Prepared and Written By
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CSE-320

[DATA COMMUNICATIONS]

HANDWRITTEN NOTE

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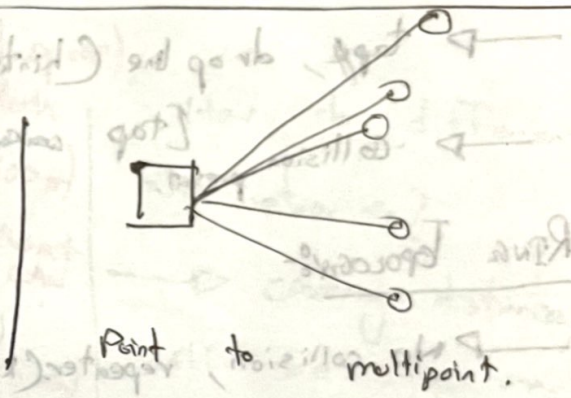
TYPES OF CONNECTION :-

Point to point : remote

Multipoint : tep telephone.



Point to multipoint.

Scenario based questions

MESH TOPOLOGY :

Q. How many ports & wires are needed to design the Mesh Topology.

Ans :- port → n-1

wire → $\frac{n*(n-1)}{2}$

(@common q.)

(For mesh)

[n = no. of device]

→ Robust.

Robust :- If one is dead all will be in proble

STAR TOPOLOGY :-

→ Point to point / point to multipoint

wires :- n

sharing :- multipoint

BUS TOPOLOGY :-

→ point to multipoint.

→ tap, drop line (hints)

[tap weakens the signal]

→ Collision present.

wires :- n+1

RING TOPOLOGY :-

→ No collision, repeater (hint)

wires :- n - 1

HYBRID TOPOLOGY (Imp for exam) :-

(Imp for exam.)

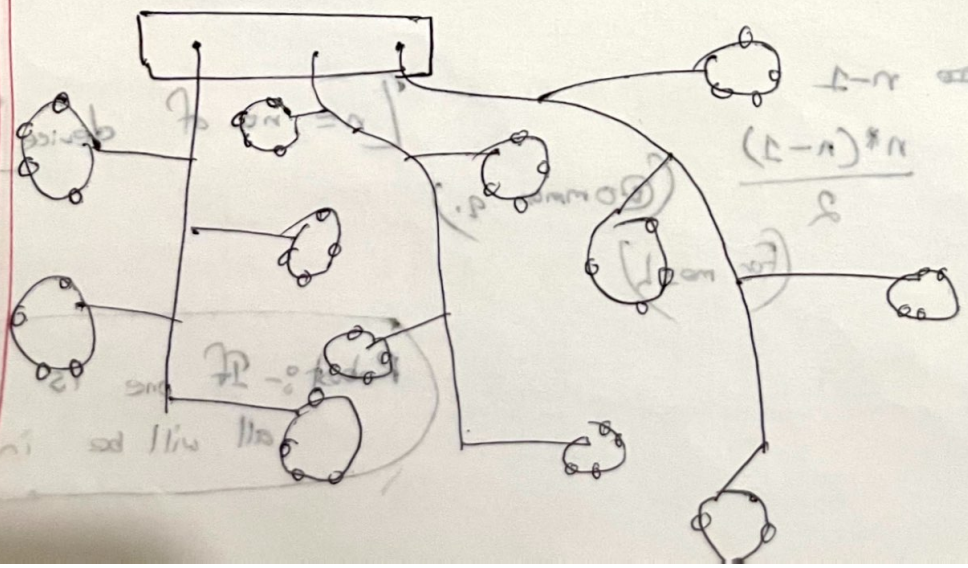
3 building → bus topology

↓ star topology

4 labs in every building

↳ 4 station in every lab.

↓ ring topology



INTERMEDIATE DEVICE :-

which connets all the other devices.

Software → services
Software → processes

eg:- service - degee
(Varsity) process — study, quiz, mid, final, g°

NETWORK TYPES :-

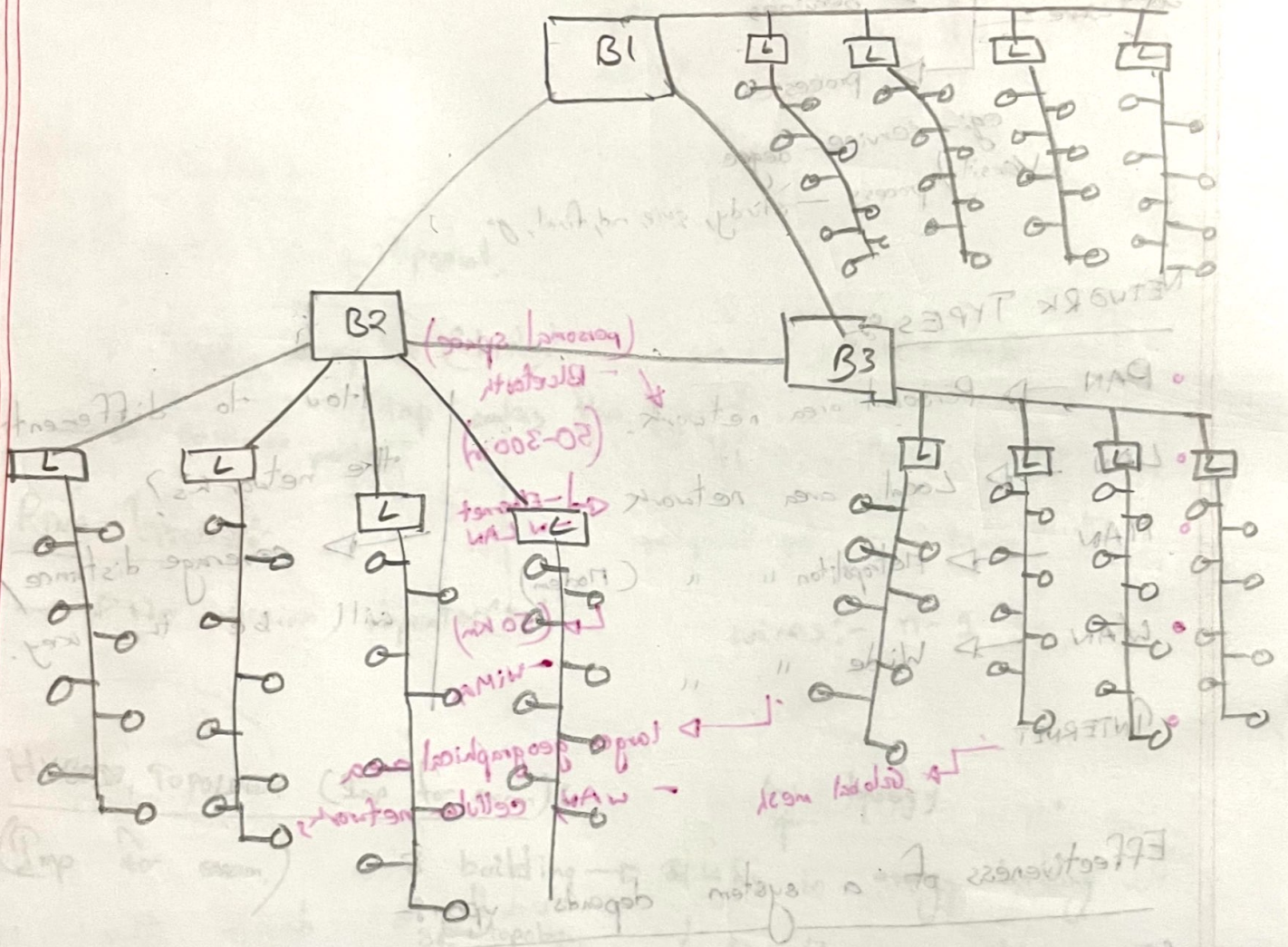
- PAN → Personal area network. (personal space) - Bluetooth (50-300 m)
- LAN → Local area network - Ethernet - W LAN
- MAN → Metropoliton " " (Modem) (50 km) - WiMax
- WAN → Wide " " → larger geographical area - WAN, cellular networks
- INTERNET → Global mesh

How to differentiate the networks?
→ coverage distance / radius will be the key.

Effectiveness of a system depends upon :-

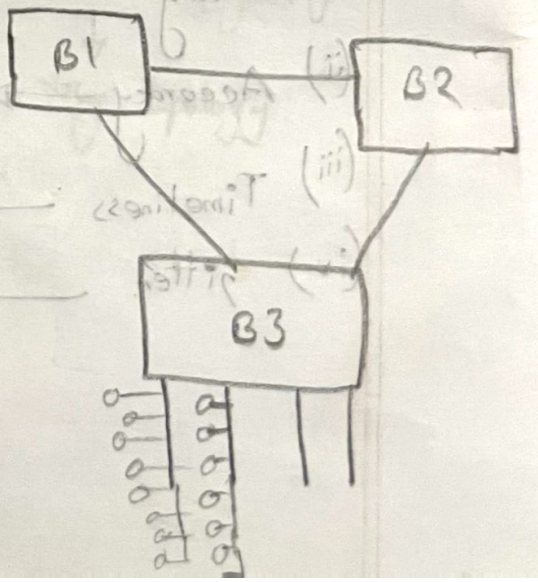
(i) Delivery
(ii) Accuracy → the transmitted data should be accurate.
(iii) Timeliness →
(iv) jitter. → There should be no overflow/underflow.

Hybrid Topology practice



Wires : 36x3 +3 = 111

~~15x3~~



☆ APPLICATION LAYER

→ Allow access to network resources.

→ ~~prep~~ prepares human communication for transmission over the data network.

Q. → Which type of layer Banking is?

BENEFITS OF LAYERS →

(i) To find out fault easily.

(ii) changes in one layer does not affect other layers

Presentation layer :-

→ Works for data encryption.

→ " " compressing data.

→ responsible translation, Compressin, ~~de~~ encryption.

SESSION layer :-

(i) Authentication :- If the User ID & Password is correct.

(ii) Authorization :- Permission to enter/access the server

responsible for dialog control and synchroniza

establish, manage terminate session

USE :-

→ To operate a active session ~~corre~~ smoothly

session layer?

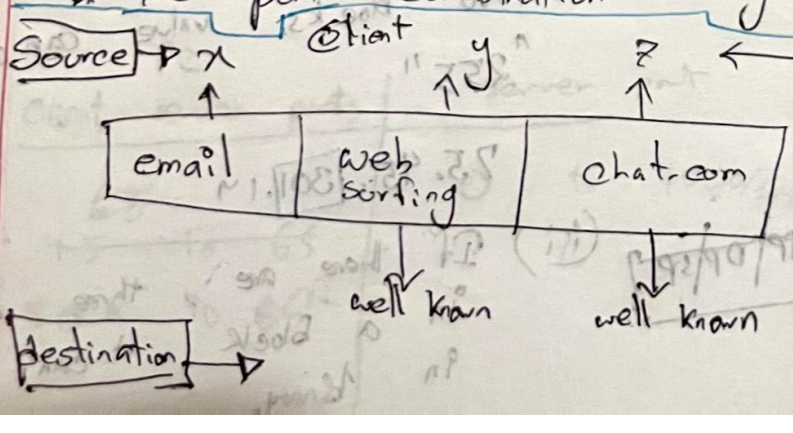
PORT ADDRESS :-

Application identifier.

Port address is a 16 bit address.

The port combination ~~ran~~ range is 0 to 2^{16}

What if new programs gets installed new port generated?



Part of transport layer

transferring port

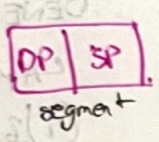
that's why transp

TRANSPORT LAYER :

→ responsible for process to process message delivery.

→ error recovery.

PDU: segments | flow & error control connection control



DP - Destination Port
SP - Source "

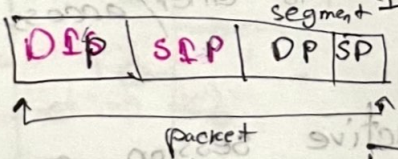
NETWORK LAYER :-

→ Router is a device of network layer.

→ Router checks IP Address

Responsible for delivery of individual packets from source to destination

PDU: Packets



IP Add use :-

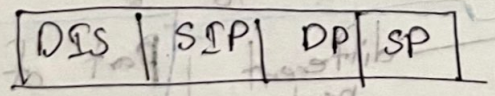
(i) helps to route

(ii) When IP

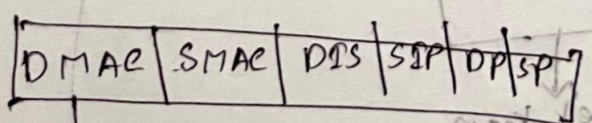
(iii) It is logical address

"Identify devices on different networks"

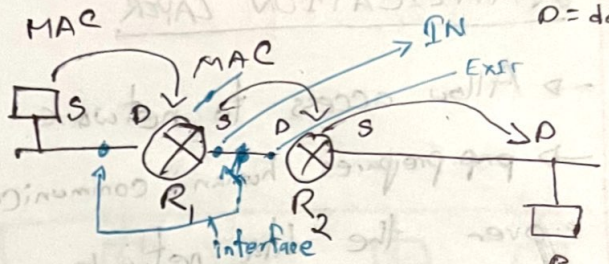
when we are adding DMAC and SMAC to

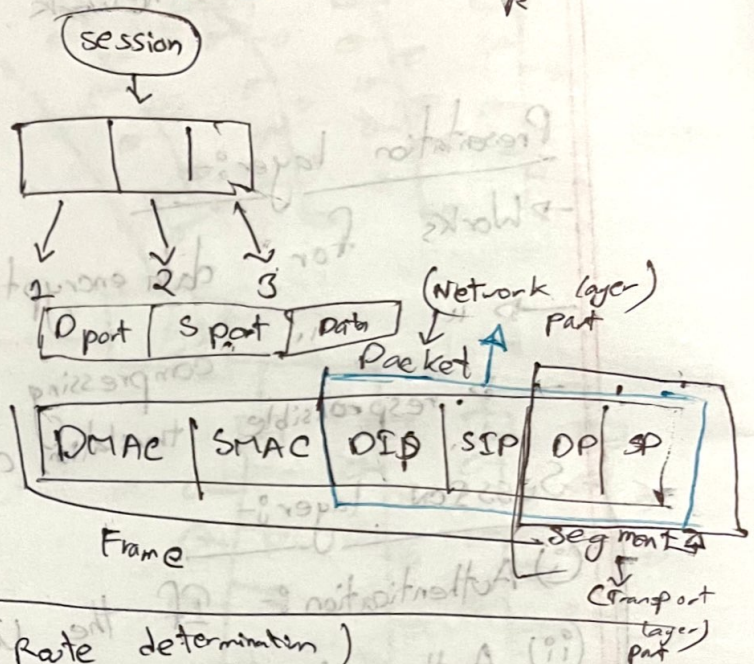


become Frame.



S = Source
D = destination





IP Address : Dynamic host address protocol

IP address format :-

(i) There will be no leading "0"

111.56.045.78

(ii) No blocks value can cross "255"

75.45.301.14

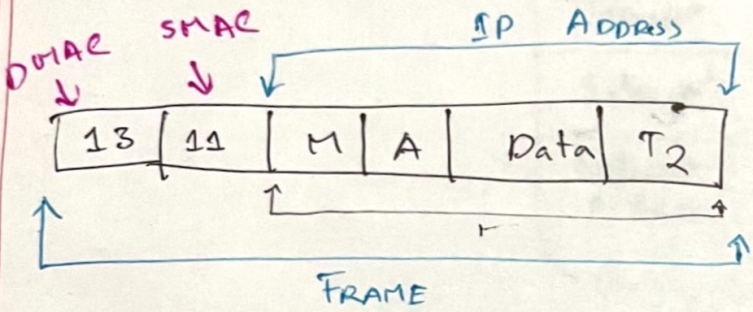
(iii) If there are three digits in a block it can't be in binary.

(iv) If 4, 5, 6, 7 no. of digits are invalid.

(v) If there are 8 digits it will check if its a binary no. or not
if. binary no.: accept else: invalid.

MAC ADDRESS USE :-

Physical address which helps to move from one MAC to another. ("Identify devices in the same network")



DATA LINK LAYER

(i) Flow control
(ii) error control
(iii) Framing
(iv) Access control.

→ responsible for moving frames from one hop to the next.

