

21 sep

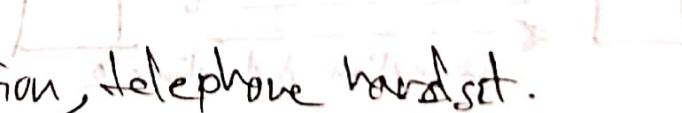
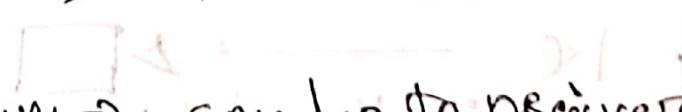
## Data Communications

(data)

Information

- "Telecommunication" means communication at a distance.
- "Data" refers to information presented in whatever form is agreed upon by the parties creating and writing using ~~data base, input & output~~ the data.
- "Data Communications" are the ~~not~~ exchange of data between two data devices via some form of transmission medium such as a ~~wire~~ twisted pair cable.

### Components

- Message ~~exchange~~ 
- Sender ~~output - input~~ 
- Receiver ~~input - output~~ 
- Transmission medium ~~sender to receiver~~    
 Examples of transmission media (twisted-pair ~~wire~~ <sup>with plastic</sup> wire, coaxial cable, fiber-optic cables and radio waves.)

[Wine]

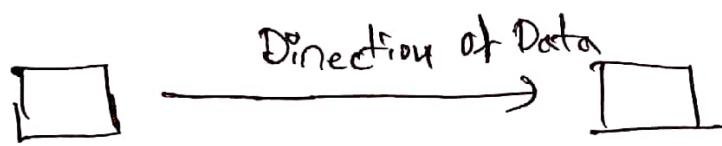
Protocol: Set of rules that govern data communication.

It represents an agreement between the communicating devices to enforce "rules" or basic guidelines with respect to message exchange.

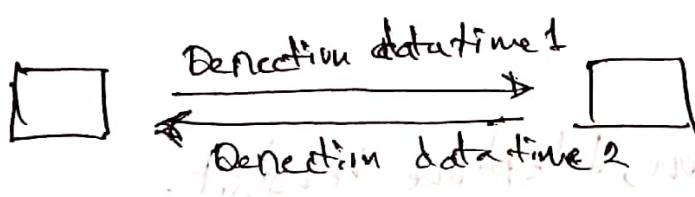
## Data Representation

bits for specifying the outcome "transmission error" & information for identifying the source and destination address in the header to send without loss.

## Direction of Data flow



Simplex



Half-duplex  
(Not same time)



Full-duplex  
(Same D + time)

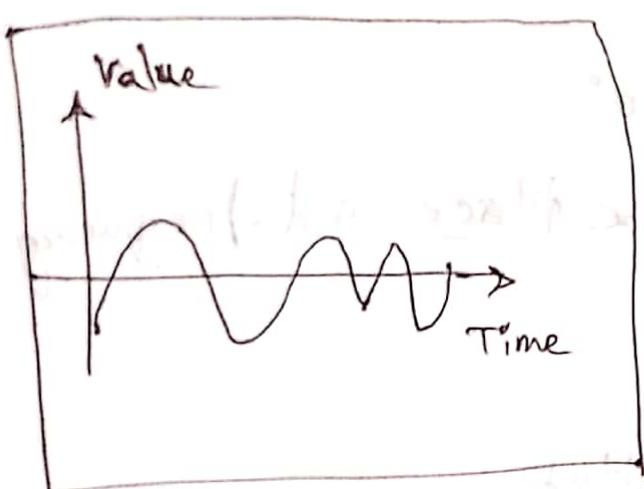
## Analog and Digital

Data can be analog or digital.

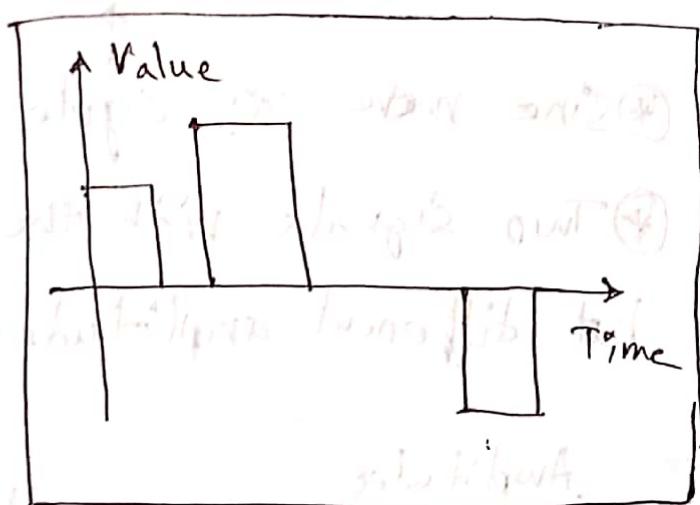
- The term analog data refers to information that's continuous; digital data refers to information that has discrete states.

Signals can be analog or digital.

- Analog signals can have an infinite number of values in a range; digital signals can have only a limited number of values.



Analog Signal



Digital Signal

We commonly use periodic analog signals and non-periodic digital signals.

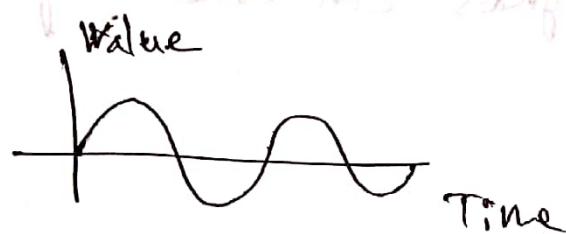
## Periodic Analog Signals

Periodic Analog Signals can be classified as 'Simple' or 'composite'.

A simple periodic analog signal, a sine wave, cannot be decomposed into simpler signals.

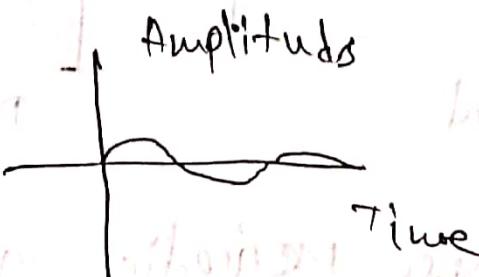
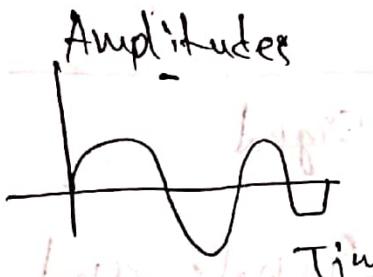
A composite periodic analog signal is composed of multiple sine waves.

Sine wave

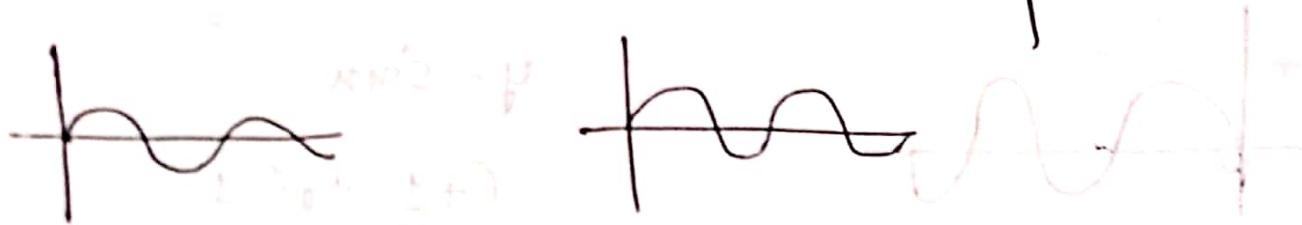


\* Sine wave  $360^\circ$  cycle =  $360^\circ$

\* Two signals with the same phase and frequency but different amplitudes.

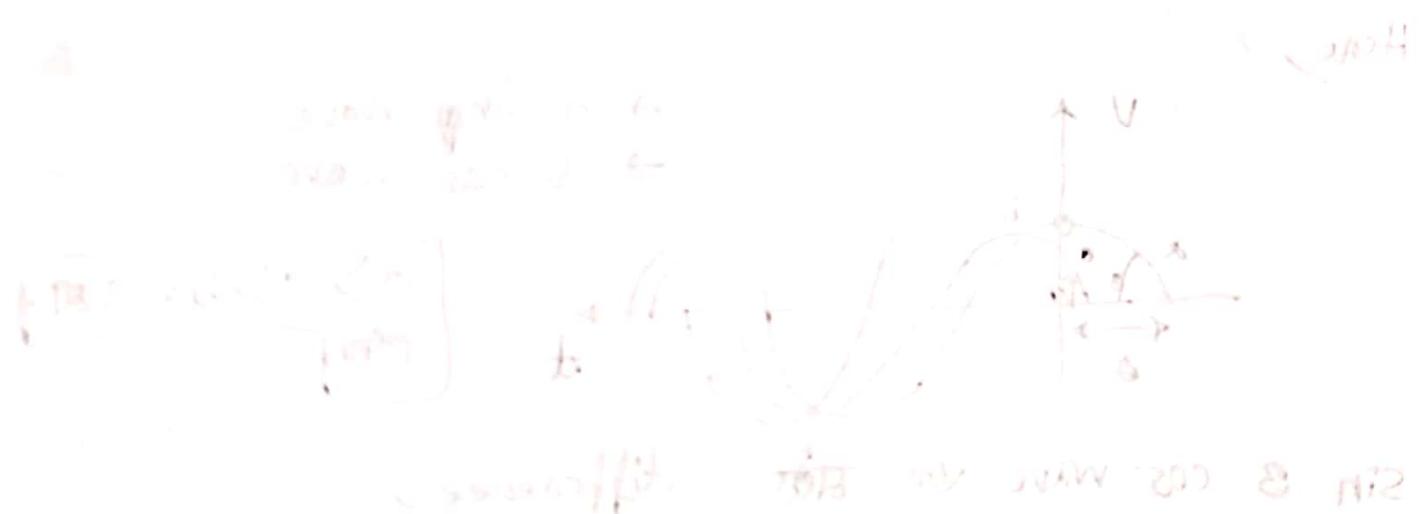


- ④ Two signals with the same amplitude and phase, but different frequencies.  $f = \frac{1}{T}$  and  $T = \frac{1}{f}$



### Frequency concerns:

- ① Frequency is the rate of change with respect of time  
 (frequency changing sinusoidally following)



$$(A + \theta_0)_{\text{max}} = 0.412$$

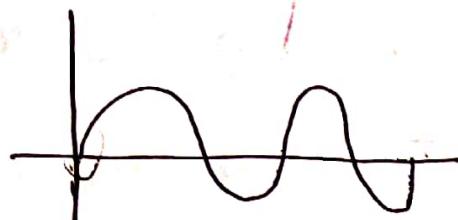
$$(A - \theta_0)_{\text{min}} = -0.100$$

Amplitude

is 0.5 during 0.2

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## Sin Wave



$$y = \sin u$$

+1 to -1

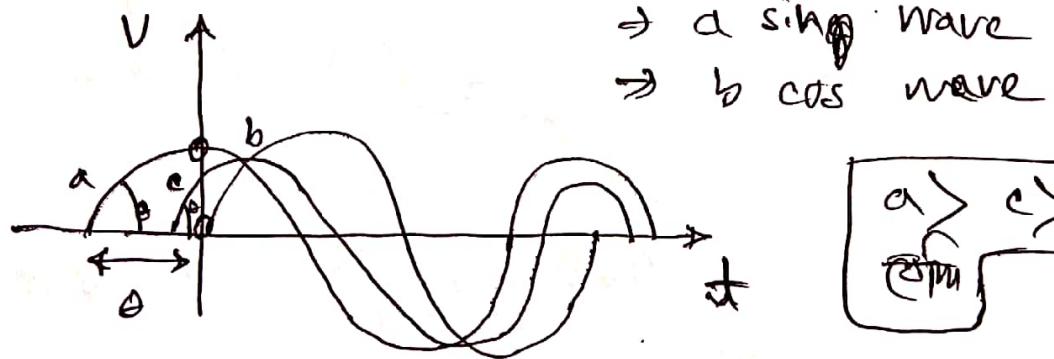
$$\textcircled{4} V = A \sin(\omega t + \phi)$$

