000
           1001
           -------
            000100   Remainder (CRC)
```

11001000 → original data for checking codeword accept or not

```
1001) 11001100 (1101
      1001
      -----
       0111
       1001
       -----
        001001
           1001
           -------
             0000   So, Codeword is correct
```

Date :

Ques find 6 bit hamming code using 101 codeword

$2^r \geq (m+r+1)$ — (i)

for $r=0$

$2^0 \quad (3+0+1)$

$1 < 4$ not satisfies eqn (i)

for $r=1$

$2^1 \quad (3+1+1)$

$2 < 5$ not satisfies eqn (i)

for $r=2$

$2^2 \quad (3+2+1$

$4 < 6$ not satisfies eqn (i)

for $r=3$

$2^3 \quad (3+3+1)$

$8 \geq 7$ satisfies eqn (i)

R_1	R_2	R_4	R_8
2^0	2^1	2^2	2^3
1	2	4	8

6	5	4	3	2	1
1	0	R_4	1	R_2	R_1

$R_1 = \{1, 3, 5\} = \{1, 1, 0\}$

$R_2 = \{2, 3, 6\} = \{0, 1, 1\}$

$R_4 = \{4, 5, 6\} = \{1, 0, 1\}$

$R_1 = 1$

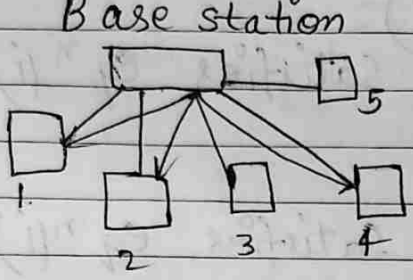
$R_2 = 0$

$R_4 = 1$

Date :

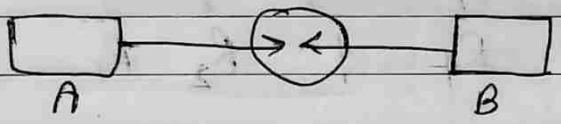
6 bit hamming code is
10 1101

- Access Control → Multiple access
  - Aloha
    - Pure Aloha
    - Slotted Aloha



Mobile Communication
20,000 Subscribers
20,001

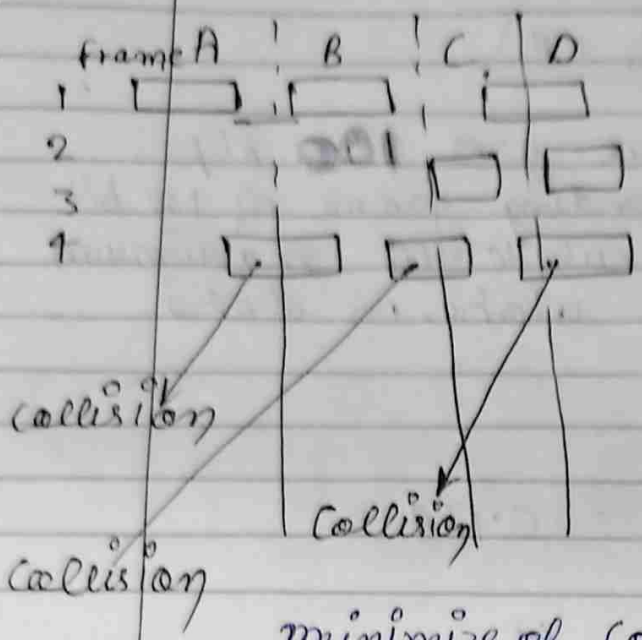
- Roles of Aloha
  - → It has a Base Station having many devices
  - → It get Acknowledgement.