DMAC SMAC D

PDU :- FRAME

Slide-57 (Simulation)

S-1 → 11 to 13 Hop-1
OUT IN

S-2 → 21 to 22 " -2
OUT IN

S-3 → 31 to 32 " -3
OUT IN

S-4 → 41 to 42 " -4
OUT IN

S-5 →

SLIDE - 73 (simulation

Source port → a
Destination " → K
Source MAC → A
Destination " → M

Quiz-1 (chapter 1 & 2)

PC
Client ports: 50K to 65K

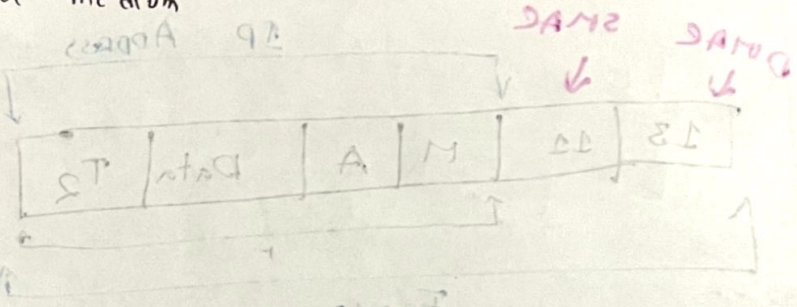
server port: 0 to 1000/1023

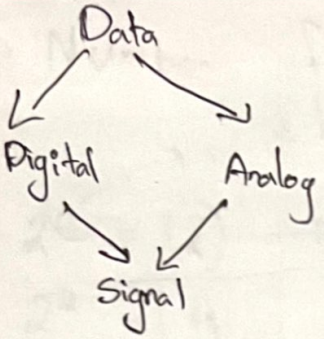
Addressing / slide-58

Physical layer:

→ responsible for movements of individual bits from one hop to the next

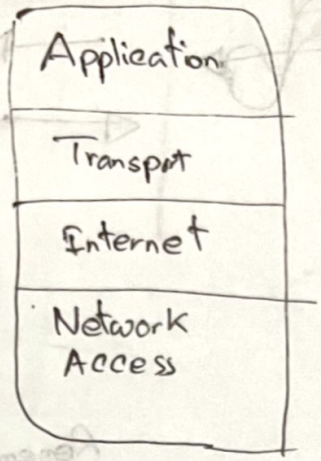
→ Transmit bits over a medium





What is it in De facto standard?

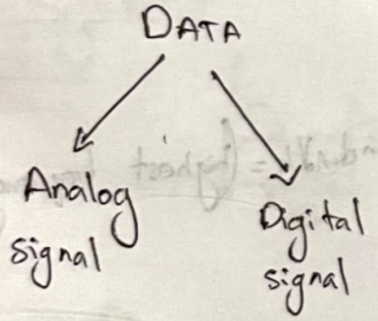
Ans:- follow TCP/IP



In TCP/IP there isn't anything like PDU

☆Write an example of specific address?
(exam Q.)

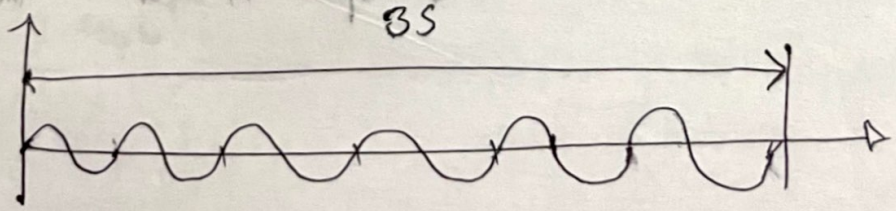
DATA & SIGNALS



We use periodic analog signal to communicate. Because, we can easily ~~mo~~ modu and demodulate the signal.

Also, we use non periodic digital signa

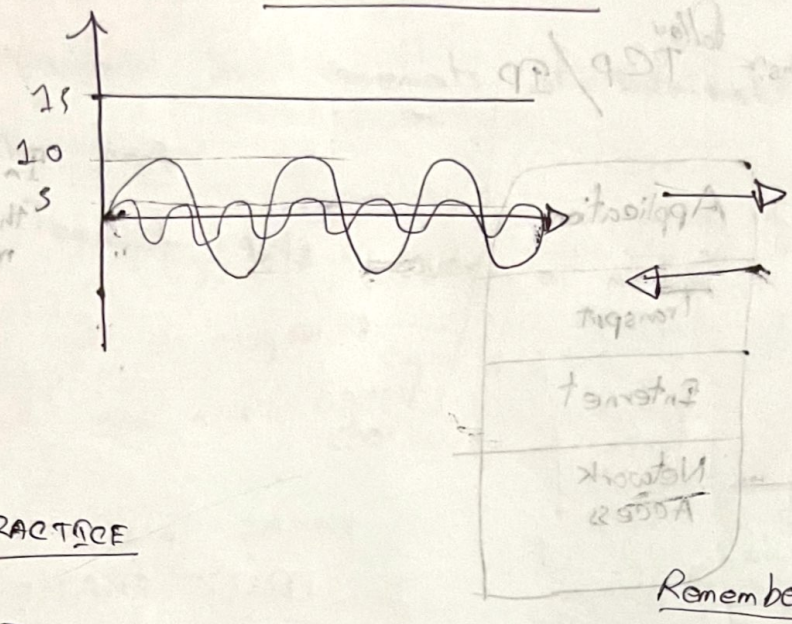
Frequency & Time period:-

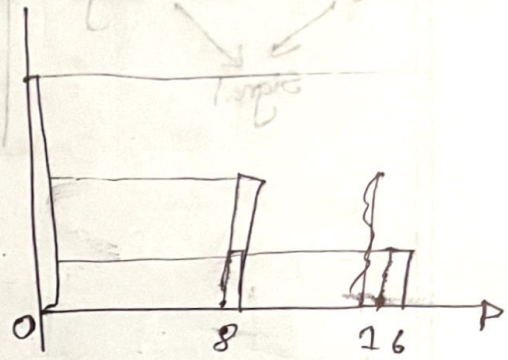


3S → 6

$f = \frac{6}{3} = 2$

Imp for exam





PRACTICE

Remember all these units :-

$T = 100\ ms = 100 \times 10^{-3}\ s$

-12 -9 -6 -3 0 3 6 9 12

nano micro milli Kilo

$$f = \frac{1}{T} = \frac{1}{100 \times 10^{-3}} = 10\ Hz = 10 \times 10^{-3}\ kHz = 10^{-2}\ kHz$$

BANDWIDTH :

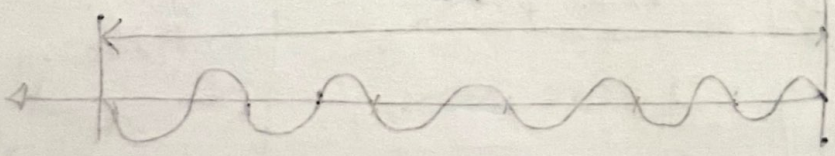
The per second passing capacity.

Bandwidth = (highest frequency - lower f freq

Possible Math :-

highest frequency = 900 Hz

Bandwidth = Diw the band spectrum of the frequency



Number of bits per level = $\log_2(L)$ → no. of level.

$2^{(1)} = (2)$ → no. of level.
(1) → no. of bit

$2^2 = 4$

$2^3 = 8$

$\log_2 N = 9$

$2^N = 9$ → This will be result into fractional no. of bits (N). It is not possible because no. of bits have to be integer. and as well as power of "2"

PROBLEM 8–

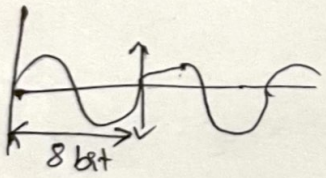
1 character → 8 bit

80 " → 80 × 8 bit

3.18 :-

$100 \times \underbrace{24}_{\text{given}} \times \underbrace{80}_{\text{given}} \times 8$ bps

PROBLEM :- 3.19



$f_H - f_L = B$

f_H → upper, f_L → lower, B → Bandwidth

→

$2 \times 4000 \times 8$

8 bits per sample

☆ $P_1 \longrightarrow P_2$ / (~~P_1~~)

loss of power = / gain of power $= 10 \log_{10} \frac{P_2}{P_1}$

P_2 → destination point

P_1 → start point

positive → gain condition / state

negative → loss condition / state

Attenuation : power signal reduced

Distortion :-

why the sender and receiver getting different signals.

→ distortion, → Phase shifting.

Signal to noise ratio :-

☆ $SNR = \frac{\text{average signal Power}}{\text{average noise Power}}$ ☆ $SNR_{dB} = 10 \log_{10} SNR$

Ex-5.31

high SNR is good for transmission channel

✓ $SNR = \frac{4}{2}$ good ↑ noise low

$SNR = \frac{2}{4}$ ✗ bad ↓ noise high

Noiseless channel (Nyquist bit rate)

Bandwidth = $f_h - f_l$ (f_h: highest frequency, f_l: lowest frequency)

$$\text{Bitrate} = 2 \times \text{bandwidth} \times \log_2 L$$

maximum capacity / maximum transmission.

[Noiseless channel] ↑

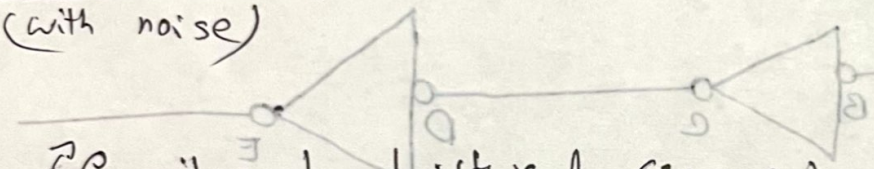
Data rate depends on three factors:-

(i) bandwidth available

(ii) Levels of signal we use

(iii) noise of the signal

Shannon capacity (with noise)



Capacity = bandwidth × $\log_2(1+SNR)$

is these two the same

noise = 20 mW

signal = 60 × 20

PRACTICE SHEET.

data rate = 108 GB / 6 hour

$= \frac{108 \times 10^9 \times 8 \text{ bits}}{6 \times 60 \times 60 \text{ s}}$

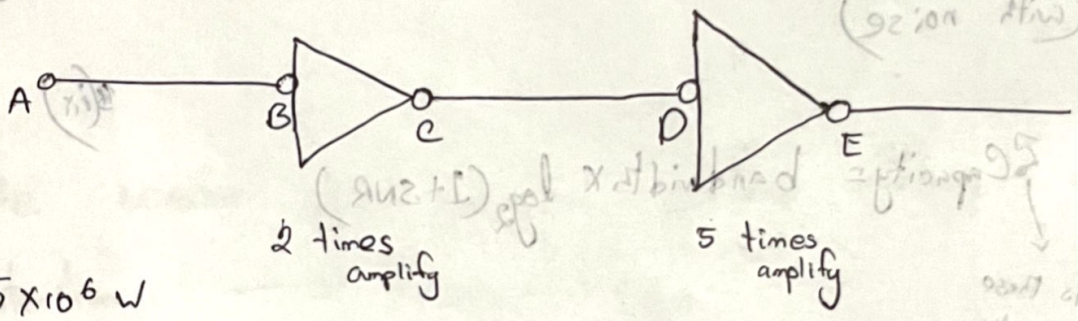
$= 40 \times 10^6$ bps

$BW = f_h - f_l$

$= 14 \times 10^6 -$

→ Incomplete.

PROBLEM :



At A: 5×10^6 W

A to B: $100 \times 5 \times 10^3 = 500 \times 10^3 = 0.5 \times 10^6$ W

At B: $5 \times 10^6 - 0.5 \times 10^6 = 4.5 \times 10^6$ W

Loss of Power in dB (A to B): $10 \log_{10} \frac{4.5}{5} = -0.45$ dB

$\frac{2x}{x} = \frac{2 \times 0.45}{0.45}$

Gain of Power in dB (B to C): $10 \log_{10} 2 = 3.01$ dB

Loss of Power in dB (C to D): $-(20 \times 0.05) = -10$ dB

It's already given in dB that's why we didn't used $10 \log_{10} \frac{P_2}{P_1}$ formula.

Gain of power in dB (D to E): $10\log_{10}\frac{5\pi}{\pi} = 6.98$

Total change of signal power = $-0.45 + 3.01 * -10 + 6.98$

$= -0.46$

Comment: Attenuated.

Bandwidth

(i) Analog: 20 to 30 Hz can pass through the channel.

(ii) Digital: The number of bits.

Example- 3.44

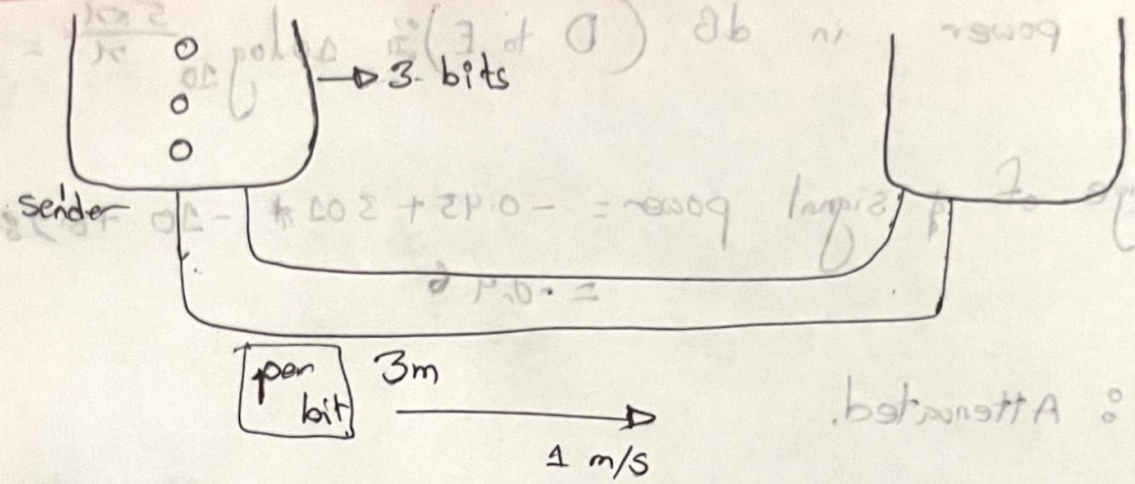
10 Mbps → capacity

$$\text{Throughput} = \frac{12000 \times 10,000}{60} = 2 \text{ mbps}$$

☆ LATENCY:-

Queuing time:- The amount of time which we need to wait.

Processing " :- " " " " " a device need to process.



The amount of time a bit takes to travel from one position to another. (Propagation time)

Transmission time :

PRACTICE: P3-33:

frame = 5×10^6 bits

The ter length (distance) = 2000×10^3 m
= 2

speed = 2×10^8 ms^{-1}

Bandwidth = 5×10^6 bps

Propagation delay = $\frac{d}{s} = \frac{2000 \times 10^3}{2 \times 10^8}$ s

Transmission time = $\frac{\text{size}}{BW} = \frac{5 \times 10^6}{5 \times 10^6}$

Queuing time = $10 \times 2 \times 10^{-6}$ s

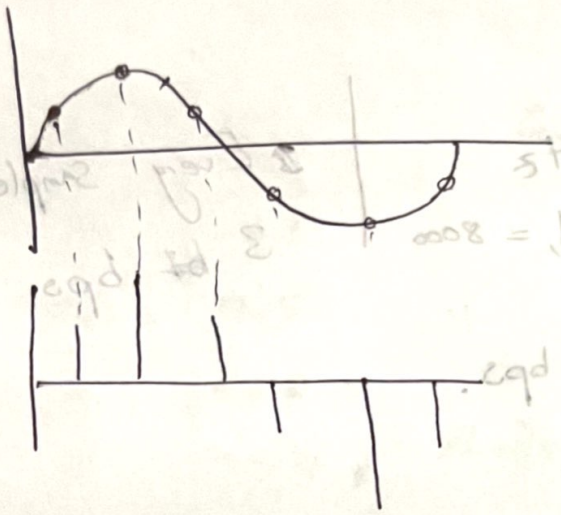
Processing time = $10 \times 1 \times 10^{-6}$ s

How can we increase the dominant factor time in latency.

Latency = P.T. + Q.T + PR. T. + T. T.

27/02/24

Sampling



Sampling → (Three types)

(i) The ideal.

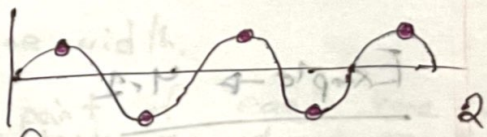
(ii) natural.