Amplitude

angular frequency

$$\textcircled{5} \omega = 2\pi f$$

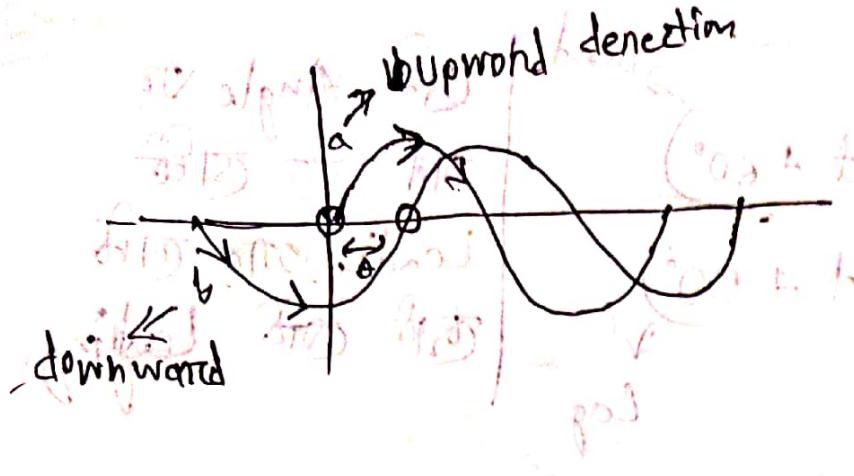
Hence,



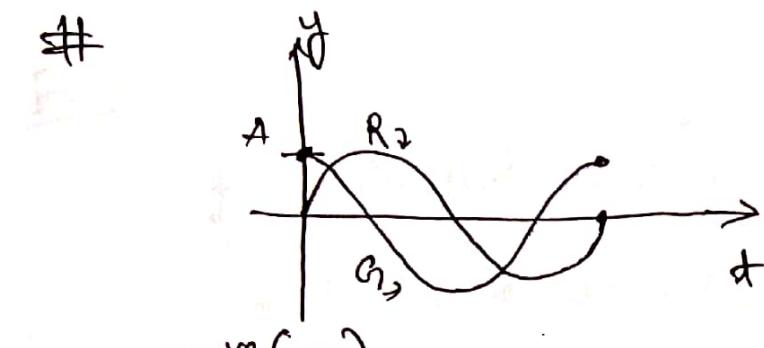
$\sin \theta$  &  $\cos \theta$  difference,

$$\sin \theta = \cos(90^\circ + \theta)$$

$$\cos \theta = \sin(90^\circ - \theta)$$



stationary wave  
at  $\theta = 360^\circ$ .  
angle difference



Green wave ( $\cos$ )

$$y = A \sin(wt + \theta)$$

$$\Rightarrow A = A \sin(0 + \theta)$$

$$\Rightarrow 1 = \sin \theta$$

$$\Rightarrow \theta = 90^\circ$$

Red wave

$$y = A \sin(wt + \theta)$$

$$\Rightarrow \theta = 0 = A \sin \theta$$

$$\Rightarrow \sin \theta = 0$$

$$\Rightarrow \theta = 0$$

$\therefore y_G$  is leading  $y_R$

$$y_R = A \sin(wt + \theta_R) \quad 0$$

$$y_G = A \sin(wt + \theta_G) \quad 90^\circ$$

(G) initial =  $A - e$

Phases.

0° → 0° &  $90^\circ$

pos (0°-90°)  $\rightarrow$  (0°-tw)  $\rightarrow$  (tw)

loss (tw)  $\rightarrow$  (tw)  $\rightarrow$  0°

Exam Imp

Exam 3 প্রয়োজন মত

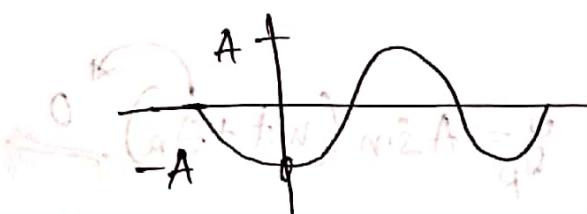
$$y = A \sin(\omega t + 60^\circ)$$

$$y = A \sin(\omega t + 30^\circ)$$

Angle  $\theta$ :  
মান করে আসি  
Leading হলে সবচেয়ে  
কম করে লেডিং।

Lag

#



$$(A + B) \sin(\omega t + \theta_B)$$

$$\Rightarrow -A = A \sin(\theta_B)$$

$$\Rightarrow \sin \theta_B = -1$$

$$\Rightarrow \theta_B = 270^\circ = (-90^\circ)$$

$$\therefore y_B = A \sin(\omega t - 90^\circ) \rightarrow \text{lag}$$

$$\therefore y = A \sin(\omega t) \rightarrow \text{Lead}$$

$$(\theta + 90^\circ) \text{ করে } A = A \in$$

$$\text{বর্তমান } \theta = 180^\circ \text{ করু$$

$$\text{কোণ } 270^\circ \text{ করু,$$

বর্ণনা

$$\sin 2A = 0 \Rightarrow A = 0$$

$$0 = \theta \text{ করু}$$

$$0 = \theta \text{ করু}$$

\* 90° পরিবর্তন করু

### Example

$$y = A \sin(wt + 120^\circ)$$

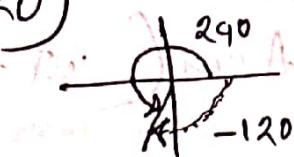


$$\sin(360^\circ + \alpha) = \sin \alpha$$

$$y_1 = A \sin(wt + 290^\circ)$$

$$= A \sin(wt + 360^\circ - 120^\circ)$$

$$= A \sin(wt - 120^\circ)$$



$$-360^\circ$$

$$+290^\circ$$

$$\boxed{-120^\circ}$$

### Ex 2

$$y = A \sin(wt - 290^\circ)$$

$$= A \sin(wt + 360^\circ - 290^\circ)$$

$$= A \sin(wt + 100^\circ)$$

$$\sin \alpha = \sin(360^\circ + \alpha)$$

or (if first)

or 88,

$$y = A \sin \alpha$$

$$= A \sin(wt - 290^\circ)$$

$$= A \sin(360^\circ + \alpha)$$

### Example - 3

$$y_1 = A \sin(wt + 130^\circ) \quad (\text{Opp} + \text{tw}) \text{ into } A = R$$

$$y_2 = A \sin(wt + 280^\circ) = A \sin(wt - 100^\circ) \quad (\text{Opp} - \text{tw}) \text{ into } A = R$$

$$y_3 = A \sin(wt - 300^\circ) = A \sin(wt + 60^\circ) \quad (\text{Opp} - \text{tw}) \text{ into } A = R$$

$$y_4 = A \sin(wt - 30^\circ)$$

Sol

$$y_1 > y_3 > y_4 > y_2$$

$$(\text{Opp} - \text{tw}) \text{ into } A = R$$

(Ans)

X —————

$$20^\circ \text{ into } A = R$$

$$(\text{Opp} - \text{tw}) \text{ into } A =$$

$$(\text{Opp} - \text{tw}) \text{ into } A =$$

$$20^\circ \text{ into } A = R$$

3 Oct

What is Signal? Signal is a representation of data. Signal is represented in electronic formate.

Composite Signal: Many simple sine wave.

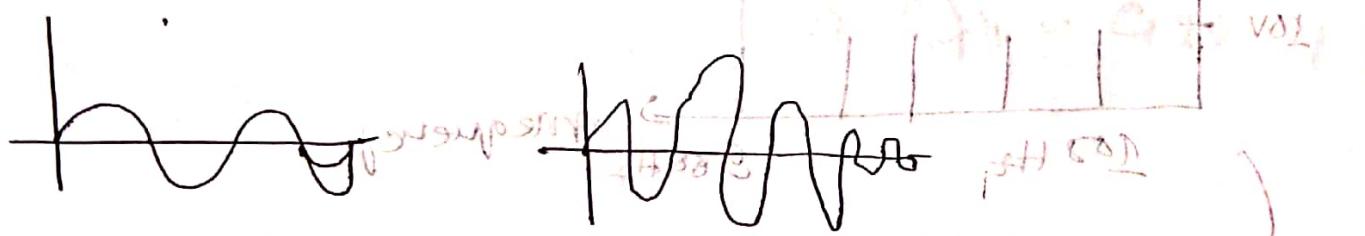
\* Fourier analysis, any composite signal

sine waves, amplitudes and phases.

Composite signal and periodicity

\* Periodic  $\rightarrow$  discrete frequencies.

\* Non-periodic  $\rightarrow$  Continuous frequencies.



periodic

Non-periodic

[walk - walk = Attributed to]

Bandwidth → A composite signal is the difference between the highest and lowest frequencies.

Example: GP → 1800 MHz to 1850 MHz

50 MHz

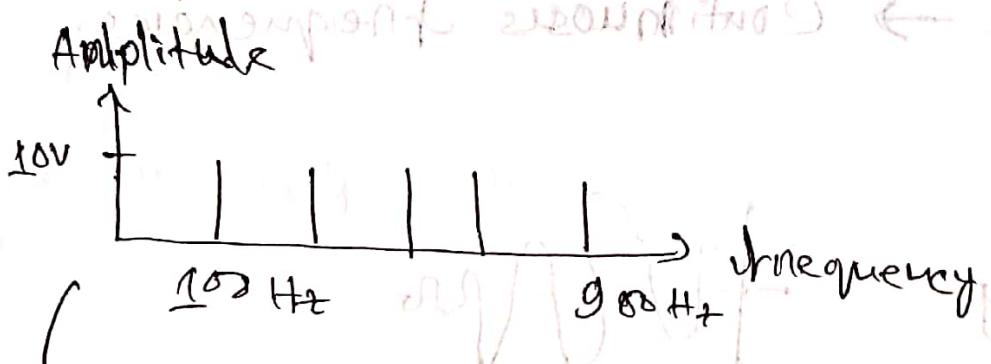
Imp. Robi → 1860 MHz to 1890 MHz

∴ High → GP, Low → Robi

30 MHz

P1: 800 Hz [Bandwidth problem]

$$B = f_u - f_l = 900 - 100 = 800 \text{ Hz}$$

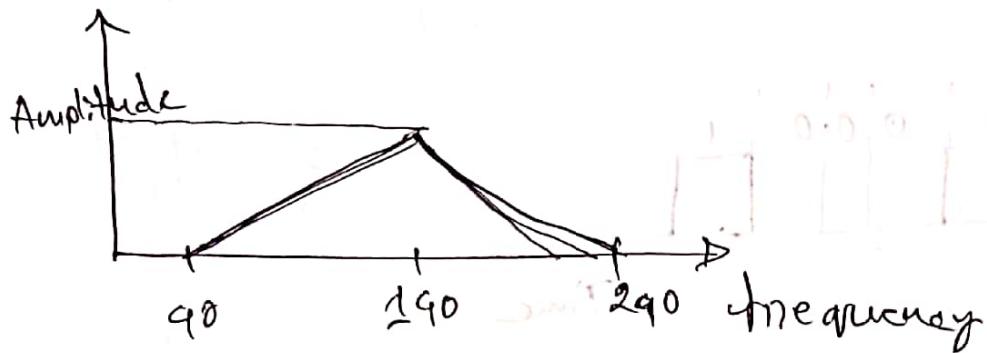
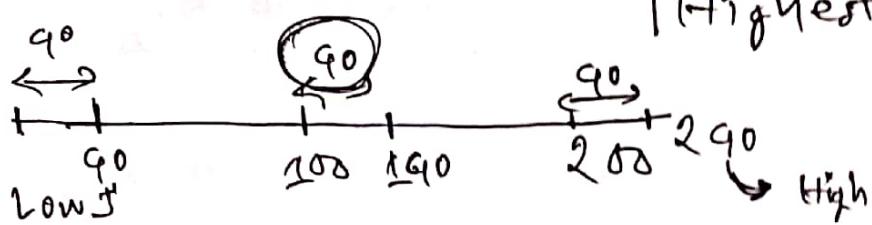