- Collision



When one device sends message at the same time the other device is sending message towards first device then it creates Collision

Date :

Pure Aloha



$$\eta = Ge^{-2G}$$

efficiency

G = no. of host ~ node

e = exponential

minimize of collision

48 %

37 %

Slotted aloha

$$\eta = Ge^{-G}$$

- Poisen Distribution

$$P(K) = \frac{G^K \cdot e^{-a}}{k!} = P(G, K)$$

K = no. of frames

Frame Time = T_f

$P(0) = ?$ $K = 0$ $G = ?$

$K = 0$ $G = 2G$

$$P(0) = \frac{(2G)^0 e^{-2G}}{2!} = e^{-2G}$$

$$\eta P_0 = GP(0) = Ge^{-2G}$$

Date :

$$\eta P_A = Ge^{-2G}$$

$$\text{Throughput} = \eta P_A \times B$$

Ques An aloha network uses **100** kbps bandwidth for sending frame of 100 bit long size calculate the maximum throughput of pure aloha in aloha network

Solution

Given,

$B = 100$

$\eta_{max} = 18.4\% = 0.184$

$$\text{Throughput} = \eta_{max} \times B$$
$$= 0.184 \times 100$$
$$= 18.4$$

Ques we have a pure Aloha network with 100 station if $T_{fr} = 1$ ms what is the no. of frame per ___ second each station can send to achieve the max efficiency

$$T_{vul} = 2 \times T_{fr}$$

Vulnerable time is a time period whose collision is maximum.

Soln

Maximum efficiency = 18.4%

$$T_{vul} = 2 \times T_{fr}$$

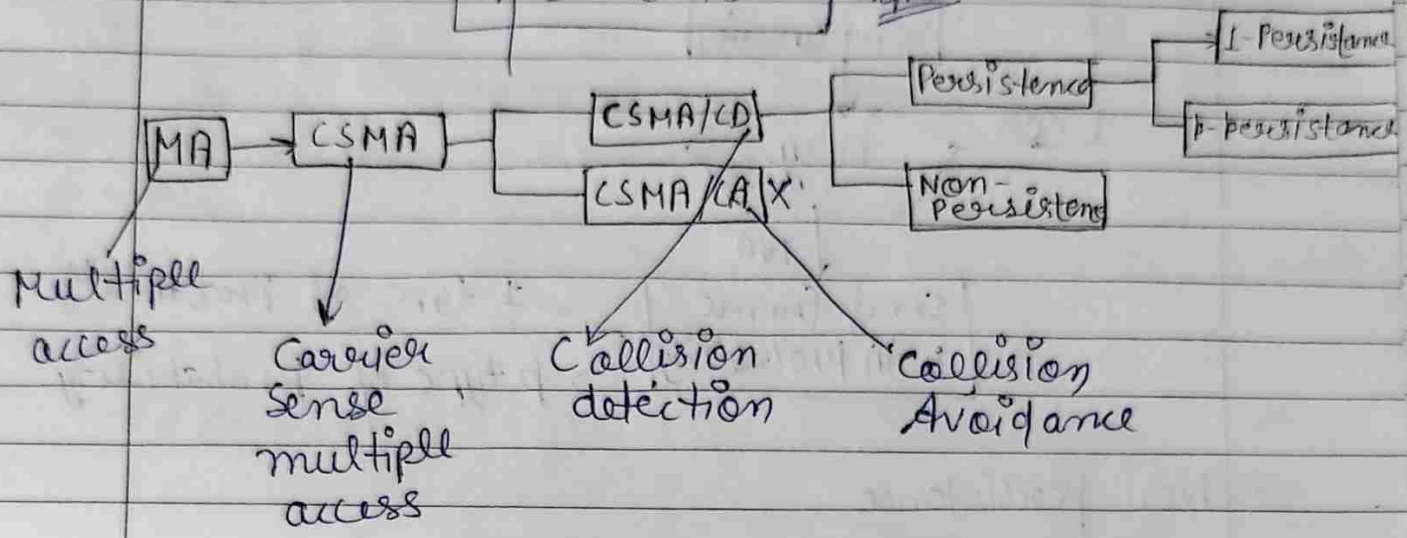
$$T_{fr} = \frac{T_{vul}}{2}$$

$$\eta = G \times e^{-2G}$$

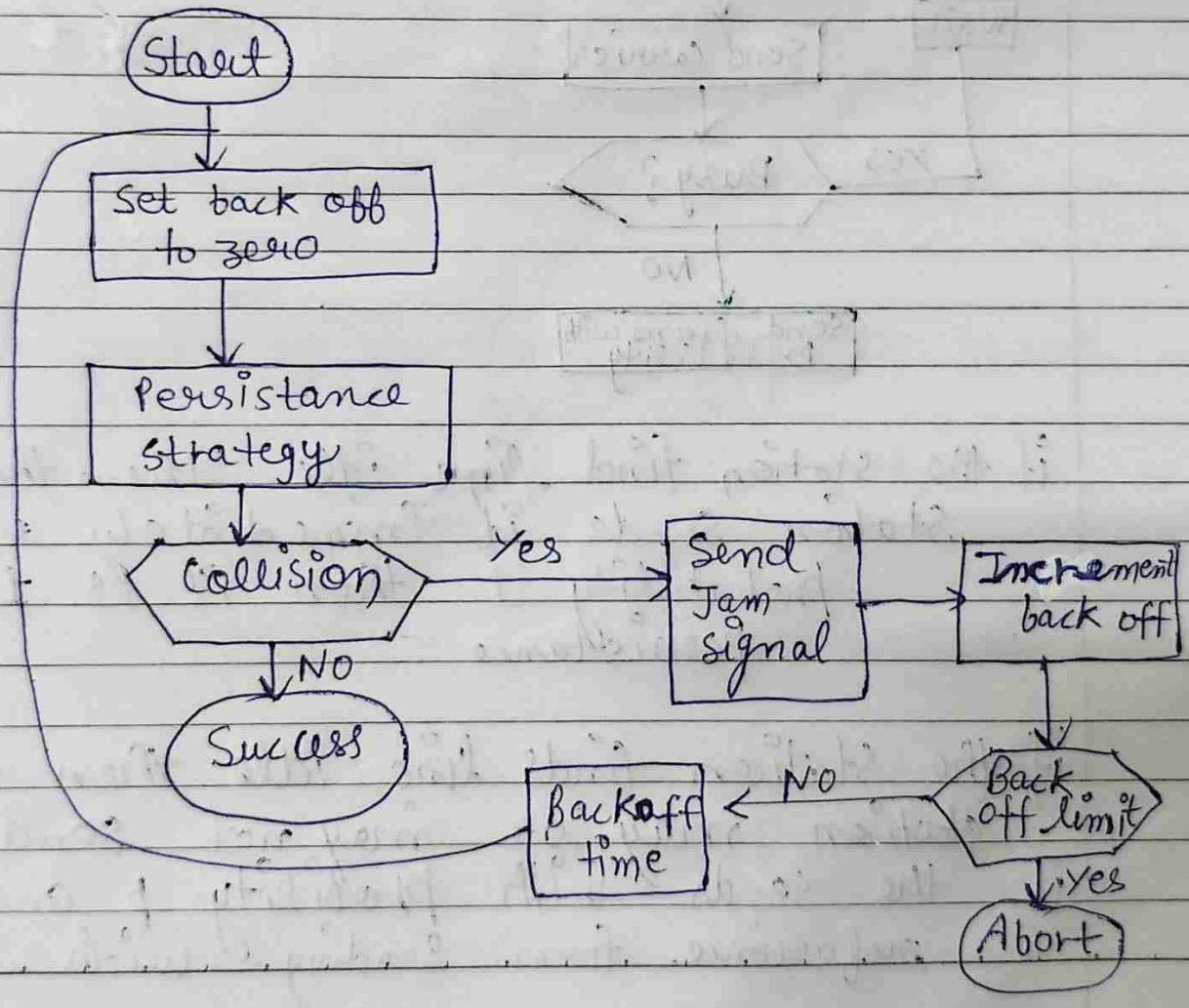
at $G = 0.5$

Date :

$$\eta = 0.5 \times e^{-2 \times 0.5}$$
$$= 0.5 \times e^{-1}$$
$$= 0.5 \times 0.36$$
$$\eta = 0.18$$ Ans

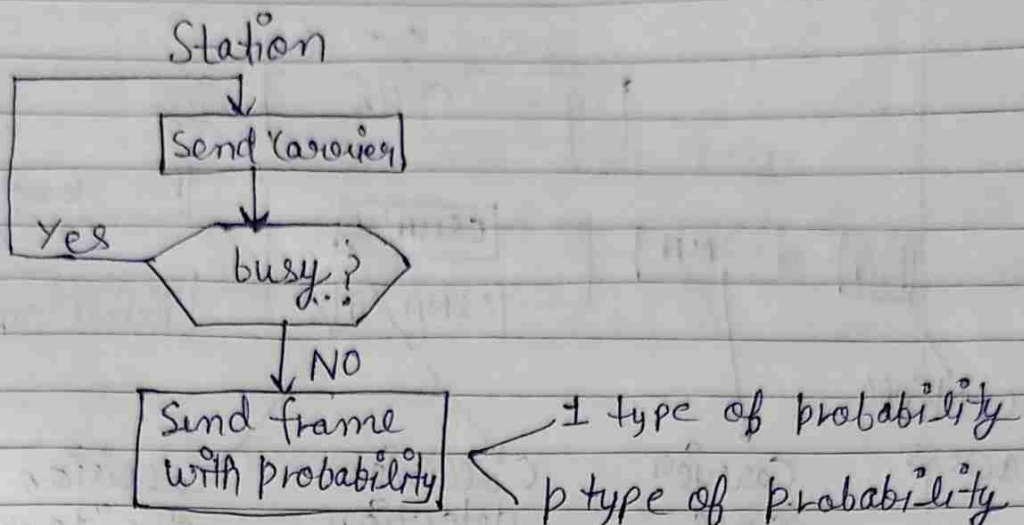


- Procedure of CSMA/CD

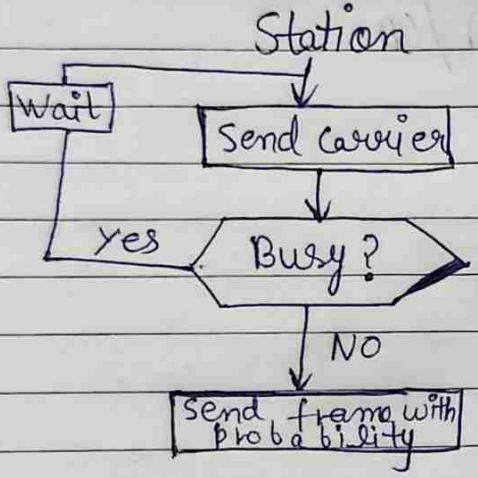


Date : _____

- Persistance



- Non persistence



if the station find line idle then the station sends it immediately with probability 1 then it is 1 persistance

if the station finds line idle then the station may or may not send if the sends with probility p and reference from sending with