(iii) Flat-top. (vastly use)

No. of samples, $f_s = \frac{1}{T_s}$.

for 6 samples → $T_6 = \frac{1}{f_s}$ [sampling rate / sampling frequency]

→ Nyquist rate sampling, $f_s = 2f$

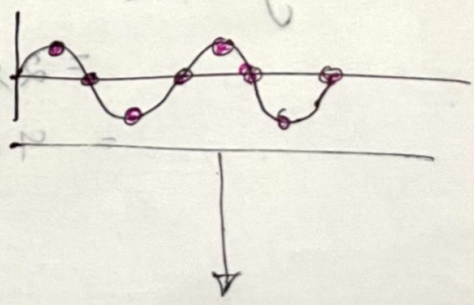


2.5

$f_s = 2 \times 2.5 = 5$

→ Undersampling, $f_s = 1.4f$

[less than nyquist rate]



→ Oversampling, $f_s = 4f$

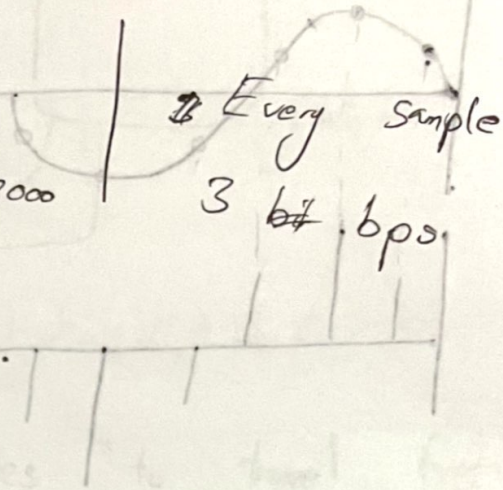
[more than nyquist rate]

Example:- 4.9

Given, max frequency = 4000 Hz

Sampling rate per second, = 8000

= 8000 x 3 = 24000 bps.



Every sample is 3 bits.

Low pass & Band pass:

Low pass:

$f_{min} = 0$ Always

Given, BW = 200 kHz

$f_h - f_l = BW$

$200 - 0 = B$

$f_h - 0 = 200$

Example → 4.1

Sampling rate = $2 \times f_{max}$

$= 2 \times 200$

$= 400$

$BW = f_h - f_l$

$f_h = 200$.

Figure - 4.26 (PCM) [V.V. imp for mid]

t(s)	A(V)
0	-6.1
1	7.5
2	16.2
3	19.7
4	11.6
5	-5.5
6	-11.3
7	-9.4
8	-6.0

Given, max y val → +20 V

min " " → -20 V

Every sample is 3 bit.

$\therefore \Delta = \frac{\text{highest} - \text{lowest}}{\text{no. of zone}}$

$\Delta = \frac{20 - (-20)}{8} = 5$ [zone width]

$\therefore \log_2 L = 3$

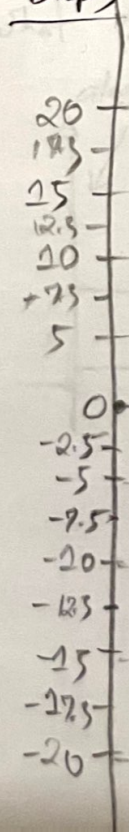
$L = 2^3$

$= 8$ [no. of zone]

Step-1 → divide the zones using zone width.

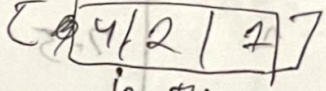
Step-2 → find out the mid point of each zone width.

Step-3 → find the normalized value (dividing the mid point with the zone width)



Quantized error = Normalized mid point − Normalized point value

Quantization code = The number of zone, in



in this format.

How we can minimize the amount of error?

⇒ increase the no. of segments.

Unipolar :-

only at one side

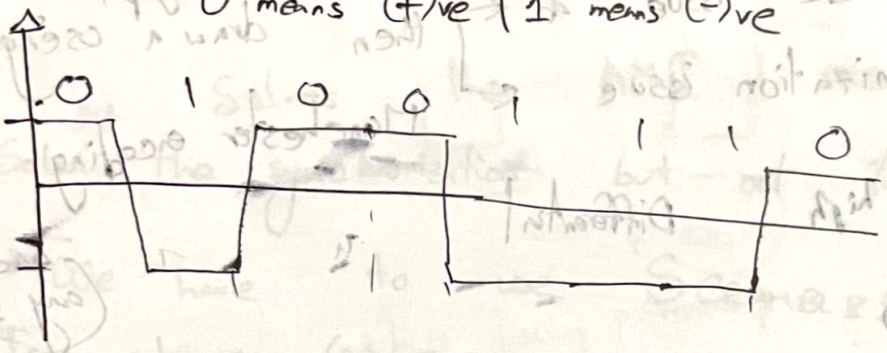
(problem)

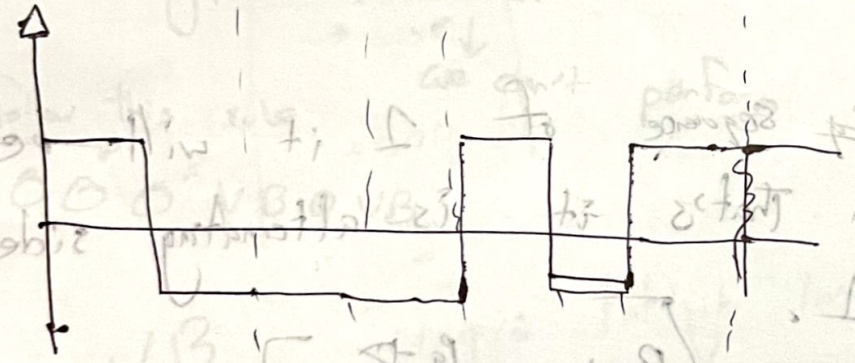
(problem)

long sequence of 1 or problem

NRZ - L (Encoding) Bipolar :-

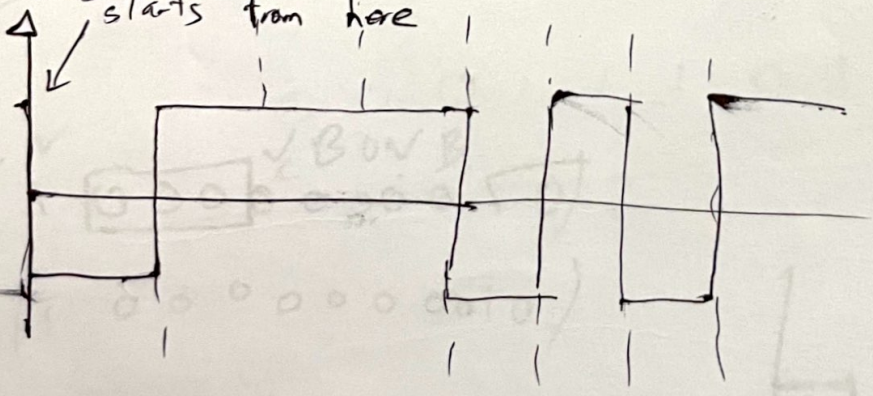
0 means (+)ve | 1 means (-)ve





What if starts with '1'

always starts from here



NRZ - I (Encoding) Bipolar :-

0 means (no inversion, stays same

1 means inversion.

Manchester Encoding (Biphase / Differential Encoding)

0 ⟶ ⊓ (falling edge) 1 ⟶ ⊔ (rising edge)

If there is no dc issue & then draw a using graph
no self synchronization issue ← Manchester encoding

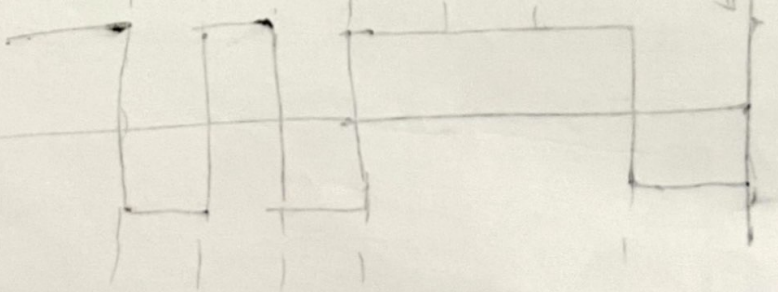
→ BW requirement high Differential
→ 2 NRZ
→ self clocking

(any 1)

AMI Encoding :-

If there is long sequence of 1 it will be dc component. That's it is alternating side where there is 1.

(Book → fig 10.5)



4B/5B encoding

20 Bits
↓ slice

4B | 4B | 4B | 4B | 4B
↓ ↓ ↓ ↓ ↓
5B 5B 5B 5B 5B

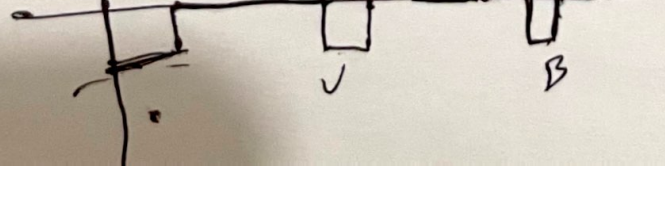
→ Solves the AMI encoding problem
Solve the synchronization but not the DC.

↳ We have to use "SCRAMBLING" technique.
Two types (i) B8ZS.
↓
we can't perform B8ZS without 8 zero's
follow this rule
000VB0VB

VB0VB

000VB0VB

following the previous bit becomes
(+)ve → (-)ve
(-)ve → (+)ve

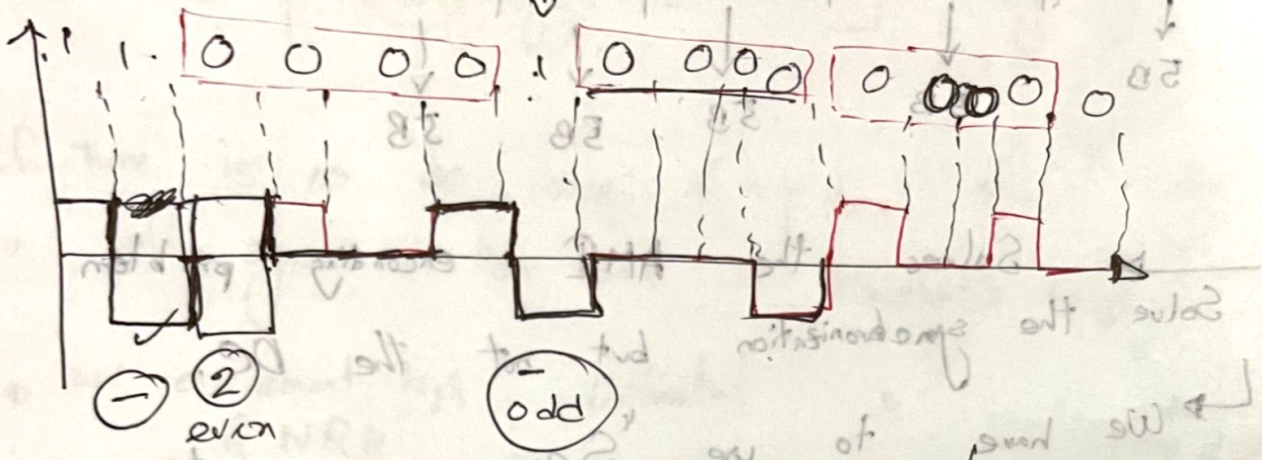


HDB3

0000

even positive

count the in between no. of 1's



B → Bipolar bit

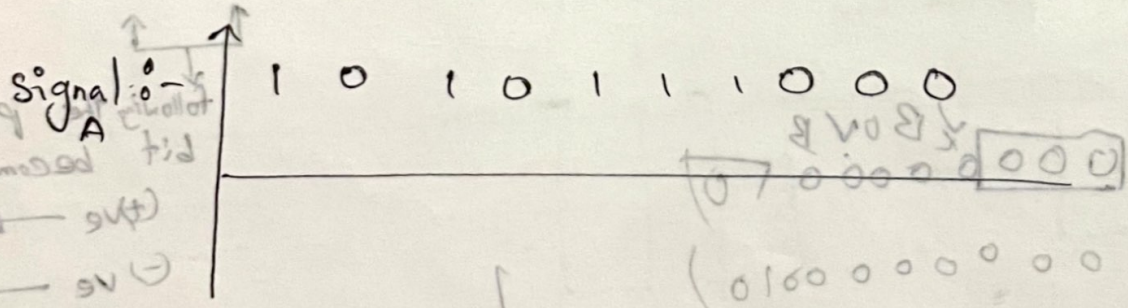
V → Violation bit

preceeding pulse	odd	even
−	000 −	00
+	000 +	

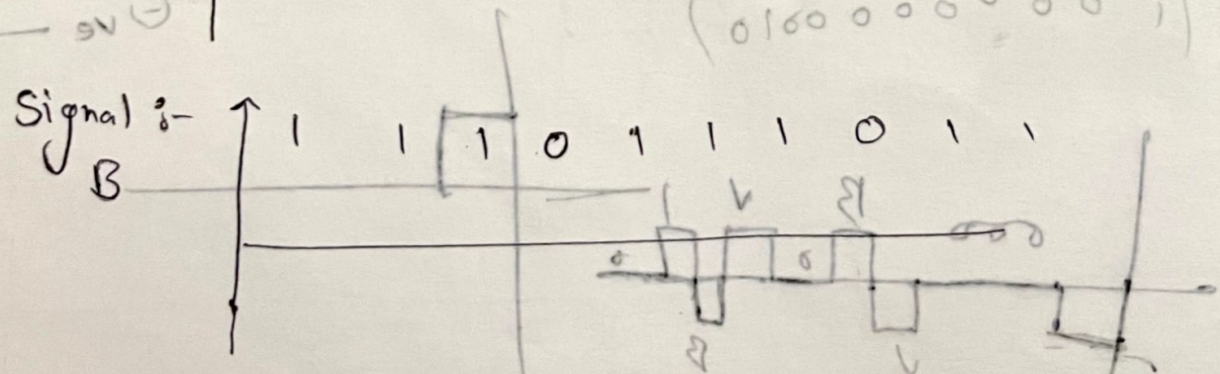
MSD → 3(a) final digital signal

apply manchestar

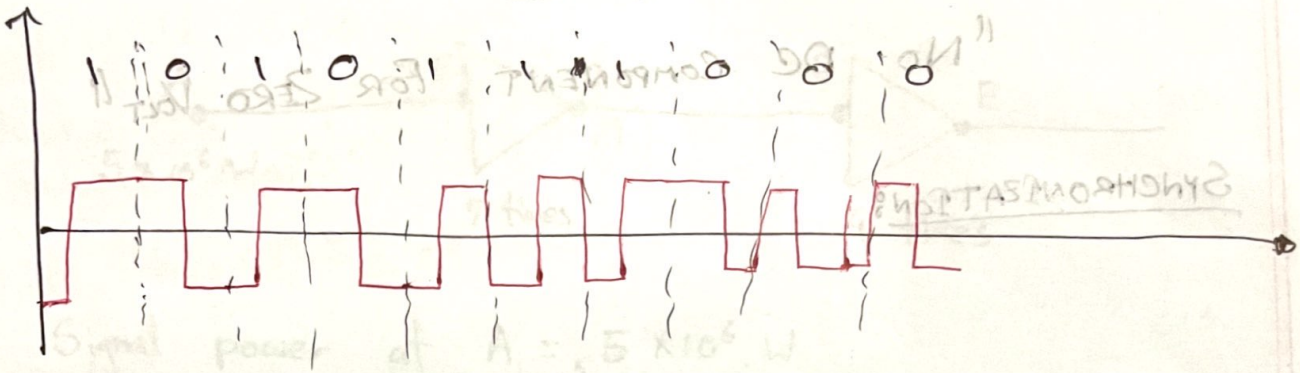
Signal A :-



Signal B :-



signal C : A AND B → C



Binary bits given ⟵ ⟶ Draw signal.
characteris given ⟵

characteristic given ⟵ ⟶ generate bits
signal given ⟵

opto MCT3 Slide. 33

charactic ~~no charcte~~

self synchronization
of long sequence of
zero missing

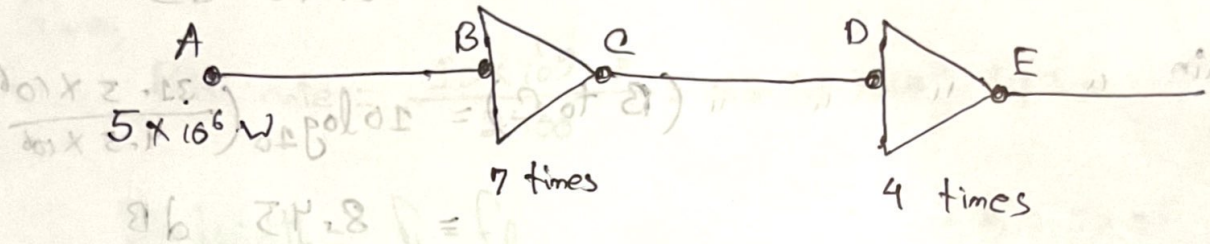
9 bps → 4

+ve
0
-ve

(1)

0 → same level

Answer to the q. no. - 1



Signal power at A = 5×10^6 W

Total power loss from A to B = $100 \times 5 \times 10^{-3}$
$= 0.5 \times 10^6$ W

Signal power at B = $5 \times 10^6 - 0.5 \times 10^6$
$= 4.5 \times 10^6$

Total power loss from C to D = $150 \times 5 \times 10^{-3}$
$= 0.75$ W

Signal power at D = $7 \times 4.5 \times 10^6 - 0.75$ W
$= 31.49 \times 10^6$ W

Signal power at E = $31.49 \times 10^6 \times 4$ W
$= 12.5 \times 10^7$ W

Loss of power in dB (A to B) $= 10 \log_{10} \left(\frac{4.5 \times 10^6}{5 \times 10^6} \right)$

$= -0.46$ dB

Gain " " " " (B to C) $= 10 \log_{10} \left(\frac{31.5 \times 10^6}{4.5 \times 10^6} \right)$

$= 8.45$ dB

Loss " " " " (C to D) $= 10 \log_{10} \left(\frac{31.49 \times 10^6}{31.5 \times 10^6} \right)$

$= -1.37 \times 10^{-3}$ dB

Gain " " " " (D to E) $= 10 \log_{10} \left(\frac{12.5 \times 10^7}{31.49 \times 10^6} \right)$

$= 6.02$ dB

Total change of signal power $= -0.46 + 8.45 - 1.37 \times 10^{-3} + 6.02$

$= 14.01$ dB [positive]

COMMENT: The power is being "Amplified".