Spectrum Draw

$$\# \text{ Bandwidth} = f_{\text{high}} - f_{\text{low}}$$

P22

$$\text{Bandwidth} = 200 \text{ kHz} \quad \left. \begin{array}{l} \text{Low} = 40 \text{ kHz}, \\ \text{Highest} = 240 \text{ kHz}. \end{array} \right\}$$



Explain.

$$f_n - f_L = 200$$

$$\Rightarrow (f_n + f_L)/2 = 190$$

$$\text{Hd } f_n - f_L = 200$$

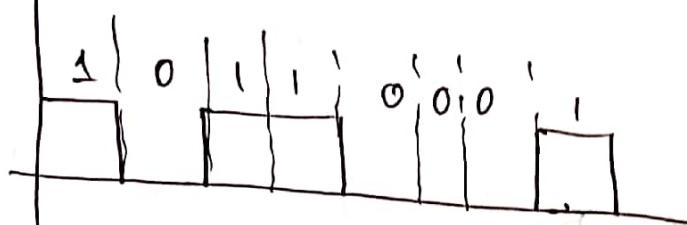
$$\Rightarrow f_n + f_L = 280$$

$$\Rightarrow 2f_n = 280$$

v

Digital Signal      Digital      Analog

~~Hedysarum~~ = ~~hedgehog~~



Octal = 3 bit

hexadecimal = 4 bit

- If we need ~~not~~ ~~then~~ get ~~one~~  $2^n$  bits.

④ We can work with 2, 4, 8, 16, 32 levels.

## Math Problem

$\log_b a \rightarrow$  argument  
 $b \downarrow$  base

On the argument for which base length?

~~Base~~  $\overset{n}{\text{no}}$

Given,

Levels = 8

$$\therefore \text{bits per level} = \log_2 8 = 3$$

(Ans) / 3 bit.

# 2, 4, 8, 16, 32 match top half in Level 2

Upper limit of first 16,

$2^{10}$  without overflow to the next level

$2^{10} \times 2^3 = 2^{13}$  without overflow no steps exist

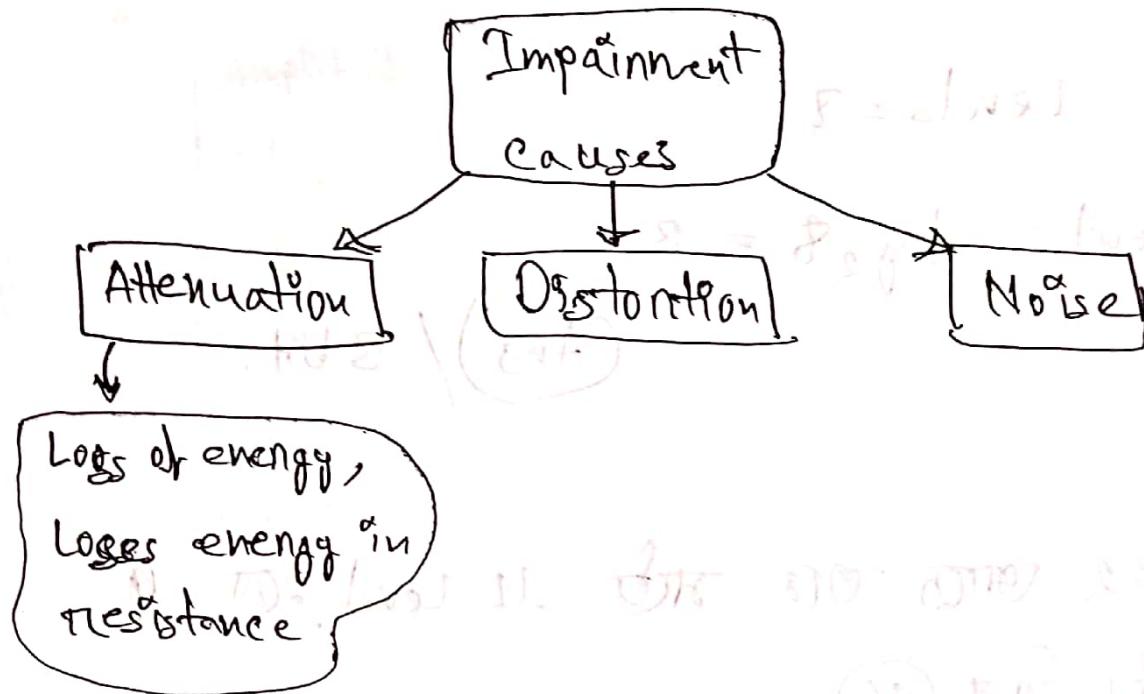
$$2^{10} \times 2^3 = 2^{13}$$

lowest length  $\log_2 2 = 1$

$$\therefore n = \log_2 1024 = 10$$

## Transmission Impairment

Signal travel through media which is not perfect. Three causes of impairment.



### Measurement of Attenuation:

Loses ~~are~~ on given energy units 'decibel'

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

Where,

$P_1$  = Input Signal Power.

$P_2$  = Output ~~Power~~  $\parallel$ .

### #3 Math

Given,  $P_2 = \left(\frac{1}{2}\right) P_1$

(-) Attenuation Loss  
(+) " Gain

Hence,

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

$$\stackrel{\text{Attenuation}}{=} 10 \log_{10} \left( \frac{0.5 P_1}{P_1} \right)$$

$$= 10 \log_{10} (0.5)$$

(Ratio 3/2)

$$\stackrel{\text{WdB}}{=} 10 \times (-0.3)$$

$$= -3 \text{ dB}$$

WdB of 0D = 0D + 6.

$\therefore$  Loss of 3 dB.

Given,

power increase 10 times.

$$P_2 = 10 \text{ power increase}$$

Hence,

$$\begin{aligned} 10 \log_{10} \frac{P_2}{P_1} &= 10 \log_{10} \left( \frac{10 P_1}{P_1} \right) \\ &= 10 \log_{10} (10^1) \\ &= 10 \times 1 = 10 \text{ dB} \end{aligned}$$

$\therefore$  Gain 10 dB.

(Ans)

$$10^{\log_{10}(\frac{P}{P_0})} = 10^0$$

$$\frac{10^0}{10^{-3}} \text{ or } 10^3 \text{ mW}$$

Given,

milliwatts  $\rightarrow$  Power at milli  
convert to dB,  
 $(P_m)_{dB} = 10 \log_{10} P_m$

Hence,

$$dB_m = 10 \log_{10} P_m \quad P_1 = 1 \text{ mW}$$

$$\Rightarrow -30 = 10 \log_{10} P_m$$

$$\Rightarrow P_m = 10^{-3} \text{ mW}$$

Given,

Per kilometer loss  $= -0.3 \text{ dB/km}$

Input,  $P_i = 2 \text{ mW}$

$$\text{so, loss} = 5 \times (-0.3) \\ = -1.5 \text{ dB}$$

$$dB_{out} = P_{out} - P_i$$

Condition: shall mind it.

Hence,

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

~~1.5~~  $\Rightarrow$  ~~1.5~~

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

$$\Rightarrow P_2 = 0.71 \times P_1$$

$$P_1 = 2$$

$$\Rightarrow P_2 = 0.71 \times P_1$$
$$= 0.71 \times 2$$
$$= 1.4 \text{ mW}$$

watt  $\Rightarrow$  dB

milliwatt  $\Rightarrow$  dB<sub>m</sub>

$$\log_{10} n = y$$

$$\Rightarrow n = 10^y$$

Last moment  
have to set

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

(Ans)

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

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

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

$$\Rightarrow 0.71 = \frac{P_2}{P_1}$$

Distortion

→ composite Signal.

delay & आवृत्ति  
or shape changes  
आवृत्ति का  
Distortion.

$$2^4 \times 10^{-10} = 2^4 \times 10^{-10}$$

## Noise

different types of noise →

Thermal → noise of electrons in the wire creates an extra signal.

Induced →

10 Oct

## Signal to Noise Ratio (SNR)

$$\uparrow \text{SNR} = \frac{S}{N} \uparrow$$

so better SNR with more symbols for better performance.

$\therefore$  If SNR is greater then noise is less than signal.

①  $\text{SNR} = 1.4$

$\therefore$  Signal is greater.

②  $\text{SNR} = 0.8$

$\therefore$  Noise is greater.

✓

~~③  $\log_2\left(\frac{S}{N}\right)$~~

$\therefore (+)$  Gain,  $(-)$  Loss.

Note: digital ~~use~~ ~~in~~ log base '10'  
use ~~base~~, ~~in~~ digital ~~use~~ '2' use ~~base~~,

## Math SNR

$$\text{SNR} = \frac{15000 \text{ mW}}{1000 \text{ W}} = 15000$$

$$\text{SNR}_{\text{dB}} = 10 \log_{10}(15000)$$

$$= 10 \log_{10}(10^4)$$

[Edit for reduction in J]  $N_J = \frac{1}{(10^4)}$

$$= 40$$

10 log 10 (10^4)  
(12 dBm)

2 + 2 = 4

Ideal Condition 1, 011, 101, 011, 110, 010, 100, 100 to

SNR and SNR<sub>dB</sub>,

$$\text{SNR} = \frac{\text{Signal power}}{0} = \infty \quad [Real Life]$$

$$\text{SNR}_{\text{dB}} = 10 \log_{10} \infty = \infty$$

We can never achieve this ratio. It is an ideal condition.