Date :

probability (1-P) then it is called P-persistance.

- Ethernet

1) Topology → Bus topology
2) Access control → (CSMA / CD)
3) No acknowledgement
4) encoding → Manchester
5) Data rates → 10 MbPS, 100 MBPS, 1 GBPS, 10 GBPS
6) Limitations

ethernet is a lan technology that communicates to each other from one device to another device

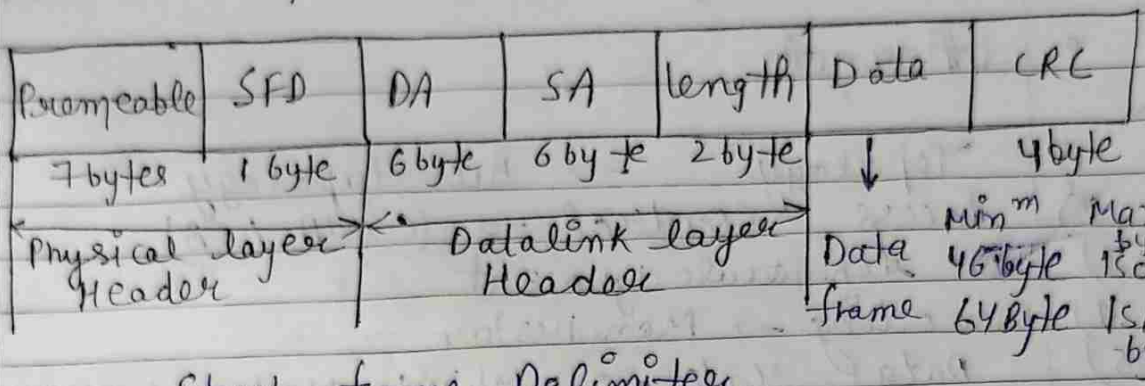
☆ 10MBPS → Normal ethernet
☆ 100MBPS → fast ethernet
☆ 1 GBPS → Gigabits ethernet
☆ 10GBPS → 10 Gigabits ethernet

Limitations

1) No guarantee in time to complete work (Real Time Application)
2) Minimum size of data → 46 byte
3) frame → 64 byte

Date :

Ethernet frame format



SFD → Start frame Delimiter
DA → Destination address
SA → Source Address
(48 bit MAC address)

Ques An: ethernet max Sub layer receives 42 byte of data from upper layer How many bytes of padding must be added to the data.

Soln