Answer to the q. no.- 02

(a)

Given,

$$\text{Bit rate} = \frac{10 \times 10^9 \times 8}{2400} = 33.33 \times 10^6 \text{ bps}$$

$$\text{Bandwidth} = f_h - f_l$$
$$= 5 \times 10^6 - 90 \times 10^3$$
$$= 4.91 \times 10^6 \text{ Hz}$$

$f_h = 5 \times 10^6$
$f_l = 90 \times 10^3$

For noiseless channel,

$$\text{Bit rate} = 2 \times \text{Bandwidth} \times \log_2 L \quad | \quad L = \text{signal level}$$

$$\Rightarrow 33.33 \times 10^6 = 2 \times 4.91 \times 10^6 \times \log_2 L$$

$$\Rightarrow \log_2 L = \frac{33.33 \times 10^6}{2 \times 4.91 \times 10^6}$$

$$\Rightarrow \log_2 L = 3.39$$

$$\Rightarrow L = 2^{3.39} = 10.5$$

We have to take next available bit. Because, floating point level does not exist.

$$\therefore L = 2^4 = 16$$

(Ans)

(b)

From 'a' we get,

$L = 16$

From 'a'

Bandwidth = 4.91×10^6

Half of the signal level,

$L = 8$

Now,

$$\text{Bit rate} = 2 \times 4.91 \times 10^6 \times \log_2 8$$

$$= 29.46 \times 10^6 \text{ bps}$$

We can observe that bit rate has been been reduced to 29.46×10^6 from 33.33×10^6 bps. So, we are losing some amount of ~~bits.~~ or data for the half of signal level.

So, it ~~is~~ would be a disadvantage ~~for us~~ of using half of the number of signal levels. Bea Because, we are losing some amount of data, or bits.

(c)

Given,

Signal power strength = $60 \times 20 \times 10^{-3}$

Noise power strength = 20×10^{-3}

$$SNR = \frac{60 \times 20 \times 10^{-3}}{20 \times 10^{-3}} = 60$$

From 'a'

Bandwidth = 4.91×10^6 Hz

$$\text{Capacity} = 4.91 \times 10^6 \times \log_2(1+60)$$

$$= 29.1 \times 10^6$$

(Ans)

Answer to the q. no. - 03

Here,

Processing Time = $5 \times 3 \times 10^{-6} = 1.5 \times 10^{-5}$ s

no. of router = 5

Queuing Time = $5 \times 5 \times 10^{-6}$

$= 2.5 \times 10^{-5}$ s

Now,

$$\text{Propagation Time} = \frac{\text{distance}}{\text{speed}}$$

$$= \frac{3000 \times 10^3}{2 \times 10^8}$$

$$= 0.015 \text{ s}$$

and,

$$\text{Transmission Time} = \frac{\text{size}}{\text{Bandwidth}} = \frac{5 \times 10^6}{1.5 \times 10^9}$$

$$= 3.33 \times 10^{-3} \text{ s}$$

$$\text{Latency} = 0.015 + 3.33 \times 10^{-3} + 2.5 \times 10^{-5} \times 1.5 \times 10^{-5}$$

$$= 0.018 \text{ s}$$

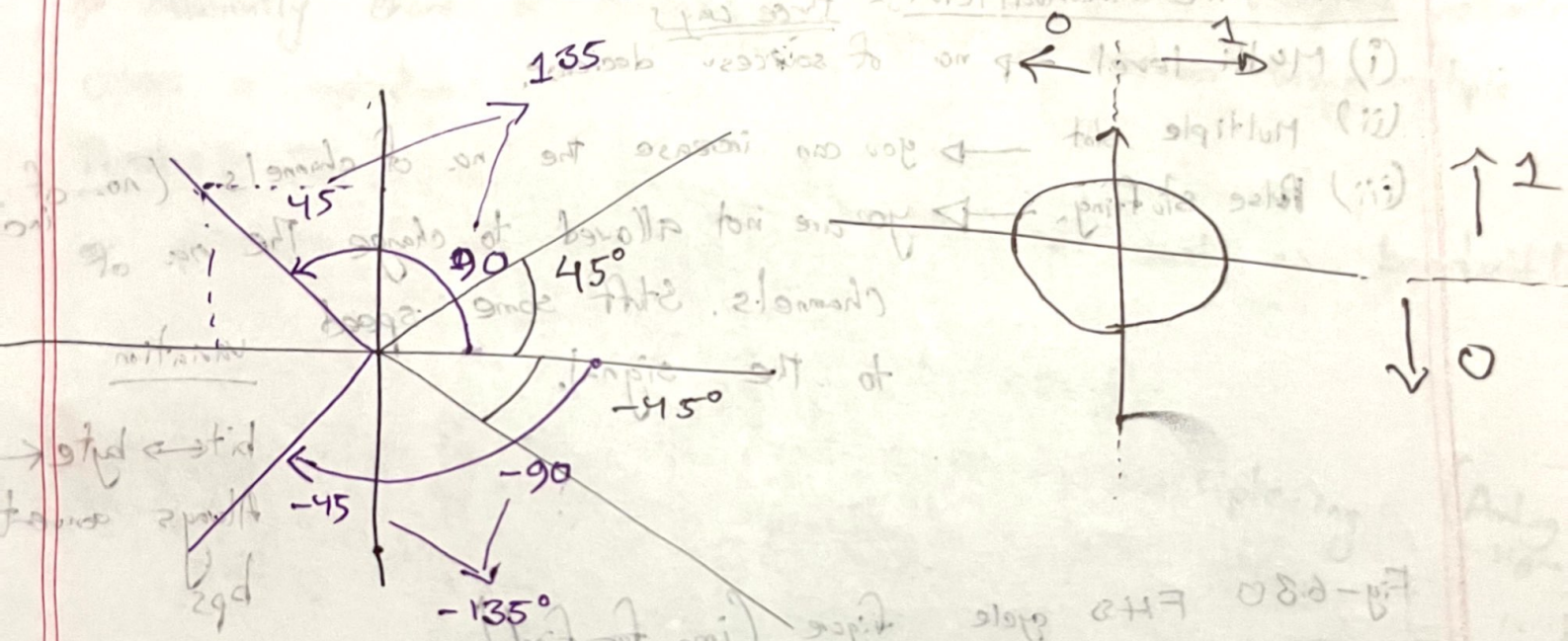
Here,

Dominant component is Propagation time [largest]

Negligible " " Processing " [smallest]

(Some parts need to be retrieved)

CONSTELLATION DIAGRAM:-



(MULTIPLEXING)

05/04/24

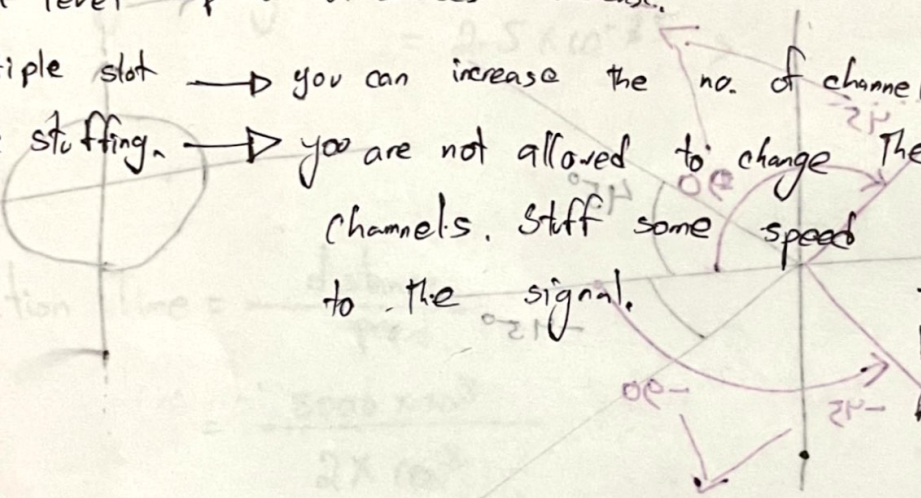
Empty slots in synchronous medium

DATA RATE MANAGEMENT:- three ways

(i) Multi level → no. of sources decrease.

(ii) Multiple slot → you can increase the no. of channels. [no. of sources increase]

(iii) Pulse stuffing. → you are not allowed to change the no. of channels. Stuff some speed to the signal.



variation

bit ↔ byte ↔ bps

Always convert to bps

Fig-6.30 FHSS cycle figure (imp for final)

(ONLINE) (BASIC)

~~Class 1~~

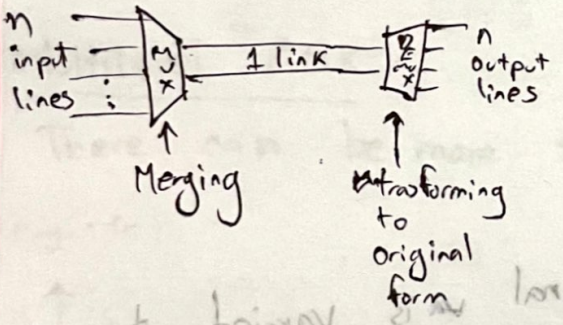
MULTIPLEXING

We have to utilize bandwidth properly for that we have to achieve ~~bandwid~~ specific goals [→ This chapter goal]

MULTIPLEXING :-

Multiplexing is a technique used in telecommunication and computer networks to efficiently share a communication channel or medium among multiple users or applications.

PURPOSE :- To maximize the available resources, such as bandwidth or physical transmission lines.



Types of multiplexing :-

(i) frequency division multiplexing (Analog signal)

(ii) wavelength

(iii) Time (Digital)

[Chapter-5]

ANALOG TRANSMISSION:-

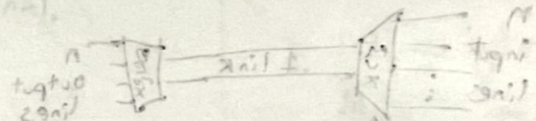
Digital to analog conversion is the process of changing one of the characteristics of an analog signal based on the information of in digital data

↳ what characteristic?
(i) phase (ii) Amplitude (iii) Frequency.

Digital to analog conversion three types:-

(i) Amplitude shift keying [ASK]
(ii) Frequency " " [FSK]
(iii) Phase " " [PSK]

combines the techniques → Quadrature Amplitude Modulation (QAM)

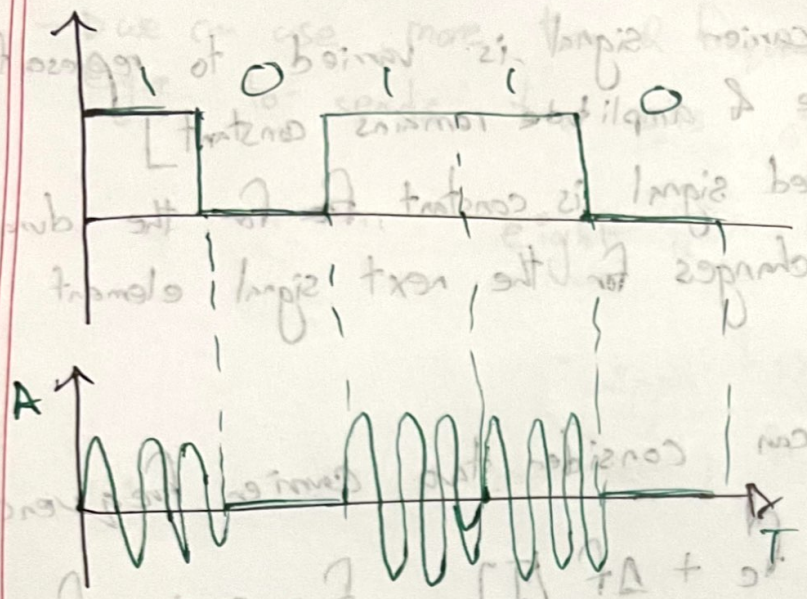


Amplitude shift keying:-

→ The amplitude of the carrier signal is varried to create signal elements.
[Both frequency & phase remain constant]

→ ASK is normally implemented using only two levels.
[Although there are several levels]
This is referred to as Binary Amplitude shift keying or On-off shift keying (OOK)
(BASK)

Example:-



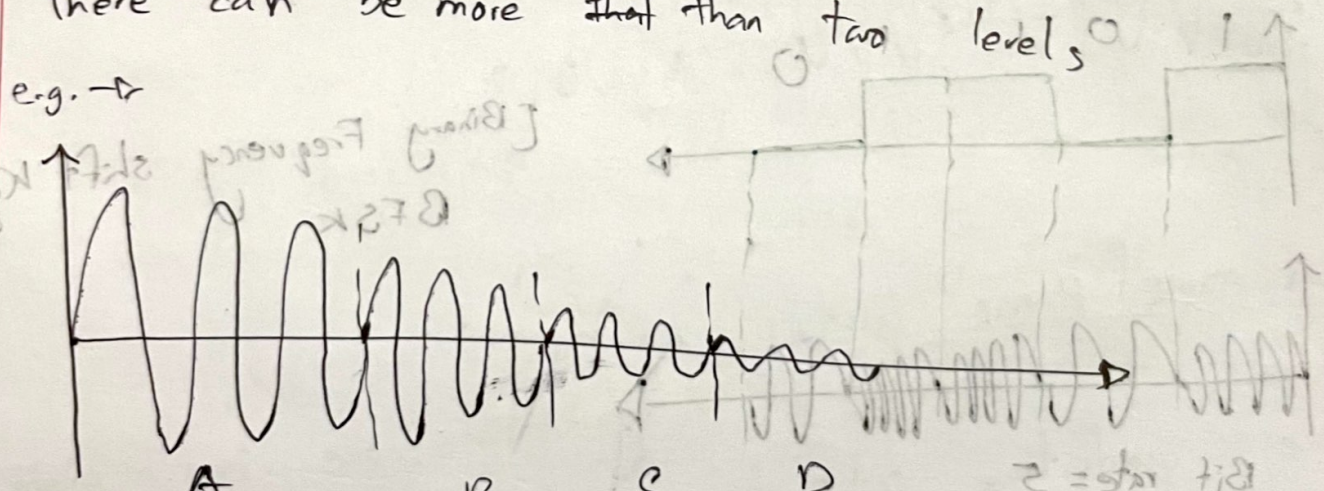
1 → Same frequency as the carrier frequency

0 → 0 V

Multilevel ASK:-

There can be more that than two levels

e.g. →



→ Amplitude decreases as we proceed.

FREQUENCY SHIFT KEYING (FSK)

→ The frequency of the carrier signal is varried to represented data. [Phase & amplitude remains constant]

→ Frequency of the modulated signal is constant ~~for~~ for the duration of one signal element, but changes for the next signal element if the data changes.

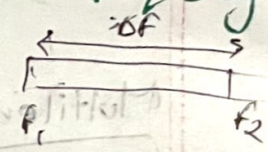
→ In binary FSK we can consider two carrier frequencies f_1 & f_2. where,

$f_1 = f_c + \Delta f$ [1] — frequency higher than original frequency

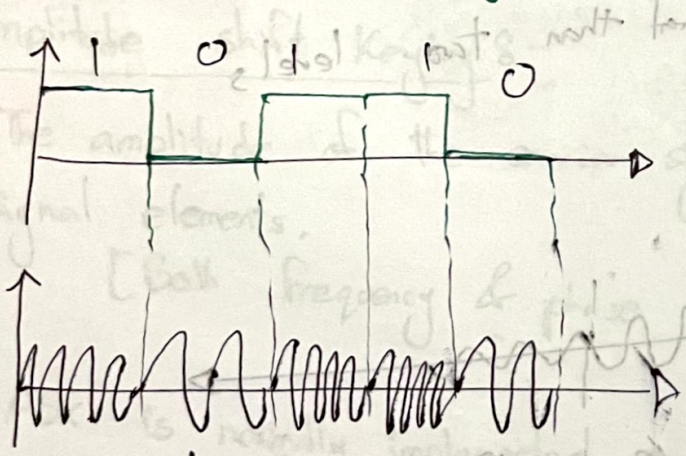
$f_2 = f_c - \Delta f$ [0] — frequency lower than original frequency.

f_c = carrier frequency.