④ Signal to noise ratio  $\infty$ , noise  $\infty$  can't happen,

we have to be 100 times less noise

## Mechanical - ③

## Data Rate Limits

W-65031 W-65032 W-65033

1970-71 (1971) of school year

Q ⇒ Explain :

Explain:  $(\text{FOB})_{01 \ 001 \ 01} =$   
 $L = 2^n$  [n number of bits]

$$\therefore L = 2^3 = 8$$

$\Rightarrow 000, 001, 010, 011, 100, 101, 110, 112$  *111, 100, 101*

## Logic →

$$0 \xrightarrow{V} 0 \\ 0 \xrightarrow{V} 1$$

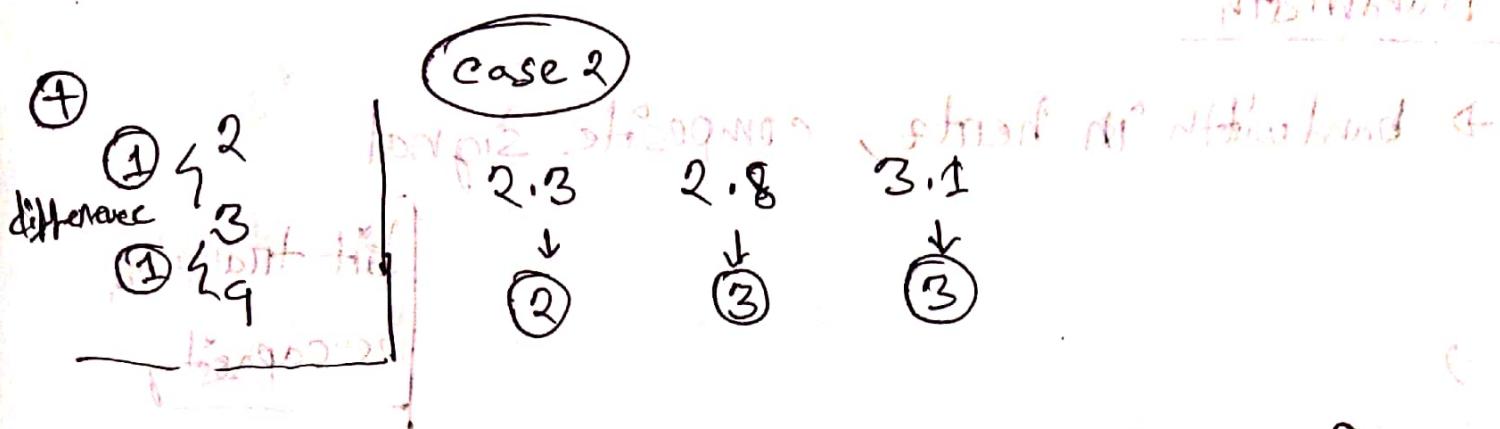
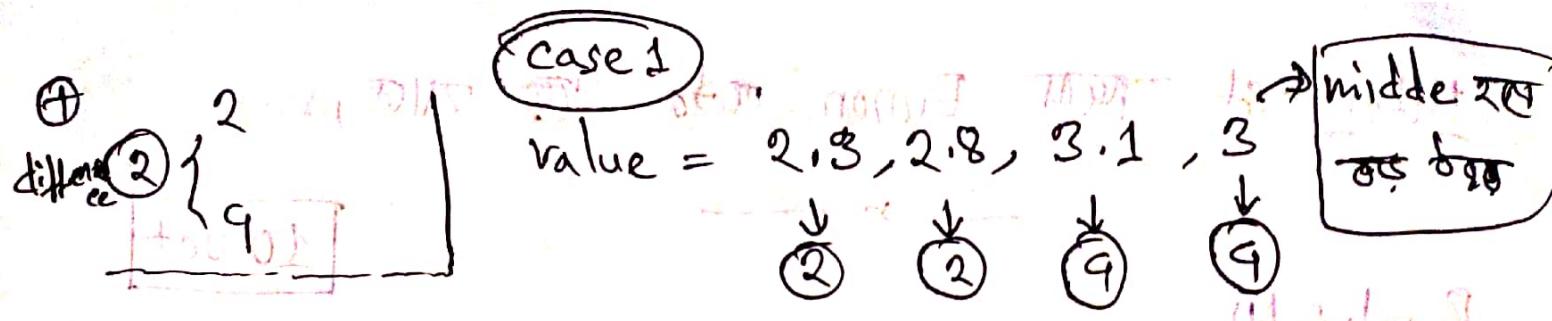
$\approx 9.5$  V হলে '1'। Totally '5V' পাও না গিয়ে Lose হয়,

A row of nine circles, each containing a handwritten digit from 1 to 9. The digits are arranged horizontally: 1, 4, 2, 3, 5, 6, 7, 8, 9.

Value of  $\Theta = 2.7 \rightarrow 2$

৭. ত্রিমুখীয়া নামে noise add কর ২.৯  
১.০৫ = ২.৪

$\Rightarrow$  noise ~~বৰ্ত~~ ~~B.I~~ ~~জন~~ ~~(c)~~ এ,



\* Case 1 & Case 2 හෝ එහි නොමැත්තායි!

⇒ Case 2.

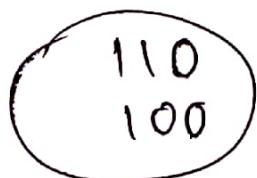
Example:



00  
01  
10  
11

00 → 5010 (first 2 bits)  
01 → 1001 (next 2 bits)  
10 → 0100 (last 2 bits)

∴ පෙන්වා 110 යා එකඟ මාගිස්තර, එහි 100 ප්‍රාග්‍රැම  
1 සිට අදාළ,



$$\therefore \text{Ennon} = 3310$$

Note: Bit ~~direct~~ Enron ~~not~~ ~~direct~~ आए,

10 Oct

### Bandwidth

→ bandwidth in hertz, composite signal



→

bit transmits,  
is capacity -

If 5 waves from Enron fit in 2 seconds & 1 second

### Capacity of a System

→ When we increase ~~level~~ level on bit then  
capacity will increase.

No.  $\rightarrow$  10

No.  $\rightarrow$  11

No.  $\rightarrow$  12

No.  $\rightarrow$  13

No.  $\rightarrow$  14

No.  $\rightarrow$  15

No.  $\rightarrow$  16

No.  $\rightarrow$  17

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No.  $\rightarrow$  110

No.  $\rightarrow$  111

No.  $\rightarrow$  112

No.  $\rightarrow$  113

No.  $\rightarrow$  114

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No.  $\rightarrow$  240

No.  $\rightarrow$  243

No.  $\rightarrow$  246

No.  $\rightarrow$  251

No.  $\rightarrow$  254

No.  $\rightarrow</math$

Ex:

$$\begin{array}{l|l} C \propto B & C \propto nB \\ C \propto n & \therefore C = 2nB \xrightarrow{\text{constant}} \text{constant} \\ & = 2B \log_2 L \end{array}$$

$$L = 2^n$$

Uplink  $\downarrow$

Downlink  $\uparrow$

$$1 \text{ Mbps} \times 000000 \times 8 = 500 \text{ Gbps}$$

$$2 \text{ Gbps} \approx 1 \text{ Tbps}$$

$$2 \text{ Gbps} \approx 1 \text{ Tbps}$$

Nyquist Theorem (F.C.) It is applicable noiseless

It states that a noiseless channel

$$C = 2B \log_2 2^n$$

Where,

$C$  = Capacity in bps

$B$  = bandwidth in Hz

$$[NB: 2^n = 2^6]$$

$$1 \text{ Mbps} \times 1000 \times 2^6 = 1 \text{ Gbps}$$

$$F \leq 2B = n$$

Important: If more than one user

### Example - 3.36

Given,

$$265000 = 2 \times 20000 \times \log_2 L$$

$$\Rightarrow \log_2 L \approx 6.625$$

$$\Rightarrow L \approx 2^{6.625}$$

Question  $\Rightarrow L = 98.7$  levels

$$\begin{aligned} C &= 2B \log_2 L \\ &= 2B \log_2 2^n \\ &= 2B n \log_2 2 \quad (\text{since } \log_2 2 = 1) \\ &\Rightarrow 2B n \text{ bits per frame} \approx 8 \\ &\quad \boxed{C = 2Bn} \end{aligned}$$

$$\Rightarrow 265000 = 2 \times 20000 \times 80000 n$$

$$\Rightarrow n \approx 6.625 \approx 7$$

Note: '8' এর অঙ্গুল কাছে '7' নিচে।

## Shannon's Theorem

This theorem gives the capacity of a system in the presence of noise.

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

Explains:

$$SNR = \frac{S}{N}$$

⊕ When the SNR is '0'. Then the capacity will be '0'

$$C = B \log_2 (1+0) \xrightarrow{\text{Simplifying}} 0$$

Since  $S = P_s B$  and  $N = N_0 B$

$$\Rightarrow C = B \log_2 \left( \frac{P_s B}{N_0 B} \right) = B \log_2 \left( \frac{P_s}{N_0} \right)$$

(Ans)

Example : 3.39

(Exam)

Given,  $\text{SNR}_{\text{dB}} = 36$

What is the data rate in Mbps with bandwidth of 2 MHz?

Hence

$$\text{SNR}_{\text{dB}} = 10 \log_{10} \text{SNR}$$

$$10 \log_{10} x$$

$$\Rightarrow 36 = 10 \log_{10} (\text{SNR})$$

$$\Rightarrow \log_{10} (\text{SNR}) = 3.6$$

$$\Rightarrow \text{SNR} = 10^{3.6}$$

$$= 3981$$

$$\left. \begin{array}{l} \log_{10} a = b \\ \Rightarrow a = 10^b \end{array} \right\}$$

And

$$C = B \log_2 (1 + \text{SNR})$$

$$= 2 \times 10^6 \times \log_2 3982$$

~~= 29 Mbps~~

$$= 29 \times 10^6 \text{ bps}$$

$$= 29 \text{ Mbps}$$

base unit

④ bps

④ Gbps

(Ans)

### Example 3.91

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

$$= 10^6 \log_2 (1 + 6^3)$$

$$= 6 \text{ Mbps}$$

and,

$$C = 2B \log_2 L$$

$$\Rightarrow \log_2 L = \frac{C}{2B} = \frac{6 \times 10^6}{2 \times 10^6}$$

$$\Rightarrow L = 4 \quad (\text{Signal level})$$

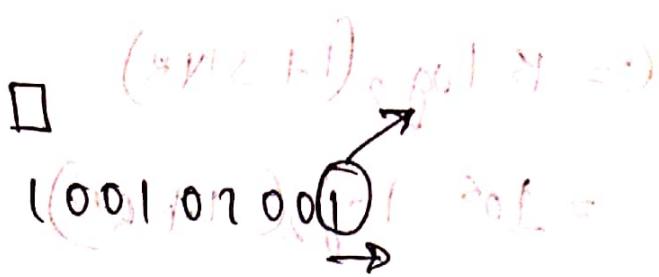
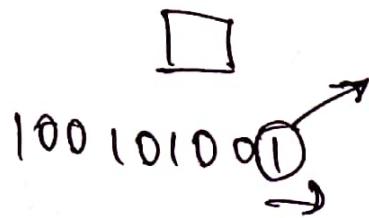
where,

$$\log_2 L = 3$$

$$\therefore n = 3, L = 2^3 = 8$$

(Ans)

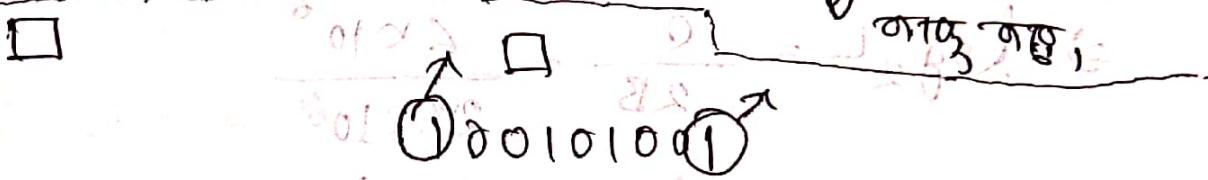
## Propagation Delay



⊕ First bit arrives at receiver after propagation delay.

Distance of propagation delay:

⊕ distance of propagation delay, ⊕ single bit delay



⊕ last bit arrives at receiver after first bit arrives at receiver + transmission delay.

⊕ total Bit arrival time depends on number of bits.

④ Propagation Delay =  $\frac{\text{Distance}}{\text{Propagation Speed}}$

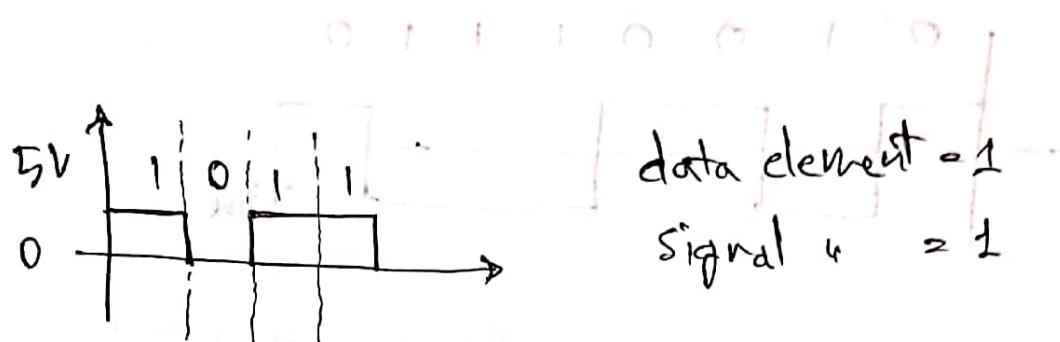
⑤ Transmission Delay =  $\frac{\text{Message Size}}{\text{Bandwidth bps}}$

⑥ Latency = Propagation delay + Transmission delay  
Queuing time + Processing time.