Δf =



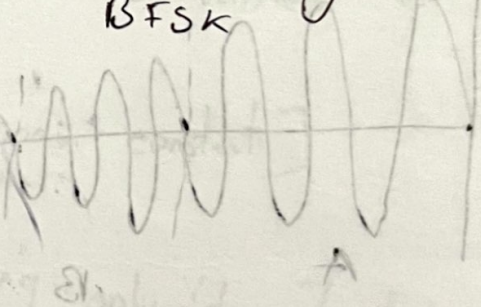
Example :



Bit rate = 5

[Binary Frequency shift keying]

BFSK



MULTILEVEL FSK:-

→ we can use more than 2 frequencies.

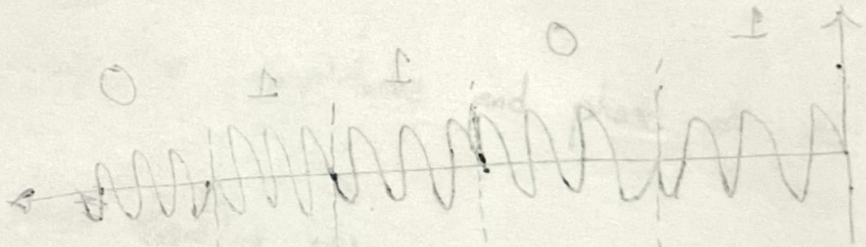
e.g. to sends two bits at a time we can use 4 frequencies

" " eight " " " " " " 8 "

$\Rightarrow 2^2 = 4$

$\Rightarrow 2^3 = 8$

EXAMPLE:



PHASE SHIFT KEYING:-

→ The phase of the carrier is varied to represent two or more different signal elements.

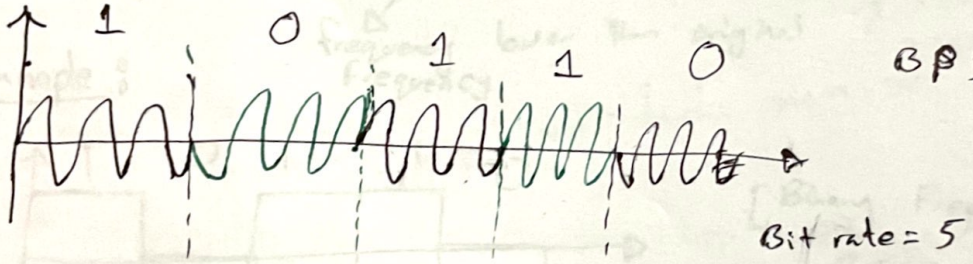
→ Peak amplitude and frequency remains constant.

BPSK [Binary phase shift keying]

1 → 0° [no changes of phase same as the original]

0 → shifts 180°

EXAMPLE:



QUADRATURE PHASE SHIFT KEYING :-

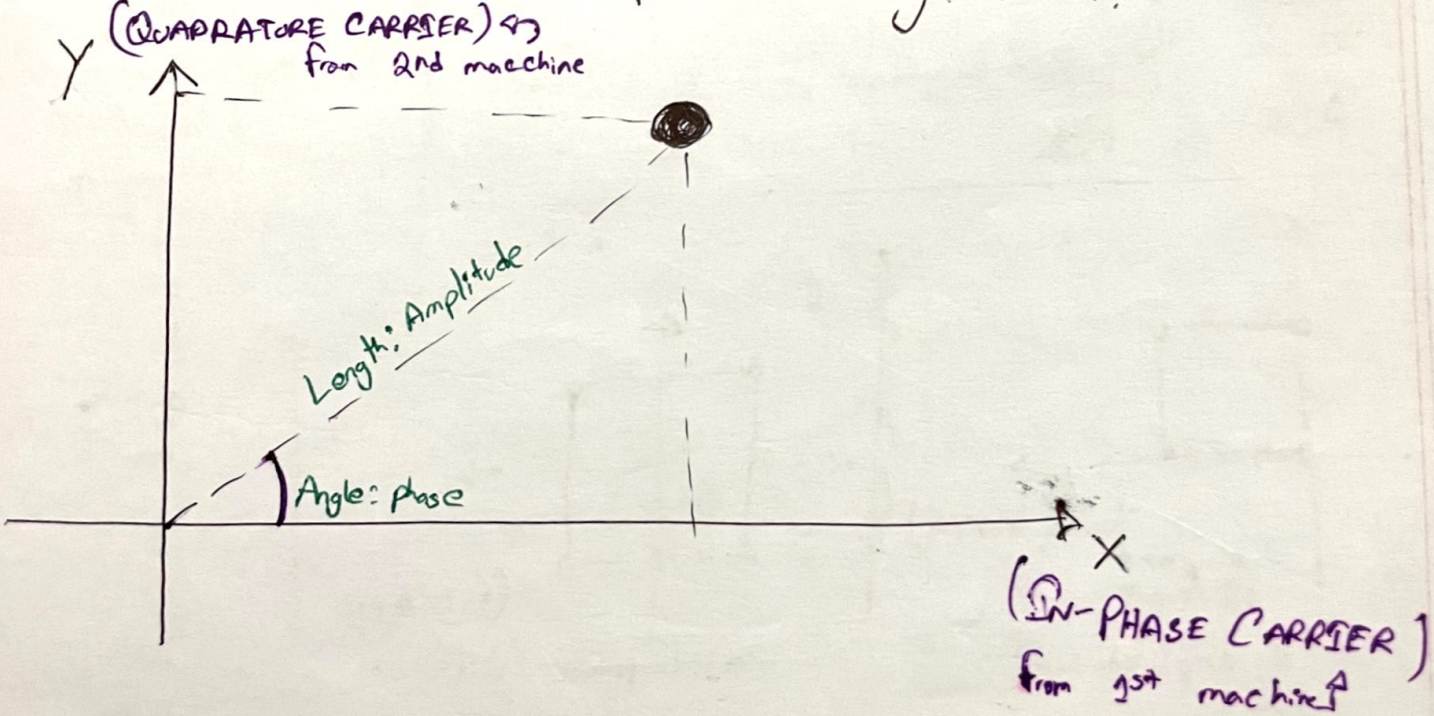
→ uses two seperate BPSK modulations; one is in-phase, the quadrature out-of-phase

CONSTELATION DIAGRAM :-

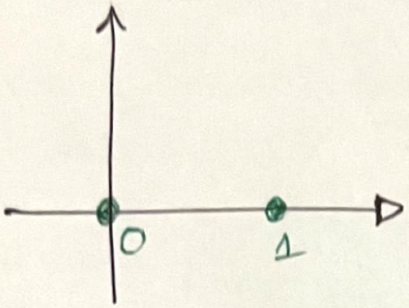
→ Help us to define the amplitude and phase of a ~~single~~ signal element.

→ Useful when we are dealing with ASK, PSK or QAM.

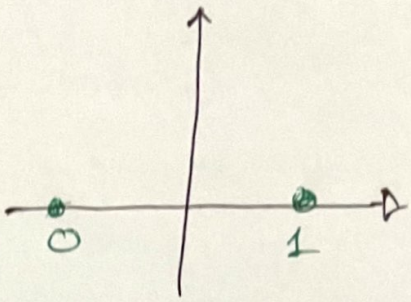
→ signal element is represented by a dot.



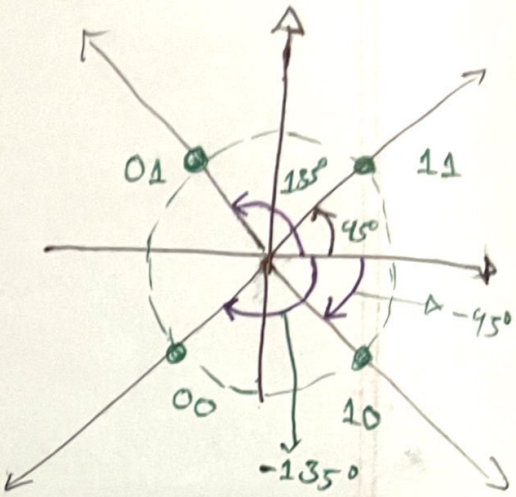
Constellation diagrams:-



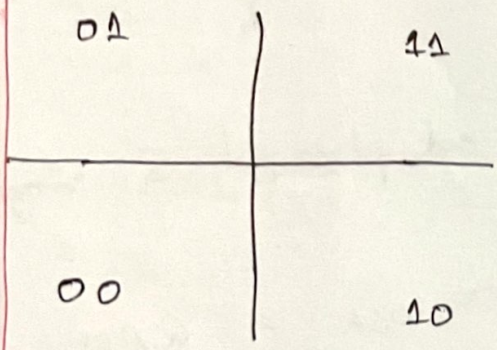
ASK
(On off keying)
[OOK]



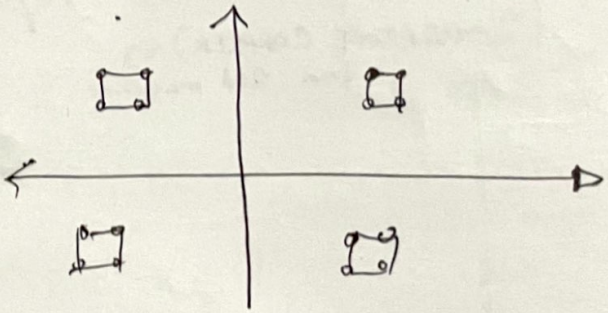
BPSK

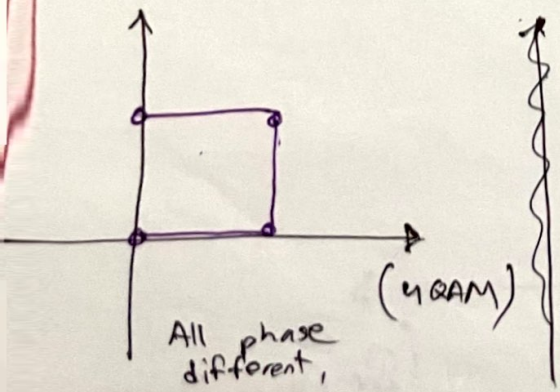


QPSK



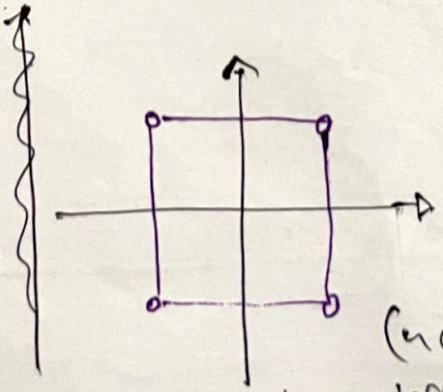
QAM:
It is the combination of ASK & PSK





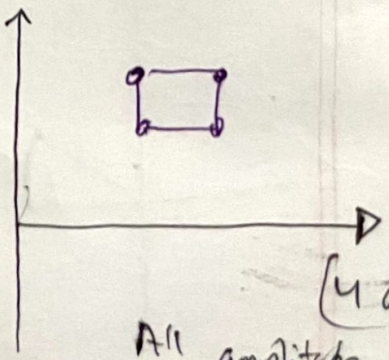
(4 QAM)

All phase different,
2 amplitude same
"



(4 QAM)

All phase different
" Amplitude same

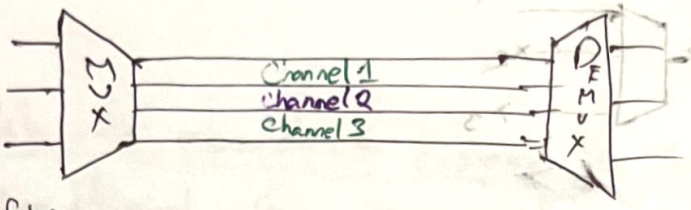


(4 QAM)

All amplitude different

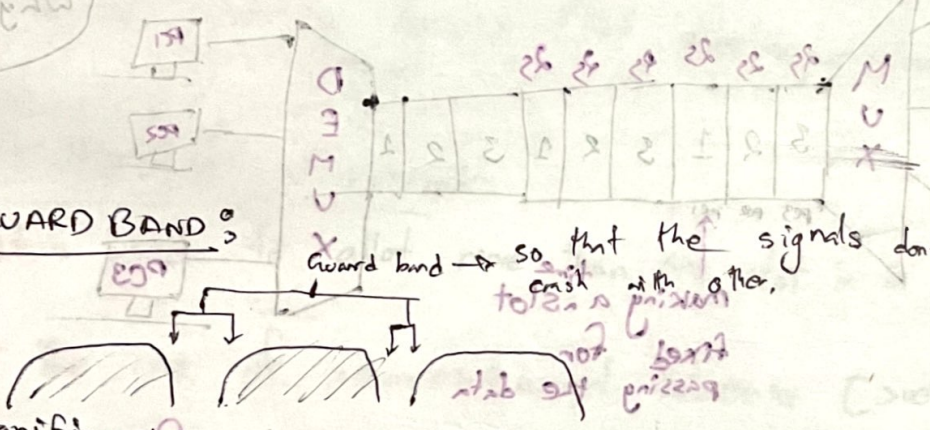
MULTIPLEXING (Part-1)

Frequency Division Multiplexing (FDM): [ANALOG]



Profit :-
Suppose there is a signal of 2 kHz then it will all pass through the 9 kHz bandwidth then the rest of the band will stay as useless. By dividing the the channels we can utilize the whole Bandwidth.

suppose, the bandwidth is 9 kHz then it will be divided into 3 equal parts to pass through the channel :-
(i) 0-3 kHz (ii) 4-6 kHz
(iii) 7-9 kHz



Using 1 wire we can send n number of data :- benefits of multiplexing / Using 1 transmission media we can send many sources data in a composite signal form

GUARD BAND :
Guard band → so that the signals don't crash with other.

Significance :
To avoid interference between the channels.

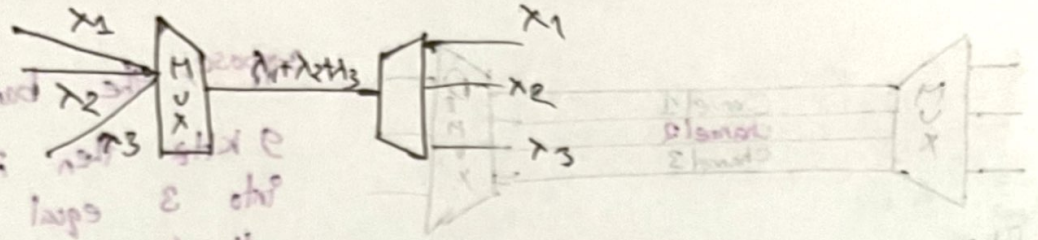
Figure-6.9

Total bandwidth from 1st to 2nd = 5 × 48 = 240 kHz
" voice channel " " " " = 5 × 12 = 60
Total BW " 2nd to 3rd = 10 × 240 kHz
= 2400 kHz
= 2.4 MHz
" VC " " " " = 60 × 10
= 600 VC

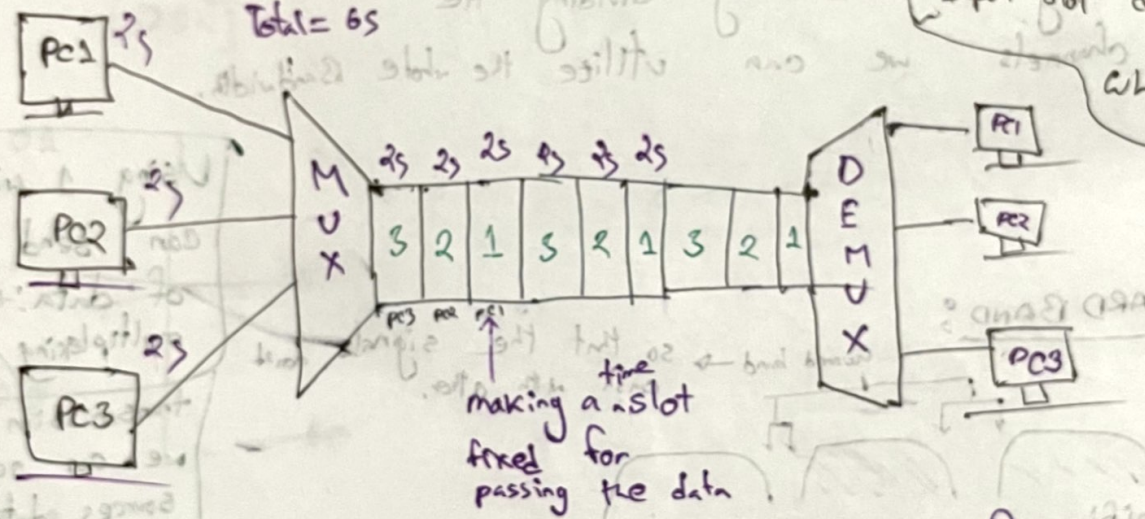
Guard Band = 2.52
Total Guard Band = 2.52 − 2.4
= 0.12 MHz
Guard Band between the Channels = $\frac{0.12}{n-1} = \frac{0.12}{10-1} = \frac{0.12}{9}$
(n = no. of groups)

Guard Band given... how to add with channels?

WAVELENGTH DIVISION MULTIPLEXING (WDM):-



TIME DIVISION MULTIPLEXING (TDM):- (V. imp) final.



Input slot duration?
Math? recorded
Why 1 char?
3 char? right

(V. imp)

Data rate / Transmission rate = bit rate for the link / frame rate × frame size.
FPS

Input slot duration ≈ Frame duration

Output slot duration = Time taken by each source = $\frac{\text{input slot duration}}{\text{no. of source}}$

Overhead bit = frame rate [if sync bit is 1]

Output bit duration = $\frac{\text{output slot duration}}{\text{interleave unit.}}$

Frame rate = $\frac{\text{bit rate}}{\text{interleave unit}}$ → $\frac{\text{bit rate}}{\text{interleave unit.}}$

input slot duration = $\frac{\text{interleave unit}}{\text{bit rate}}$

overhead = data rate − Frame rate * (15 − 1)

Fram size − syn bit

MULTIPLEXING (PART-2)

Empty slots :- Time get wasted due to empty slots.

Data rate mismatch (to overcome this there are 3 strategies) :-

(i) multilevel (ii) multiple-slot (iii) pulse stuffing.

(i) Multilevel multiplexing :-

It is used when "data rate of the input links are multiples of each other"

the no. of sources/channel decrease (such technique where no. of input sources reduce)

(ii) Multiple-slot allocation :-

It is used to allot more than one slot in a frame.

The no. of sources/channel increase [such technique where no. of input sources increase]

(iii) Pulse stuffing :-

It is used to make the input lines with lower rates as same as the dominant data rate by adding dummy bit.

The no. of sources/channel "doesn't change"!

is pulse stuffing possible if we have to add of no. of

Digital hierarchy math:- The

"The extra bits are the sync bits"

Isn't " " " " Guard band ") analog hyrrarchy?

Statistical TDM:

In this TDM the empty slots aren't taken in to the frame,

Also, for each source a binary address is provided to identify the source. (sync bit)

→ say,

for addressing we are using 80 bit

and for data " " 8 bit

we can't do that (Add bit can't be ⇒ data bit)

Q. Differences between statistica TDM & synchronous TDM

"FDM's example is radio"

SPREADING [SPREAD SPECTRUM]

combine signals from different to fit into a larger bandwidth.

Goals :-
(i) To prevent eavesdropping.
(ii) " " jamming.

2 techniques :-
(i) Frequency Hopping Spread Spectrum (FHSS)
(ii) Direct Sequence " " (DSSS) :

FHSS :-

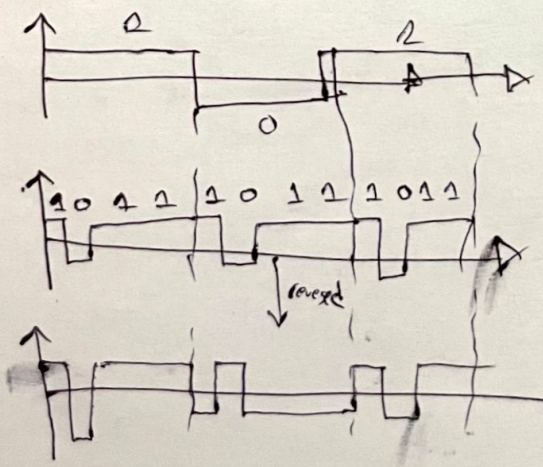
In this technique we are passing a signal with certain frequency to different larger multiple frequencies.

→ By using larger frequencies bandwidth we are preventing jamming.

→ " hopping to different bandwidth ~~multi~~ frequency multiple times we are preventing eavesdropping.

DSSS :

To ensure privacy we assing the bits to certain barker ~~seque~~ sequence.



(using NRZ encoding)

Q. type

→ pattern table given draw the frequency cycle. in the graph.

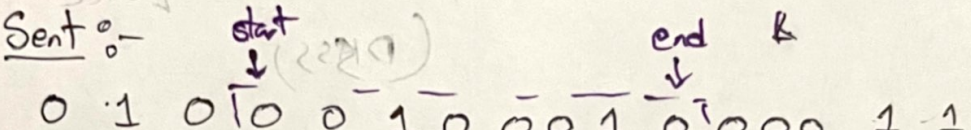
16/04/24

CHAPTER-10 ERROR DETECTION & CORRECTION

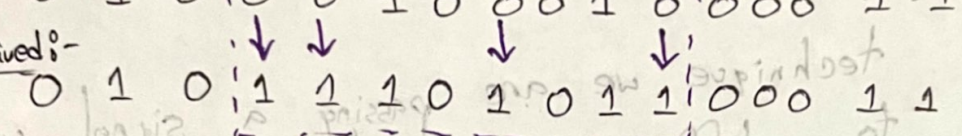
Single bit error :- Only 1 bit error in the data unit has changed.

Length of Burst error :-

Sent :-



Recived :-



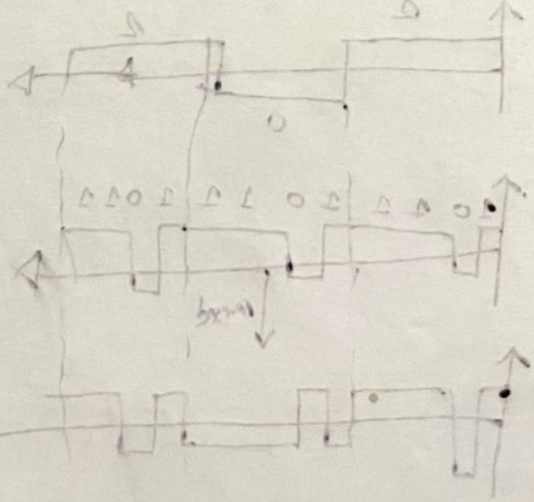
Length burst error = 8

To achieve redundancy we have to follow the coding schemes :-

(i) Block Coding.

(ii) Cyclic Codes

(iii) Check sum



BLOCK CODING:-

(i) Error detection:-

Datawords	Codewords
00	000
01	011
10	101
11	110

pair, pair

Make combination using the codewords:-

$^4C_2 = 6$

(4: no. of codewords; 2: pair length from codwords)

(ii) HAMMING DISTANCE:-

Find hamming distance from pairs

how to find? → By XORing and finding the no. of unsimilar bits or no. of '1' count.

XORing :- unsimilar bits: 1, similar bits: 0

```
  0 0 0
⊕ 0 1 1   ] pair
-------
  0 1 1
```

hamming distance :- 2

d = 2

```
  0 0 0
⊕ 1 0 1   ] pair
-------
  1 0 1
```

d = 2

$d_{min} = 2$

[The least hamming distance from all the distance]

ERROR DETECTION :-

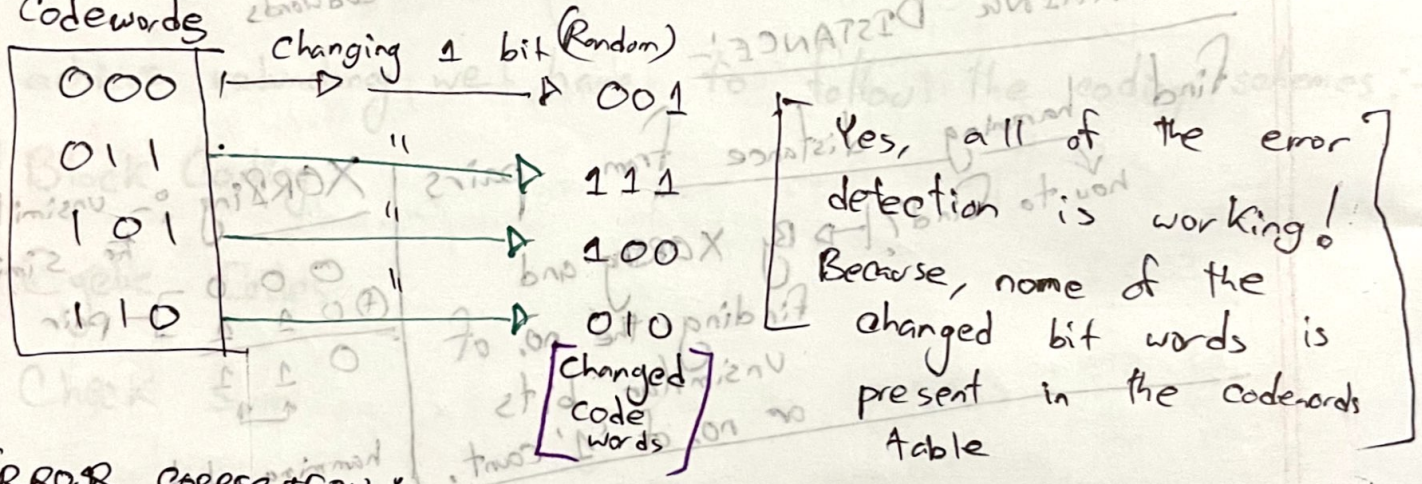
$d_{min} = S + 1$ [Here, S means :- up to 'S' bits it can detect the errors]

e.g.

$2 = S + 1$

or $\Rightarrow S = 1$ [It means up to 1 bit it can detect error. If there are more than 1 or 2 bits eg: it won't be able to detect the error]

So how will it work? [How we are going to use this 1 bit to detect the error?]



ERROR CORRECTION :-

$d_{min} = 2t + 1$ [Here, t means the number of errors it can correct]

→ Error correction codes need to have an odd minimum distance, e.g.-

3, 5, 7...

CHECKSUM

How to find negative number of a number :-

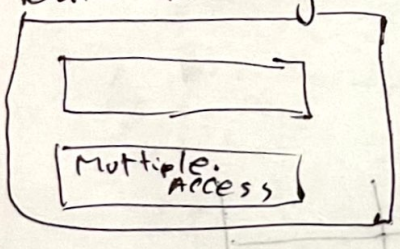
$\Rightarrow 2^n - 1 - \text{number} = \text{negative number}$ (n = number of bits)

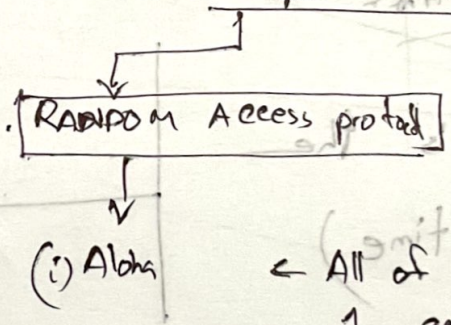
"wrapped of number can be done multiple times"

If we any number other than '0' in the receiver side checksum. Then error has been detected.

if we find '0' in checksum of receiver site then there is no error.

Chapter-12 "MULTIPLE ACCESS"





← All of the protocol have one goal → tries to reduce the collision as much as possible.

Transmission Time / Framing time: The time which takes to place on the transmission medium

$T_t = \frac{\text{size}}{BW}$

Vulnerable Time of pure Aloha protocol:-

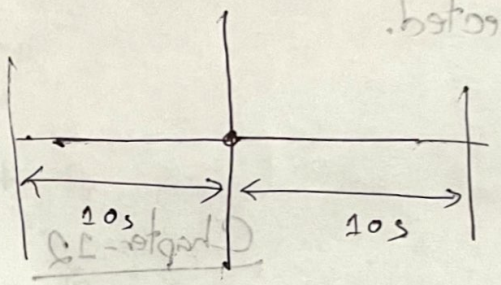
$V.T. = 2 \times T_{fr}$ [$\because T_{fr}$ = transmission time]

mac protocol pt-2
isolated vdo

ALOHA

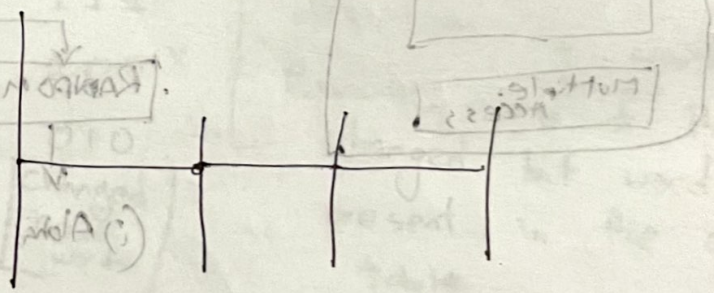
28/09/24

Pure Aloha:



SLOTTED ALOHA:

(every slot is the transmission time)



Transmission time of frame:-

$$T_{fr} = \frac{\text{packet size}}{\text{Bandwidth}}$$

$T_{fr} = \frac{10\ b/s}{2\ b/s} = 5s$

Propagation time,

$$T_p = \frac{\text{distance}}{\text{speed}}$$

Procedure for Pure Aloha :-

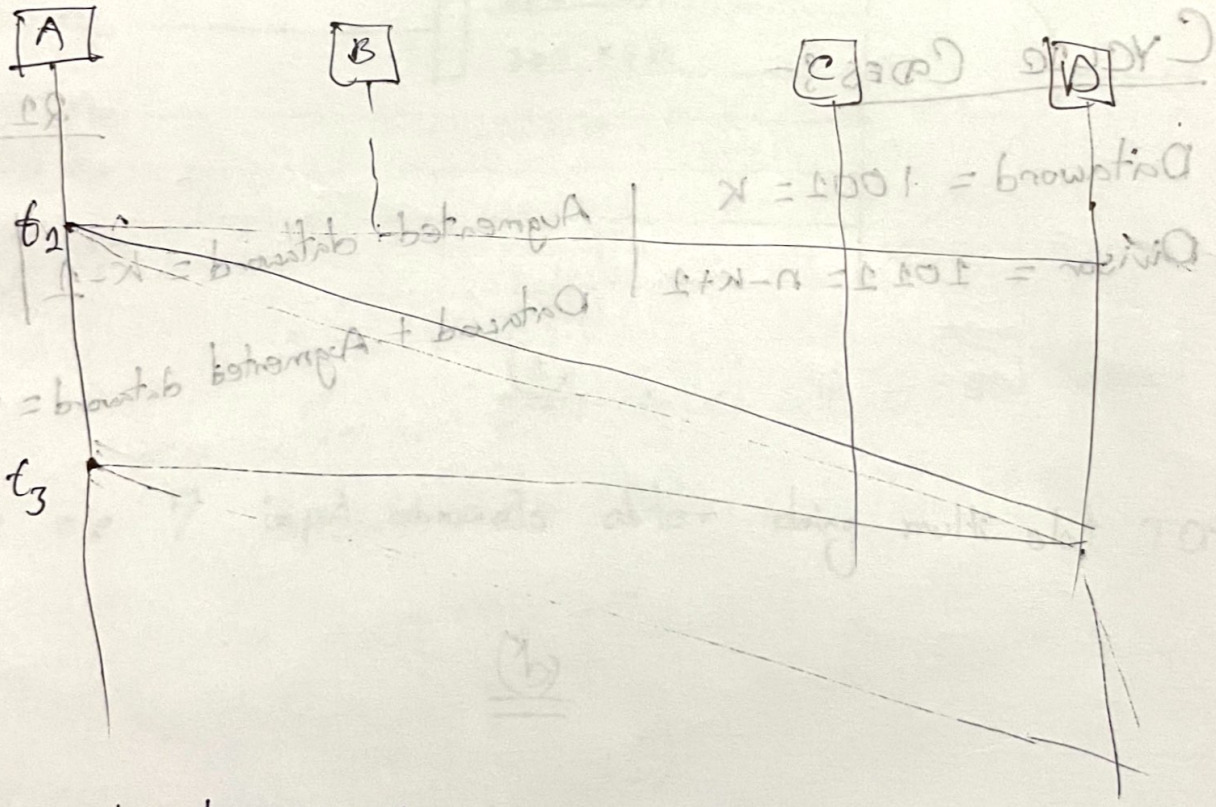
Wait T_B time = $Rx T_p$ | $Rx \cdot T_{fr}$

(i) Acknowledgement

(ii) Doesn't check carrier or media.

CSMA

Space time model | Vulnerable time = propagation time



$T_{fr} = t_3 - t_1$

t_3: time to send last bit

t_1: time to send 1st bit.