Instruction time  
Wait

## 4th Metrical

### Digital to Digital Conversion



- ④  $n$  = Number of bits.

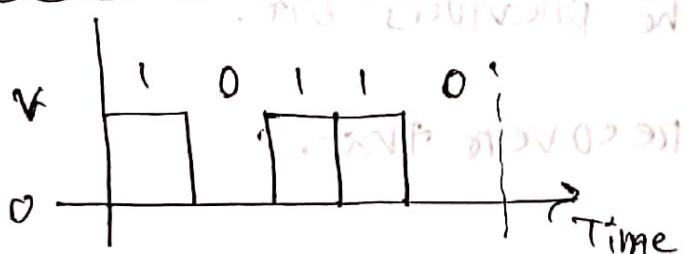
### Data Rate vs Signal Rate

Data Rate  $\rightarrow$  bits per second (bps)

Signal Rate  $\rightarrow$  baud.

### Line Coding

#### Unipolar NRZ scheme

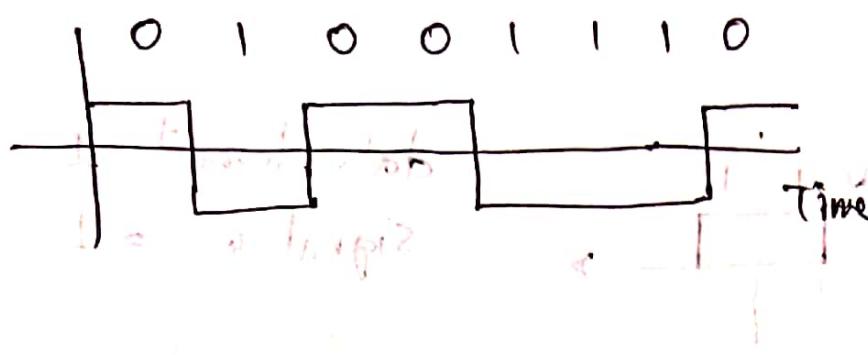


- ④ No negative value.

## NRZ-L<sup>0</sup> (Polar)

Transmitting bits

Polar  $\rightarrow$  negative  
fixed level, polar



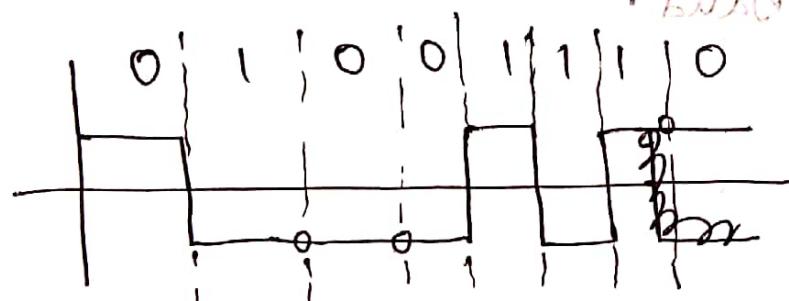
at bit 0 no change 01 (e)

## NRZ-I<sup>0</sup> (Polar)

short length 2.8 short 0.50

0 = No Change

1 = Change

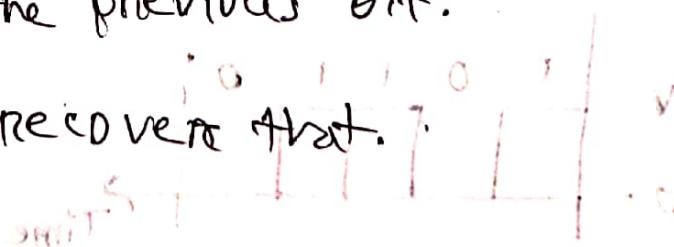


initial 0.50

means can not ignore

④ It depends on the previous bit.

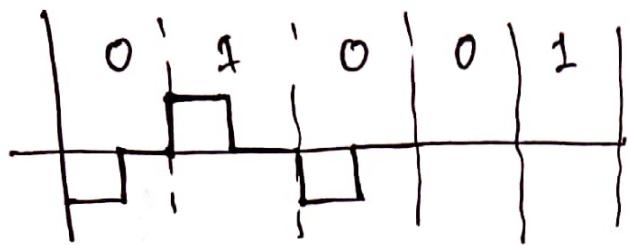
⑤ Bit missing can recover that.



water without off ④

## Polar RZ scheme

NRZ-L UP ग्राहक  
Power consumption  
लगत,



④ Energy consumption is low.

∴ RZ means Return to Zero.

# ① Power Fluctuation - Voltage up/down / oh/ohr

② Power Consumption - current loss.

③ Charge Accommodation - charge stored  
(bit dependent)

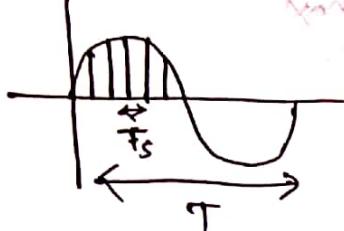
④ Error Collection = NRZ-I and Differential

Manchester.

# Analog to Digital Conversion

(PCM)

Sampling



if  $T_s = \text{constant}$  then  $T_s = \text{Sampling period}$

$T = \text{Time}$

$T_s < T$

$\frac{1}{T_s} > \frac{1}{T}$   $\Rightarrow$   $f_s > f$   $\Rightarrow$  Nyquist frequency

$T_s > T$

Natural Sampling:  $\oplus$

$\oplus$  Memory complexity.

Flat top sampling:

$\oplus$  Average error.

$\oplus$  Further calculation.

(PCM) [Pulse Code Modulation]

$\oplus$  3 for Method:

~~Sampling~~

$\rightarrow$  ① Sampling

$\rightarrow$  Discrete formate  
 $\rightarrow$  Signal without Distortion

② Quantization

$\rightarrow$  Signal discrete Amplitude  
 $\rightarrow$  minimum number of bits limited distortion

③ Encoding

- compresses digital Data.
- Doesn't cause distortion.

→ ନୂରୁଳୁ ଏହି ପ୍ରକ୍ରିୟା କୁଣ୍ଡଳ ପ୍ଲେଟ୍‌ଫଲ୍ମ୍ ପାର୍ଶ୍ଵରେ ଅନୁଭବ କରାଯାଇଛି।

## Nyquist Theorem:

$$f_s = 2f_{\text{max}} \quad \text{Nyquist rate} = 2 \times f_{\text{max}}$$

### Problem 3

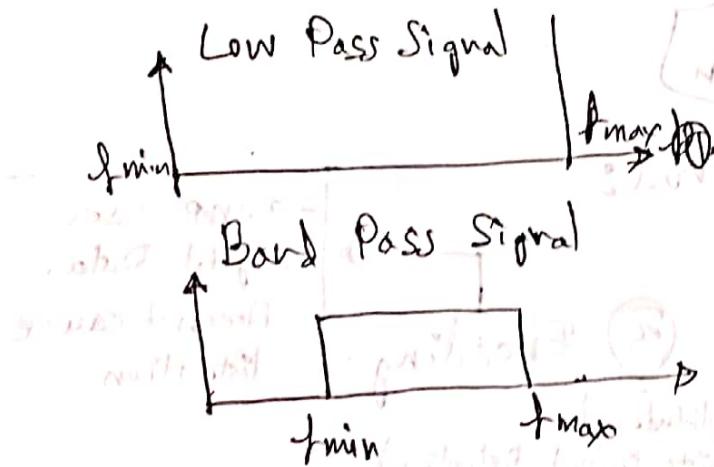
Meth

Sampling rate = 400 Hz

bandwidth = 200 kHz  
low pass signal.

P-2

$$f_s = 2 \times f_m \\ = 200 \text{ Hz}$$



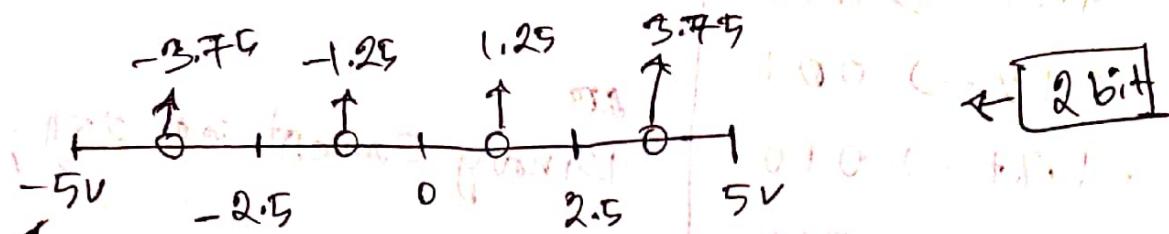
$$f_1 = 20 \text{ Hz}$$

$$f_2 = 50 \text{ Hz}$$

$$f_3 = 100 \text{ Hz}$$

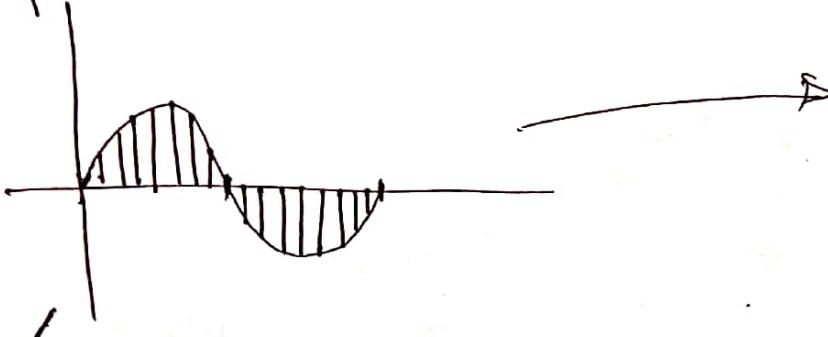
$$f_{\max} = 150 \text{ Hz}$$

## Quantization



$$\Delta = \frac{V_{max} - V_{min}}{L}$$

$$= 2.5$$



|      |      |
|------|------|
| 0V   | -3V  |
| 2V   | -1V  |
| 3.5V | 0V   |
| 5V   | 2V   |
| 3.2V | 3.2V |
| 1.8V | 4.1V |
| 0V   | 5V   |

④ Bit յից յիշ մինչև Quantization error կան:

(1.25, 1.25, 3.75, 3.75, 3.75, 1.25, 1.25, -3.75, -3.75, -3.75, 1.25)

$$\frac{\Delta}{2} = 0.5$$

$$\frac{\Delta}{2} = \text{error}$$

Example :-

$$-9.37 \rightarrow 0\ 100$$

$$-3.12 \rightarrow 0\ 01$$

$$-1.87 \rightarrow 0\ 10$$

$$-0.63 \rightarrow 0\ 11$$

$$-0.83 \rightarrow 1\ 00$$

00

Binary

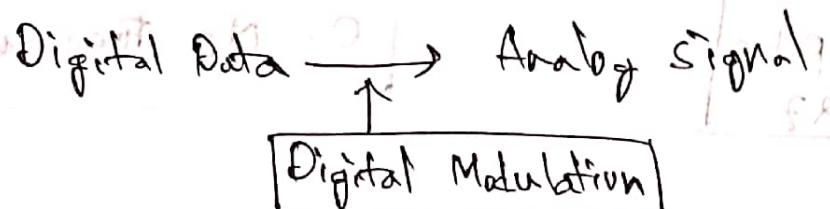
convert ~~011~~ 2~~011~~

00000000

L

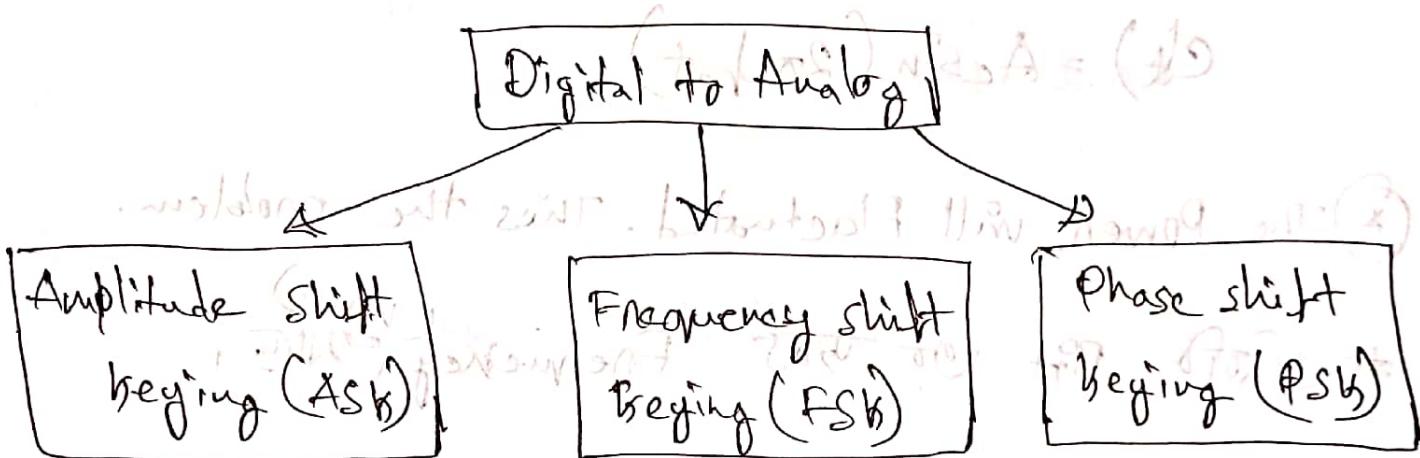
Analog Transmission

process - 1



④ Channel will be high frequency

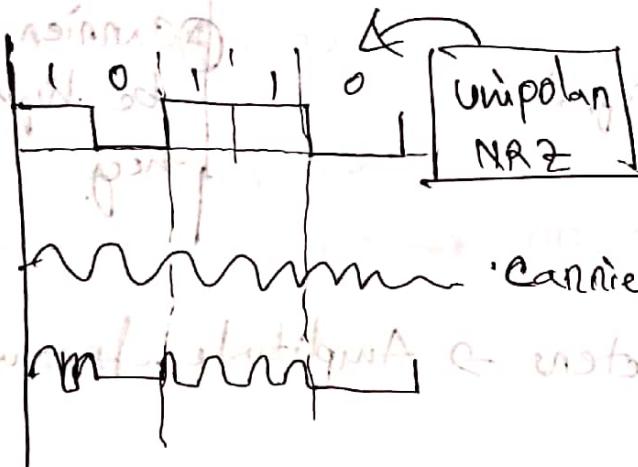
- ④ At wave no. of Parameters → Amplitude, frequency, phase.



Topic 5.1 [2-Tier FM Mod]

## Amplitude Shift Keying (ASK)

Notes: [not done]

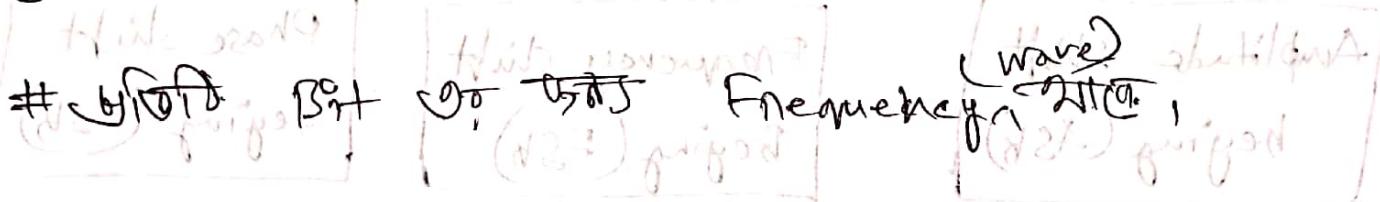


1 = Frequency

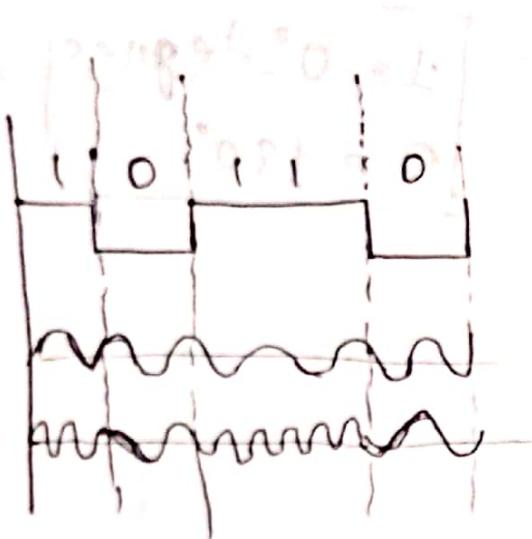
0 = No Frequency

$$e(t) = A_c \sin(2\pi f_c t)$$

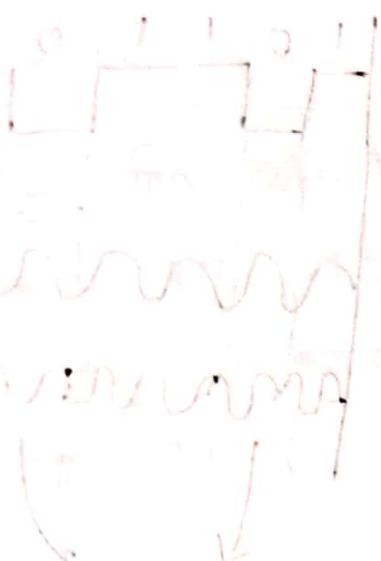
\* The Power will Fluctuate. This the problem



## BFSK Implementation



(Q203)



more narrow  
wider

① When 1 the frequency is increasing.

② When 0 it is remains the same.

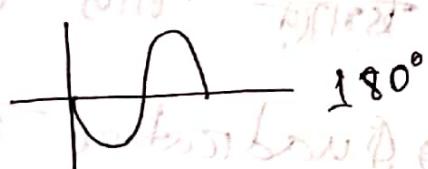
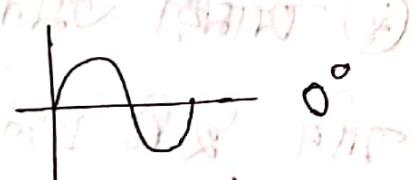
### Problem

It will increase the bandwidth.

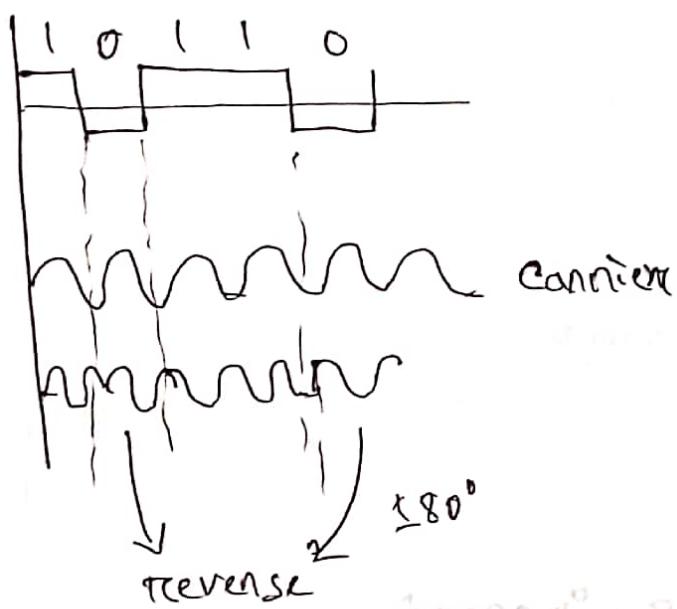
Note: In real world we want to

### Phase Shift key (PSK)

Phase  $\alpha$  is an angle.



# BPSK



$$\begin{cases} 1 = 0^\circ \text{ degree} \\ 0 = 180^\circ \end{cases}$$

Hence,

$$c(t) = A_c \sin(2\pi f_c t)$$

$$1 \rightarrow A_c \sin(2\pi f_c t)$$

$$0 \rightarrow A_c \sin(2\pi f_c t + 180^\circ) \\ = -A_c \sin(2\pi f_c t)$$

④ यानि एक '1' bit किस तरफ, '1' bit = [0, 1]

यानि 2 Bit किस तरफ, जो उत्तर [01, 10, 11, 00]

हिमाल 010, जैसे याद,

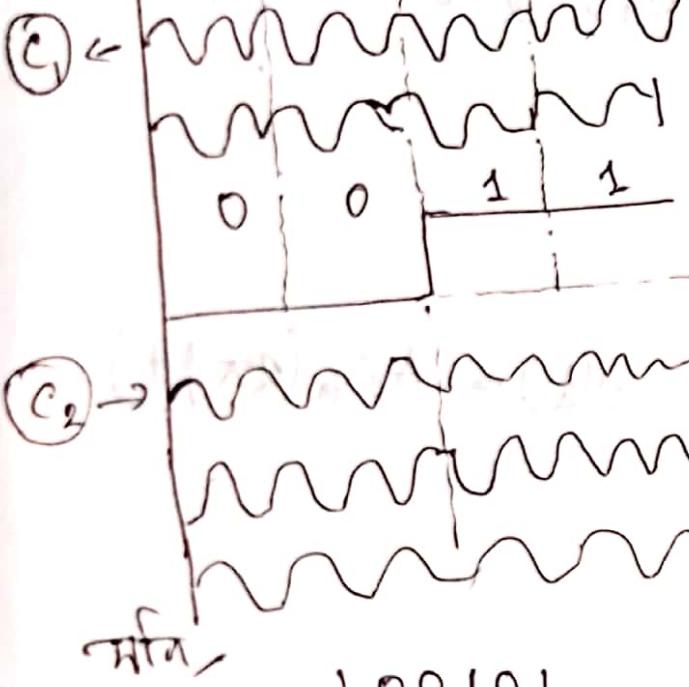
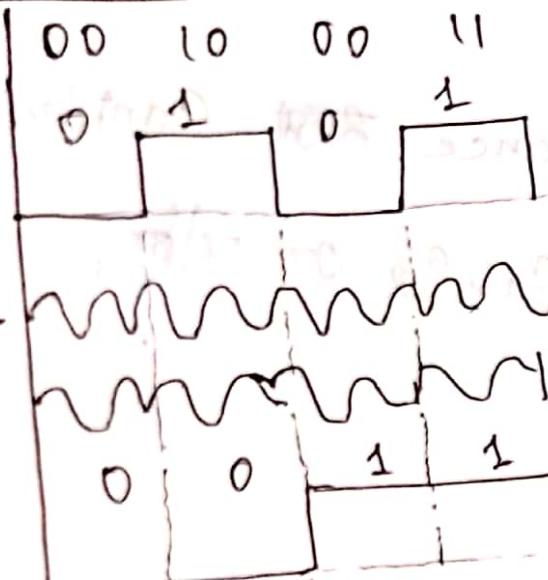
~~→ Quadrature~~ 2 Bit किस तरफ,