CSMA/CD

(i) If the jamming signal comes after transmission time it's not possible to detect the collision.

~~Error detection~~

Q. →

$\frac{\text{Size}}{BW} = 2 * \frac{d}{s}$

CYCLIC CODES :-

21/04/24

Dataword = 1001 = K

Divisor = 1011 = n-k+1

Augmented dataword = k-1 | n-k

Dataword + Augmented dataword = n

CSMA/CA → contention window.

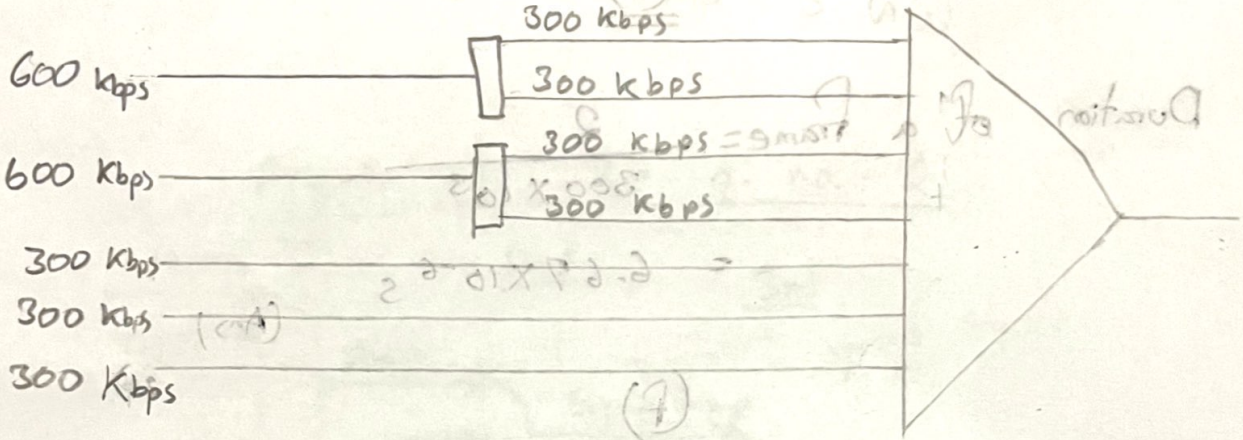
CSMA/CD → maths.

[practice sheet present]

Answer to the q. no. - 01

Given,
two channel bit rate - 600 kbps
three " " " 300 kbps

Using multiple slot multiplexing,



(a)

There are 7 input channels after doing multi slot TDM.

(b)

Input bit duration = $\frac{1}{300 \times 10^3} = 3.3 \times 10^{-6}$ s (Ans)

(c)

Frame size = 7 x 2 + 1
= 15 (Ans)

interleave unit = 2
synchronization bit = 1
no. of source = 7

(d)

$$\text{Frame rate} = \frac{300 \times 10^3}{2} = 150 \times 10^3 \text{ bps}$$

bit rate = 300×10^3 bps

(Ans)

(e)

$$\text{Duration of a frame} = \frac{2}{300 \times 10^3}$$

$$= 6.67 \times 10^{-6} \text{ s} \quad \text{(Ans)}$$

(f)

Data rate of the link = frame size × frame rate

$$= 15 \times 150 \times 10^3$$

$$= 2250000 \text{ bps} \quad \text{(Ans)}$$

(g)

$$\text{Output slot duration} = \frac{\text{input slot duration}}{\text{no. of source}}$$

$$= \frac{6.67 \times 10^{-6}}{7}$$

$$= 9.52 \times 10^{-7} \text{ s} \quad \text{(Ans)}$$

frame duration = input slot duration

$= 6.67 \times 10^{-6}$

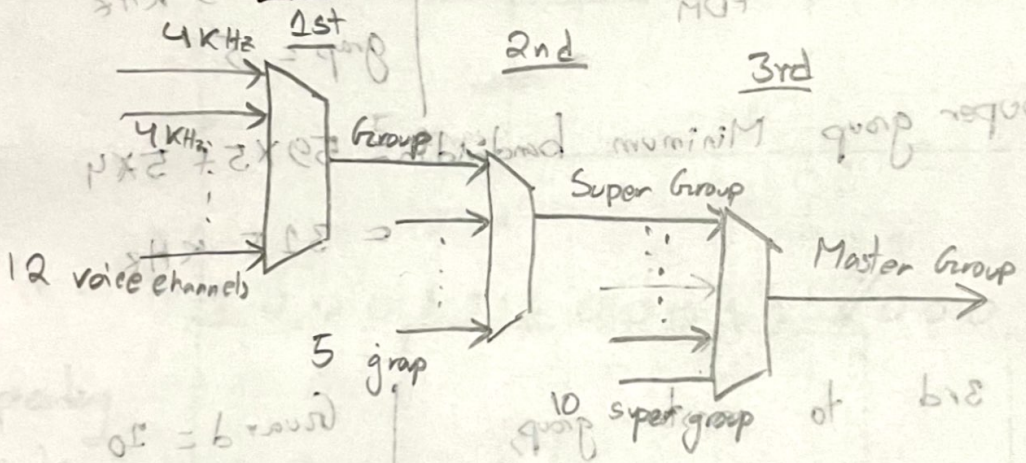
(b)

$$\text{Output bit duration} = \frac{\text{output slot duration}}{\text{interleave unit}}$$

$$= \frac{9.52 \times 10^{-7}}{2}$$

$$= 4.76 \times 10^{-7} \text{ s} \quad \text{(Ans)}$$

Answer to the q. no. - 2



The number of voice channels that can be multiplexed in the maste group :-

Master group voice channels = $12 \times 5 \times 10$

$= 600$

(Ans)

Again,

From 1st FDM to 2nd FDM, | Guard = 1 kHz
Voice channels = 12

Groups Minimum bandwith = 12 × 4 + 11 × 1
= 59 KHz

and,

From 2nd FDM to 3rd FDM, | Guard = 5 KHz
group = 5

Super group Minimum bandwidth = 59 × 5 + 5 × 4
= 315 KHz

and,

From 3rd to master group, | Guard = 10
super group = 10

Master group Minimum bandwidth = 315 × 10 + 10 × 9
= 3240 KHz

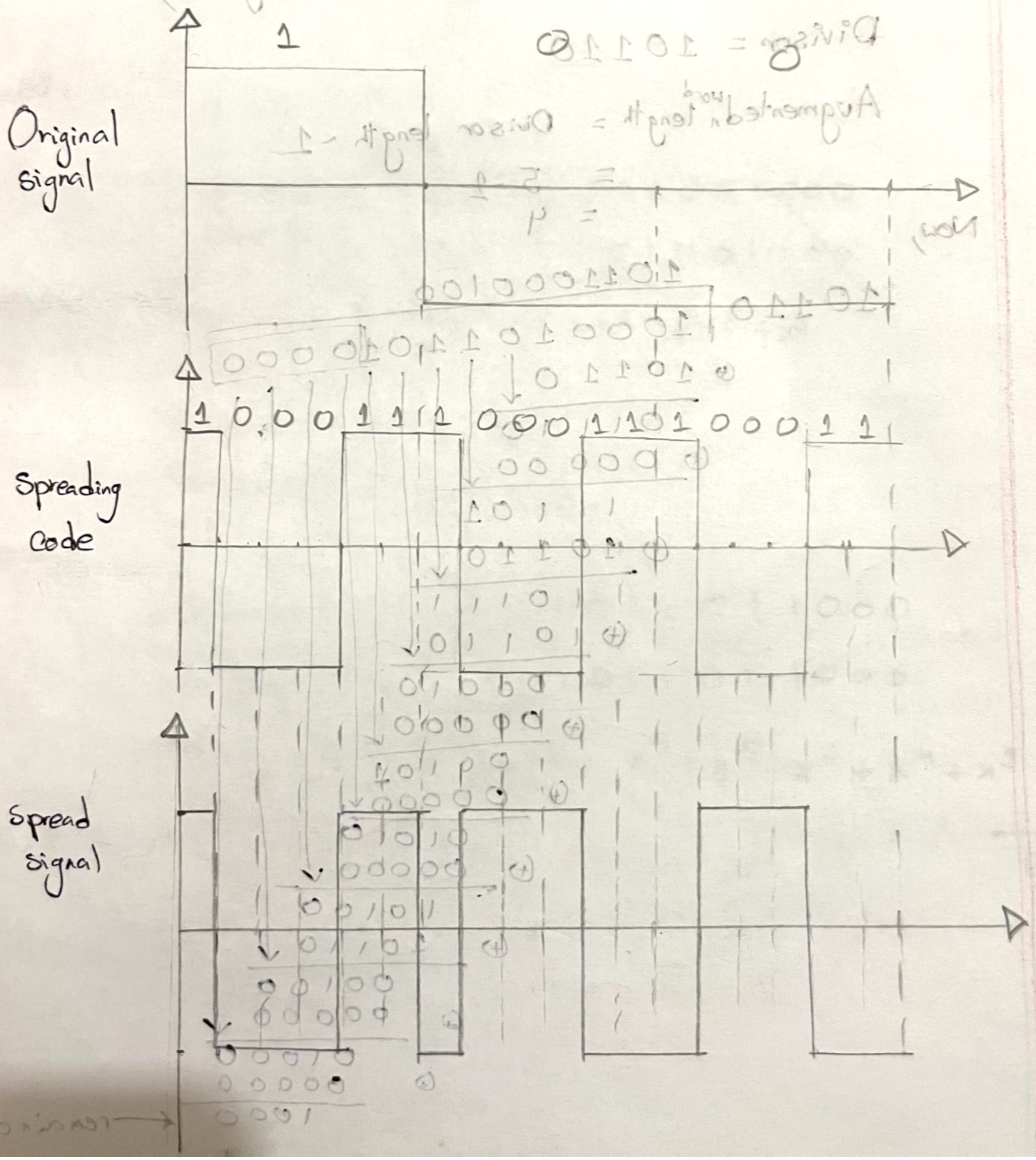
(Ans)

Answer to the q. no.- 03

Given,

Original signal = 100

Spreading code = 1000111



Answer to the q. no.- 04

(a)

Given,

Dataword = $x^9 + x^5 + x^3 + x^2 + 1$

= 1000101101 (Binary form)

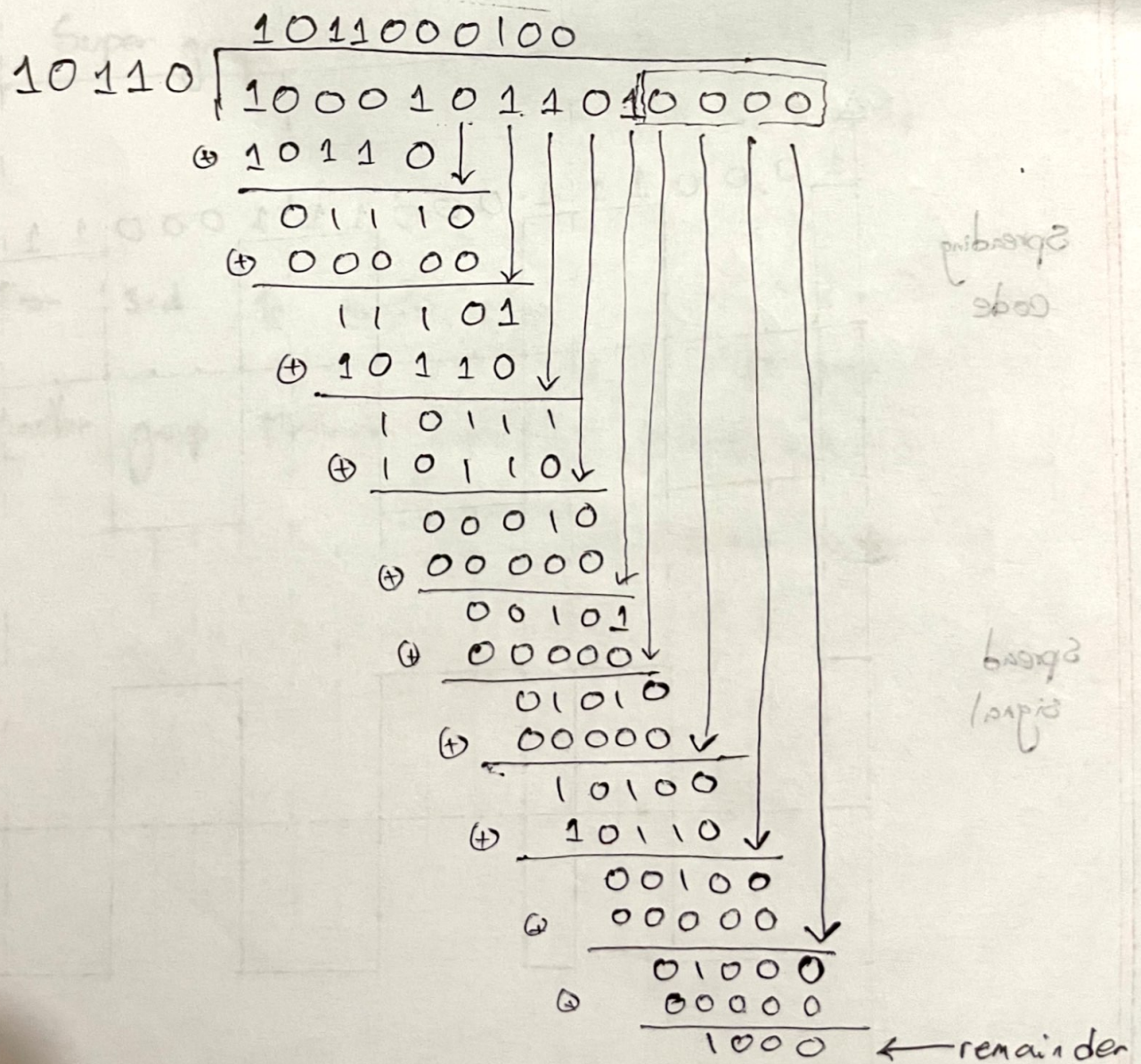
Divisor = 10110

Augmented word length = Divisor length − 1

= 5 − 1

= 4

Now,



Therefore,

Quotient : 1011000100

Remainder : 1000

∴ Codeword : 1000 1011 0001 1000

Dataword | Remainder

(b)

From 'a' we get,

Code word : 1 0 1 1 0 0 0 1 0 0 1 0 0 0

Corrupted CW : 1 1 1 1 0 0 0 1 0 0 1 0 0 0

Polynomial : $x^{13}+x^{12}+x^{11}+x^{10}+x^6+x^3$

Divisor : 1 0 1 1 0

Polynomial : $x^4+x^2+x^1$

Codeword : 1 0 0 0 1 0 1 1 0 1 1 0 0 0

Corrupted CW : 1 1 0 0 1 0 1 1 0 1 1 0 0 0

Polynomial : $x^{13}+x^{12}+x^9+x^7+x^6+x^4+x^3$

P.T.O

$$x^4+x^2+x \;\overline{)\; x^{13}+x^{12}+x^9+x^7+x^6+x^4+x^3 \;}\; x^9+x^8+x^7+x^5+x^4+x^2+x$$

$x^{13}+x^{11}+x^{10}$

$x^{12}+x^{11}+x^{10}+x^9+x^7+x^6+x^4+x^3$

$x^{12}+x^{10}+x^9$

$x^{11}+x^7+x^6+x^4+x^3$

$x^{11}+x^9+x^8$

$x^9+x^8+x^7+x^6+x^4+x^3$

$x^9+x^7+x^6$

$x^8+x^4+x^3$

$x^8+x^6+x^5$

$x^6+x^5+x^4+x^3$

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

x^5

$x^5+x^3+x^2$

x^3+x^2

Syndrom: x^3+x^2

Binary bits: 1 1 0 0

∴ Error is detected. Because, all binary bits of the syndrom is not "0"

(c)

One failure case of CRC referencing error detection capability :-

Here, If, $S(x) = 0$, either,

(i) No bit is corrupted
(ii) Some bits are corrupted, but the decoder failed to detect them.

Failure of error detection are explained below,

Received codeword = $c(x) + e(x)$

$c(x)$ = codeword
$e(x)$ = error
$g(x)$ = generator
$S(x)$ = syndrome

Now,

$$S(x) = \frac{\text{Received codeword}}{g(x)} = \frac{c(x)}{g(x)} + \frac{e(x)}{g(x)}$$

Here, If $S(x) = 0$, either, $e(x) = 0$ or, $\left[\because \frac{e(x)}{g(x)}\right]$
$e(x)$ is divisible by $g(x)$
↑ fails to detect error in this case

[we do not have to worry about $\frac{c(x)}{g(x)}$, because in $c(x)$ there is no error, so $\frac{c(x)}{g(x)} = 0$ will eventually be "0"]

∴ Those errors $e(x)$ which are divisible by $g(x)$ failure case of CRC error detection is observed.