→ BPSK ('1' Bit किस तरफ, जैसे, QPSK '2' Bit किस,

Degree  $\Rightarrow$  90° घण्टा में 90° घण्टा में

प्राथमिक बारी  $\rightarrow 0^\circ, 90^\circ, 180^\circ, 270^\circ$

**QPSK**



100101

odd  $\rightarrow$  ~~(1) (1) (1)~~  
even  $\rightarrow$  ~~(0) (0) (0)~~

odd  $\rightarrow$  ~~(1)~~, 0, 0  
even  $\rightarrow$  ~~(0)~~, 1, 1

→ 2nd for प्राप्ति  
आप्ति तरं भिन्न,  
00 इन 0 अनन्त,  
0 वाले तरं,

$\rightarrow (90^\circ)$  phase shift key

2nd wave  $\rightarrow$  ~~(1) (1) (1)~~  
~~(0) (0) (0)~~

Then,

$$c_1(t) = A_c \sin(2\pi f_c t)$$

$$c_2(t) = A_c \sin(2\pi f_c t + 90^\circ)$$

$$\Rightarrow A_c \cos(2\pi f_c t)$$

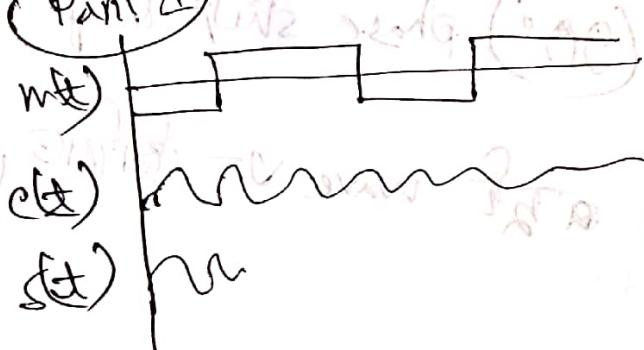
$$\text{#} \sin(90^\circ + \theta) = \cos \theta$$

④ GFSK এর মধ্যে পার্সেন্স ডিফেন্সে ২ $\pi$  কালীন

বারে বারে ডিফেন্সে ২ $\pi$  কালীন,

Hence, (Again) GFSK

Part 1



$$c(t) = A \sin(2\pi f t)$$

$$\text{If, } m(b) = 1,$$

$$s(t) = A \sin(2\pi f t)$$

$$m(t) = 0;$$

$$\begin{aligned} s(t) &= -A \sin(2\pi f t) \\ &= A \sin(2\pi f t + 180^\circ) \end{aligned}$$

## Material - 7

### Analog to Analog Conversion

① Analog to Frequency converter

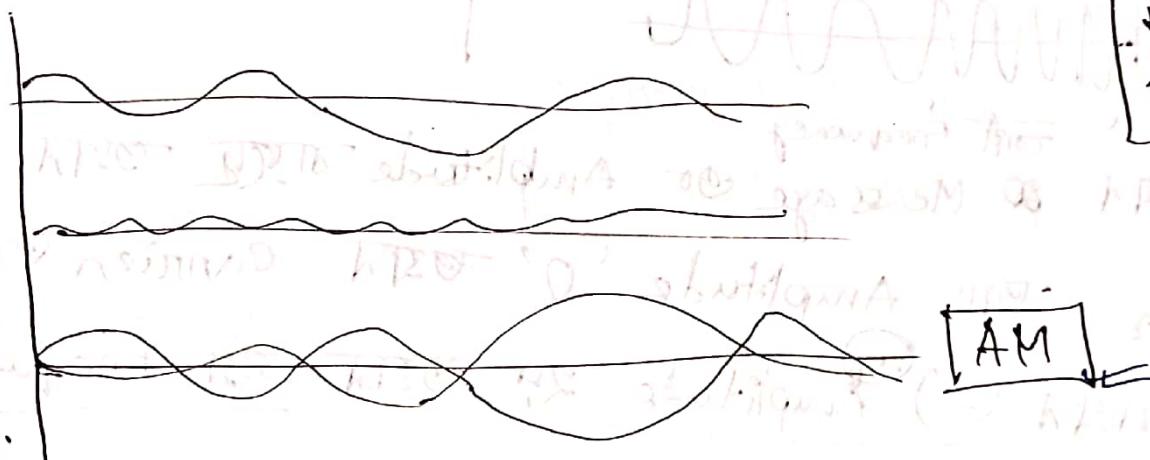
কার্ডিয়াক সেন্সর এবং Frequency converter  
কার্ডিয়াক সেন্সর এবং Frequency converter

② Carrier wave এর কাছে সিদ্ধ এবং পরিবর্তন

Information carrying এর,

③ Continuous wave.

④ Band Pass Filter. (বিশিষ্ট ফ্রিকেন্চি এর কাছে পার)



AM, FM,  
PM  
wave show

Binary

⑤ Amplitude change ২০, Message Signal ৭০  
wave change ৩০, Carrier wave change ৫০

⑥ Classification of continuous wave modulation:

① Amplitude Modulation. (AM)

② Frequency Modulation (FM)

③ Phase Modulation (PM)

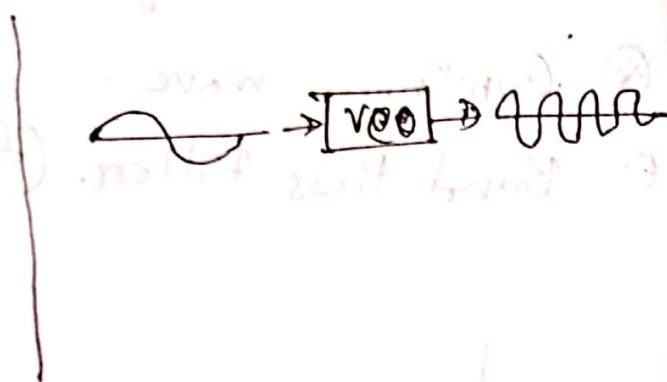
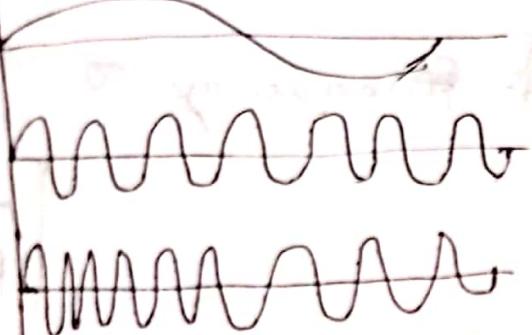
## AM (Amplitude Modulation)

- ① Amplitude change using the Message Signal.
- ② Problem is Amplitude **Fluctuation**.

## FM (Frequency Modulation)

Change

Amplitude



- ④ ~~मैसर वो~~ Message वो Amplitude वाले ~~वाले~~ Frequency अप्पा, उनके Amplitude '0' वाले Carrier वाले मौल, आँख चाहत (-) <sup>neg</sup> Amplitude वाले ~~वाले~~ Frequency फिर देख।

- ⑤ **VCO** वो मौद्दिल ~~वो~~ Voltage वो मैसर वाली आस।

- ⑥ Amplitude Fixed आप्पा, उत्तर Noise आप्पा

कृष्ण नाम दिए आप्पा,

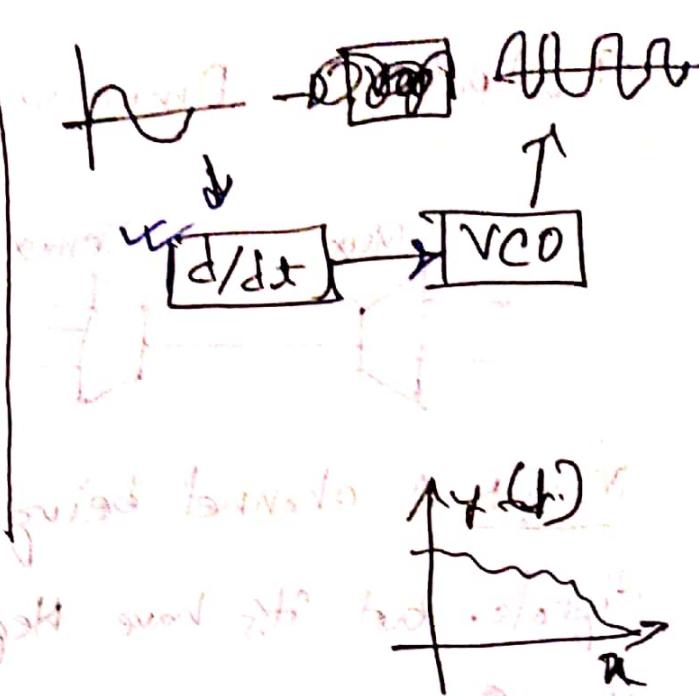
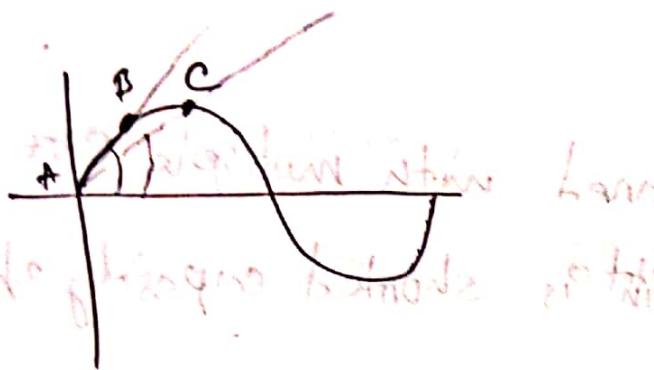
Bandwidth जोड़ी आप्पा,

- ⑦ AM वो सुनाया FM आप्पा,

## Phase Modulation (PM)

- ১৫ \*

Rate of change ~~परिवर्तन~~,



$\rightarrow$  AB वर्षा स्लोप टॉप, AC वर्षा टॉप,

ଶ୍ରୀମତେ କାଳ (୫) ଲମ୍ବ,

- ④ ~~App~~ Stop ~~right~~ ~~2M~~ Higher value ~~100~~

ୟତ୍ର, ଚାମନ୍ଦିତିକୋ) ମାଟ୍ଟିଏ

ଶ୍ଵାମ୍ଭବ ଅଣିତା ,

|  |   |
|--|---|
| <p>মানে Highen value</p> <p><del>মাটের ফটেজ গো</del></p> | <p>সমালে Different<br/>মানে মালে স্থানে</p> <p>Range.</p> |
|--|---|

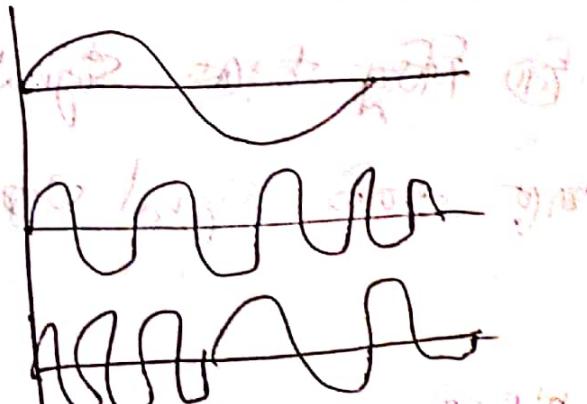
- \* It is depend on the differentiate value of the amplitude.