Because, we get $S(x) = 0$, which implies no error but actually there is.

Answer to the q. no. – 05

No. of Codewords = 4.

The possible pairs will be = $^4C_2 = 6$.

Here,

(001101, 010100) = d = 1+1+1 = 3

(001101, 100010) = d = 1+1+1+1 = 5

(001101, 111000) = d = 1+1+1+1 = 4

(010100, 100010) = d = 1+1+1+1 = 4

(010100, 111000) = d = 1+1+1 = 3

(100010, 111000) = d = 1+1+1 = 3

Minimum hamming distance, $d_{min} = 3$

We know,

For error detection,

$d_{min} = s+1$

$\Rightarrow 3 = s+1$

$\therefore s = 2$

(Ans)

For error correction,

$d_{min} = 2t+1$

$\Rightarrow 2t = 3-1$

$2t = 2$

$\therefore t = 1$

(Ans)

Answer to the q. no. - 06

(a)

Given,

we have to represent in 4 bit binary sequence.

Sender:-

7
8
5
9
21

Sum => 50

Binary of 50 → 1 1 0 0 1 0 [Wrapping]

1 1

0 1 0 1 = 5

1's complement: 1 0 1 0 = 10

∴ Wrapped sum = 5

∴ Check sum = 10

Packet:

7, 8, 5, 9, 21, 10

(Ans)

(b)

From 'a' we get,

Packet : 7, 8, 5, 9, 21, 10

Changing data : 7, 9, 6, 9, 21, 10

Receiver:

7
9
6
9
21
10

Sum => 62

Binary of 62 → 1 1 1 1 1 0

1 1

1 0 0 0 1

1

0 0 1 0 = 2

1's complement: 1 1 0 1 = 13

Wrapped Sum = 2

∴ Check sum = 13

∴ Error is detected. Because, the checksum is not 0.

Answer to the q- no. - 07

(a)

Given,
16 bit words,

Senden :-

66E
DC2
94
EE

Sum ⇒ 15B2 = ~~Wrapp~~

(b)

Packet:
66E, DC2, 94, EE, EA4D

∴ Check sum = FFFF - 15B2
= EA4D

(Ans)

(b)

From (a) we get,

Packet : 66E, DC2, 94, EE, EA4D

Changed data : 66E CO 94 FE EA4D

Receiver :

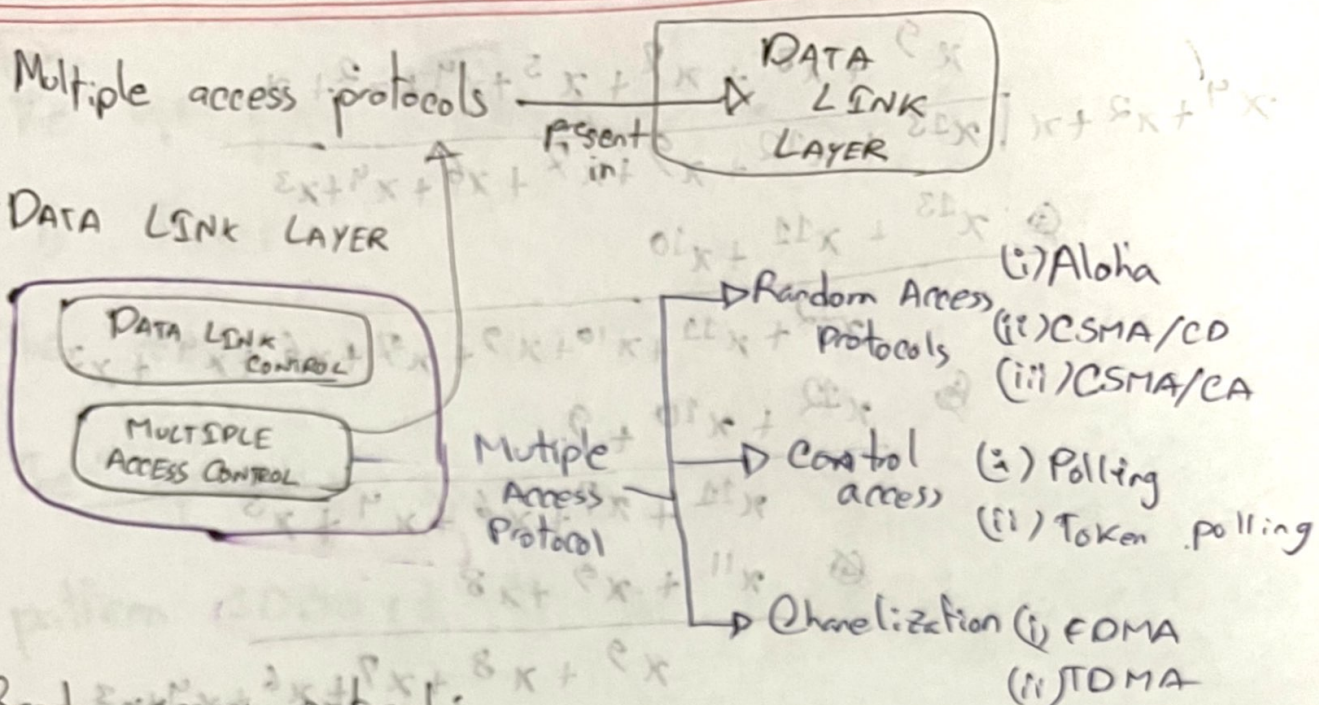
```
  66E
  CO
  94
  E#1
  EA4D
-------
Sum => F2FO
```

∴ Checksum = FFFF − F2FO

= D0DF

~~Not~~ ∴ Error is detected. Because, the checksum is not "0" in the receiver site.

Multiple Access Control



Random access protocol:

(a) Can send data at any time.

(i) no station is superior to another station.

(ii) No " has contol over another

(iv) a station uses a procedure defined by the protocol to make a decission on whether or not to send a data.

(v) A station does not permit another station to send.

* For its characteristics collision is possible between stations data

PURE ALOHA:

(i) Acknowledgement is present.
(ii) LAN based.
(iii) Only transmission time
(iv) Collision is present
(v) Any time transmission

Vulnerable time, $VT = 2 \times T_{fr}$

[$\because T_{fr}$ = transmission time]

$T_{fr} = \frac{\text{Size}}{\text{BW}}$

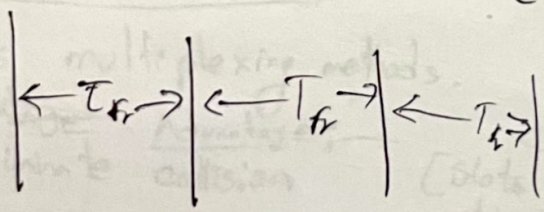
Back off time, $T_B = R \times T_{fr}$

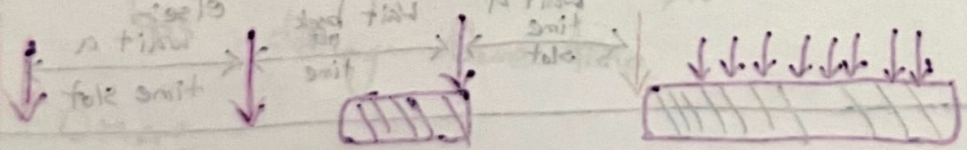
R = random number between 0 to $2^k - 1$
k is integer, starts from 0

SLOTTED ALOHA:-

(i) Transmission will start only at the beginning of the slot
(ii) Improves the efficiency of pure Aloha.
(iii) Time is divided into slots of transmission time (T_{fr})

Vulnerable time = T_{fr}





Carrier sense multiple access:

CSMA: (Check its own point)

(i) sense its path of the medium before sending frame.

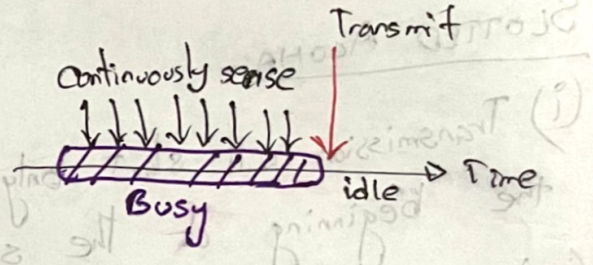
(ii) Reduce the possibility of collision, but it cannot eliminate it due to propagation delay.

3 types: (i) 1-persistant (ii) Non-persistant (iii) p-persistant.

1-persistant:

→ has the highest chance of collission.

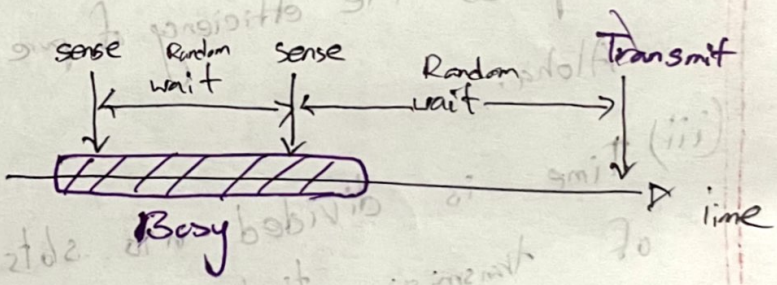
→ Continuously sense the medium



Non persistent:

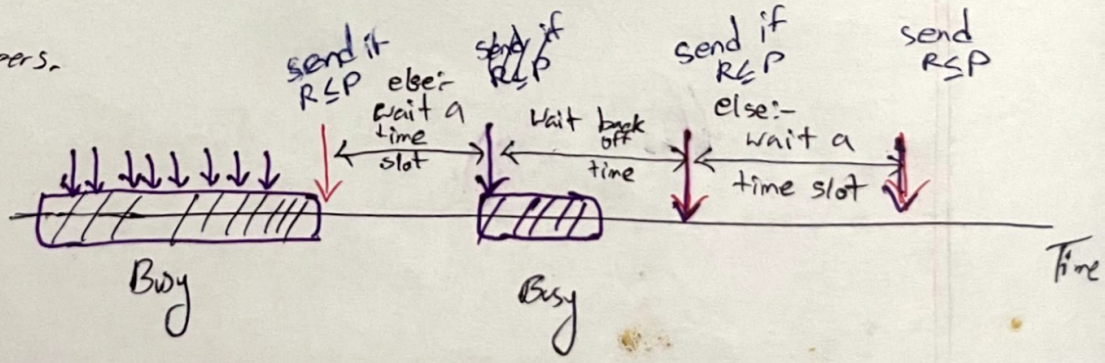
→ If the line is idle sends immediatly.

→ Not idle: waits a random time interval then sense.



P-persistent

Combines the good sides of 1 and Non pers.



CONTROLLED ACCESS:-

* One has the control over everything.

POLLING:-

Uses two functions: (i) Select
(ii) Polling

Disadvantage:-
(i) Polling multiple times.
(ii) If the primary station is dead the whole system goes down.

TOKEN PASSING:-

Provides a constant time to each of the stations by using a token.

Disadvantage:-
(i) Token overhead (token get created if ~~its not~~ the ~~used~~ station doesn't want to send anything)
(ii) latency
(iii) Single point of failure

RESERVATION:-

→ Some amount of time is reserved.

CHANNELIZATION:

Uses multiplexing methods.

~~Advantage~~ Advantage:-
(i) Eliminate collision [slots are divided into time slots]
(ii) Each node gets dedicated R/N bps during frame time.

Disadvantage:-
(i) There can be unused slots.

FDMA:-

(i) Channel spectrum divided into frequency bands
(ii) each station assigned fixed frequency bands

Disadvantage:-
(i) unused transmission time if frequency bands goes ~~free~~ idle.

(ii) limited bandwidth.

CDMA

(i) Assigns a different code to each node.

(ii) each node uses its unique code to encode the data bits it sends.

Disadvantage:-

(i) Total frequency band is used ~~inefficiently~~ inefficiently.

SUMMARY OF MAC PROTOCOLS:-

CHANNELIZATION: (i) Efficient and fair at high load.
(ii) ~~in~~ inefficient at low load.

RANDOM ACCESS: (i) Efficient at low load.
(ii) In " " high "

T_p = propagation time = PD

CSMA/CD [Collision Detection]

Used in LAN

If there is a collision
→ Immediatly abort transmission
→ The frame is sent again.

$T_{fr} = 2T_p$ $\quad$ $T_{fr} = \frac{size}{BW}$

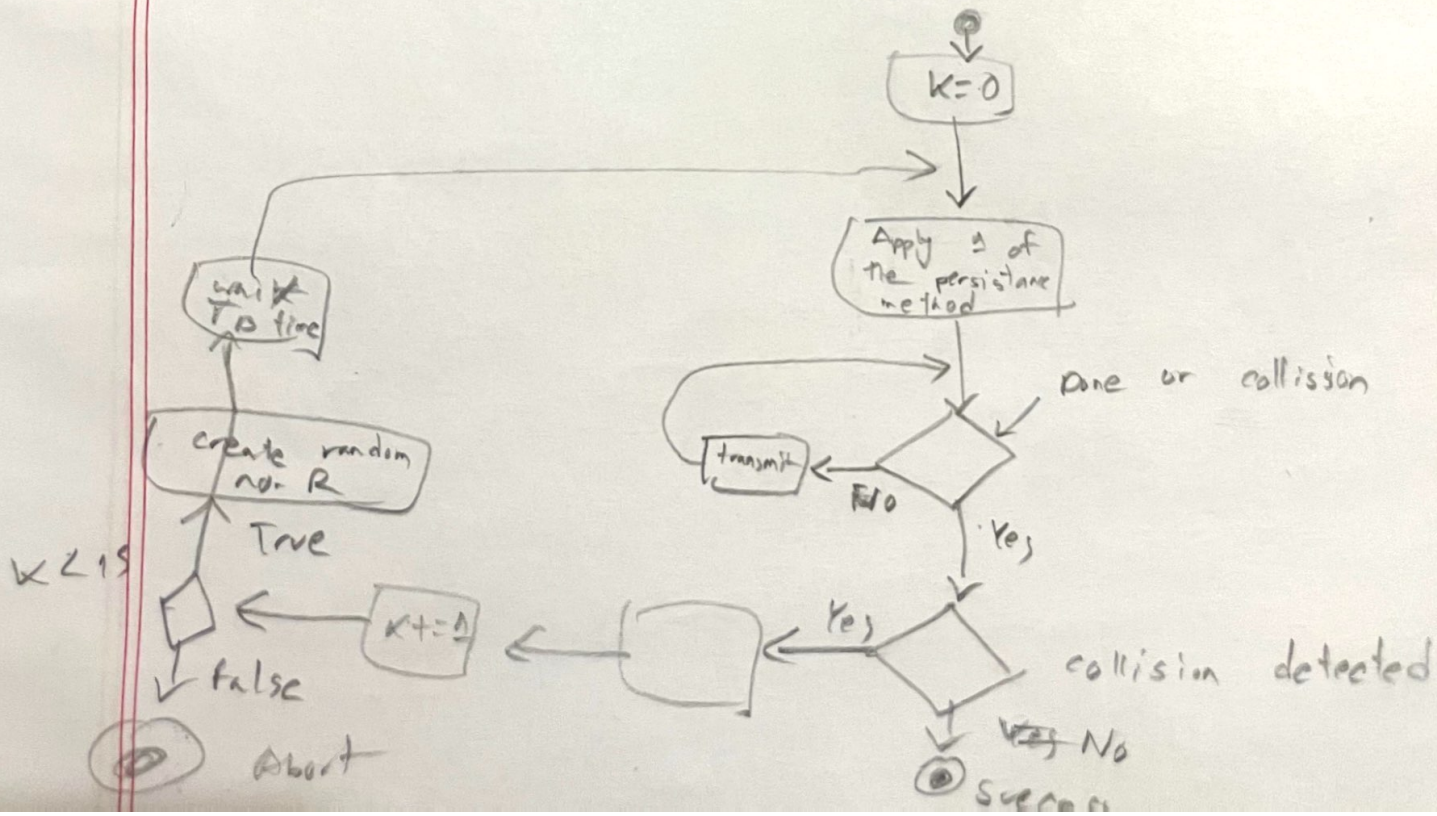
Collision signal must come during the transmission time
It can't detect the error after the transmission time [Failure case]

So, $T_{fr} > 2 \times PD$
$T_{fr} > 2 \times T_p$

Random number = R = 0 to $2^K - 1$
Backoff time, $T_B = R \times T_{fr}$
K (num of attempts) = starts from 0

$T_p = \frac{distance}{speed}$

Energy level :-
zero level → idle state
normal " → Data/frame is transferring
Abnormal " → collision occure



CSMA/CA Collision avoidance For [Wireless LAN]

Collision avoided using 3 strategies :- because of energy

(i) Interframe space (IFS)

(ii) Contention window

(iii) Acknowledgement