- ④ y এর Differentiate value

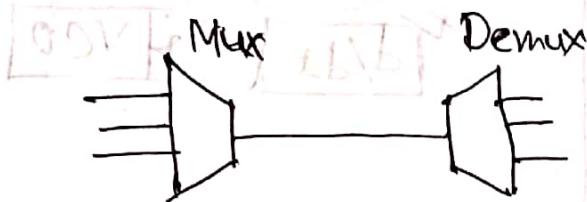
2012 SC M(3)

More efficient  $\mathcal{L}_1$

\* PM better than FM



9 output  $\Rightarrow$  Demux  $\Rightarrow$  2 $f$  switch  $\Rightarrow$  11 $f$



Mux: A channel being shared with multiple peer signals. but its have Neg. point is shared capacity of it.

→ Bandwidth are utilized.

### Multiplexing Category

- ① Frequency division
- ② Wavelength division
- ③ Time division

Analog

Digital

### FDM (Frequency division Multiplexing)

दो विभिन्न चौरासा सिग्नल को एकमात्र अन्त में अक्षर सिग्नल को उत्पादित करता है,

FDM के लिए

AM use का रूपान्तरण  
मिलता है

Math

Ex-6.1

20 - 32 kHz

2.92 MHz band.

100% × 625 kHz

625 kHz = bandwidth = 9 kHz

Combine three bandwidths 125 kHz

$\therefore$  1st person = 20 - 24 kHz

bands length  $\sqrt{248} \approx 16$

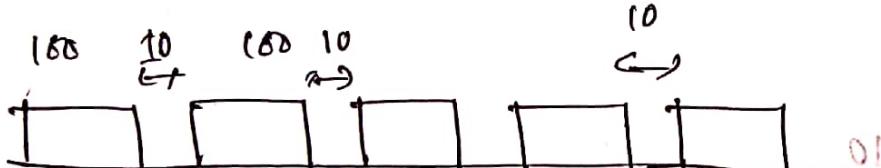
$\therefore$  2nd = 24 - 28 kHz

$\therefore$  3rd = 28 - 32 kHz

QPT → ছোঁটায়,

Ex-6.2

total amount of bandwidth = 540 kHz



⇒ good band 2400  
মানবীয় স্বাধীন কৃতি,

Ex-6.3

or Divide into four channels =  $\frac{1 \text{ M}}{4} = 250 \text{ kHz}$

Nyquist  $\Rightarrow$  প্রক্রিয়াজনের Data rate এর সমানতা

চারটি লাই এলেক্ট্ৰোনিক্স,

~~log<sub>2</sub> Lbps~~

$$= 2 \times 250 \times \log_2 L$$

~~file P = bandwidth~~  $C = 1 \text{ Mbps}$

~~25~~

$$\Rightarrow 2 \times 25.0 \times \log_2 L = 1 \text{ Mbps}$$

$$\Rightarrow \log_2 L = 4$$

~~file P = QPSK = 2 bits/signal element~~

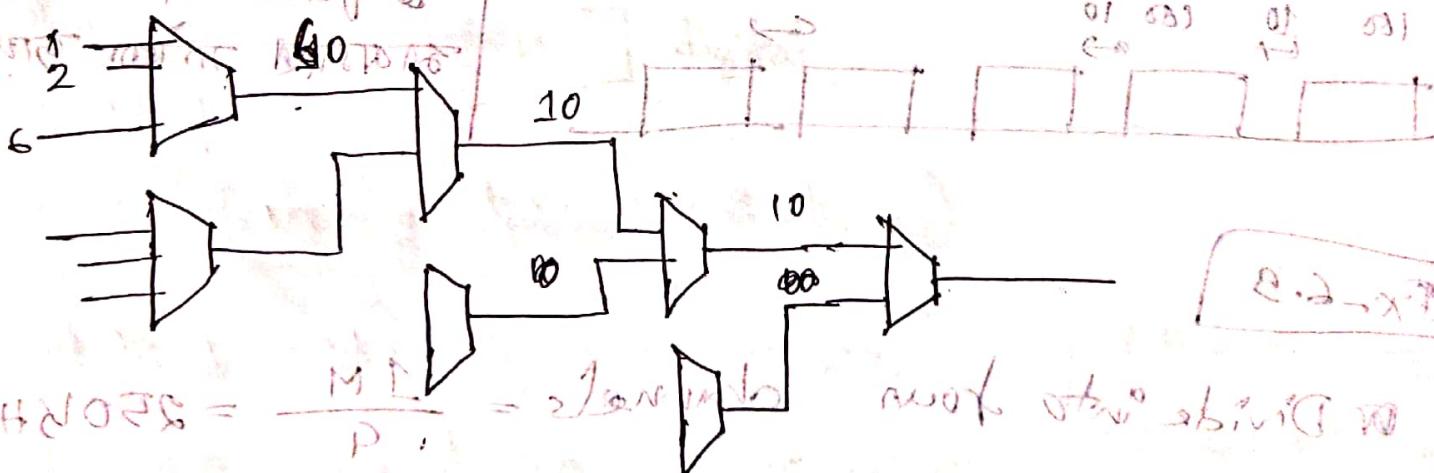
~~file P = 1 bit/signal element~~

$\therefore$  solution is QPSK

(because QPSK 2 bit signal का पार्सिंग होता है, ASK, FSK, PSK, QPSK की तरह कोई नहीं होता)

Analog Hierarchy = bandwidth for frame (slot)

PDS-based burst



$$\text{吞吐量} = \frac{M \cdot T}{P} = 2 \text{ Mbps}$$

Wi-Fi networks के अनेक लिंक के बीच वितरण होता है।

1. IEEE 802.11

Ex-6.4

(MUF) path length varied over

→ Upload bandwidth and download bandwidth?

\* Total bandwidth = 70

Grand band = 20

upload = 25, download = 25

∴ Each band is 25 MHz. Each user used 30 kHz

Each so, total person we can send =  $\frac{25 \text{ MHz}}{30 \text{ kHz}}$

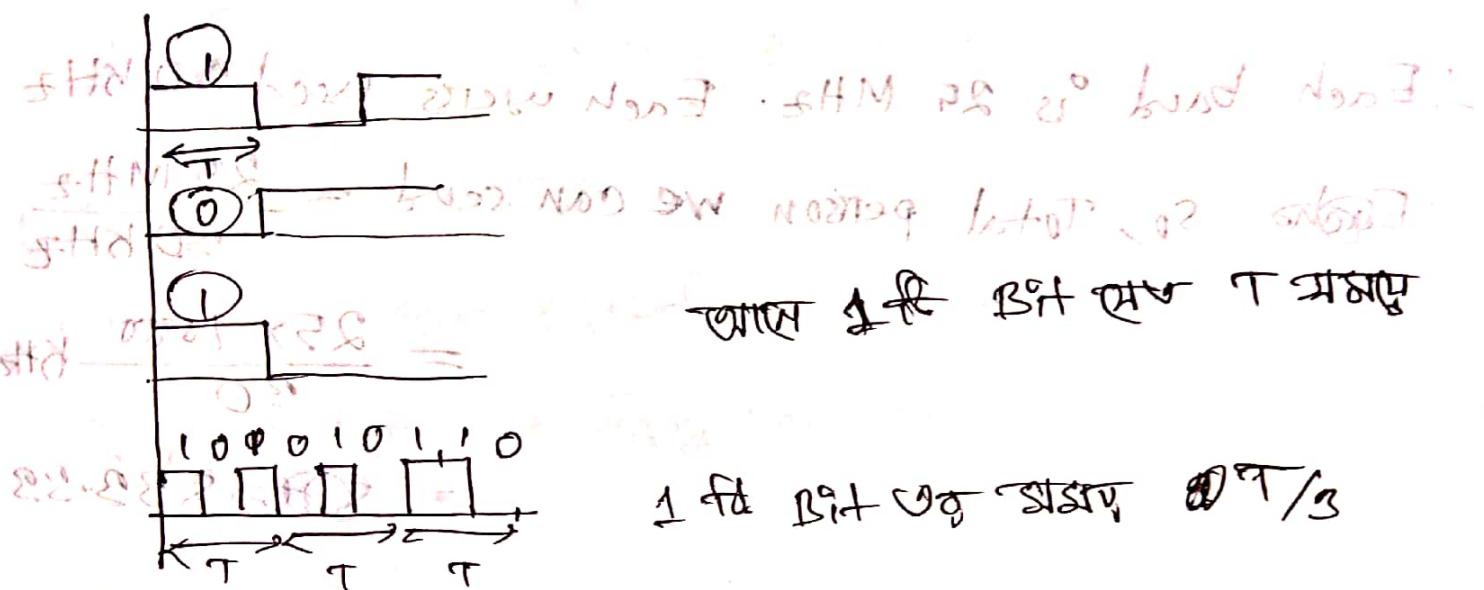
$$= \frac{25 \times 10^6}{30} \text{ kHz}$$

∴ Total users = 833.33

∴ So the total users is 833

## Time-Division Multiplexing (TDM)

मानवीय विकास के साथ ही इसका उपयोग बढ़ गया।  
 प्रारंभ में 0.1 सेकंड  
 तक प्राप्त हो जाए  
 और तो छह लाख  
 बिट = लाखों डेटा, ३० = लाख



This process is TDM. 21<sup>st</sup> user information?

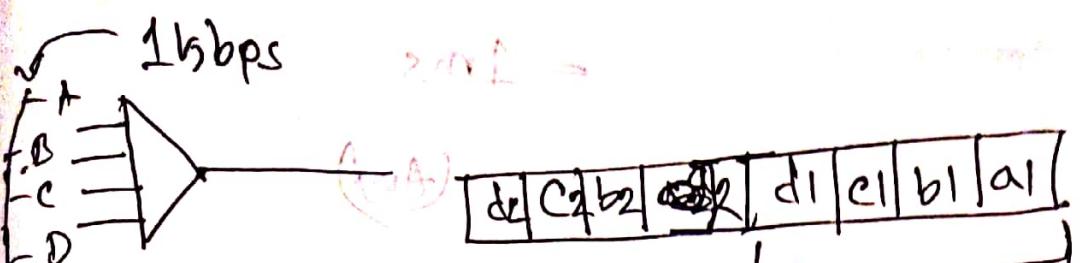
**Frame** - It is the range when every user has transmitted at least one element/bit. (उनके लिए Contribute करने की जगह नहीं कर सके)

at least one element/bit, (उनके लिए Contribute करने की जगह नहीं कर सके)

[Maths  $\rightarrow$  6.5, 6.6), 6.8]

## Math-6.7

Ques. 1) Calculate the frame for multiplexing with 15 bps



④ before multiplying A by  $\frac{1}{15}$ ,

(a)

Hence,

1500 bits take  $\frac{1}{15}$  second

$$1 \text{ bit} \text{ takes } \frac{1}{1500} \text{ second}$$

$$= 1 \text{ millisecond}$$

(b) Transmission rate =  $1 \text{ bps} \times 9$

$$= 9 \text{ bps}$$

⑤ The duration of time slot

at start time,

9000 bits take 1 sec

$\therefore 1 \text{ bit} \text{ takes } \frac{1}{9000} \text{ sec}$

$$2900 \text{ bits} = 2.5 \text{ ms}$$

$$= 2.5 \text{ milliseconds}$$

$$\frac{2900}{1500} = 0.25 \text{ ms}$$

$$2900 \text{ bits} =$$

$$\textcircled{d} \text{ The duration of a frame} = 0.25 \times 9 \\ = 1\text{ms}$$



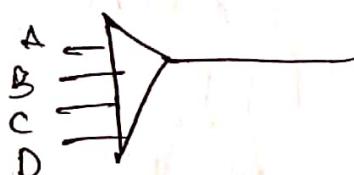
## 6.9 Math Exam (Important)

6.9

মধ্যন টে (Data মাণিক ২৫) ১৪-০৭-১৫ মাসিত,

h00532 1 3 dist 375 L

1084 bps



2011-03-08 2

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| $a_2$ | $a_3$ | $d_2$ | $d_1$ | $C_2$ | $C_1$ | $b_2$ | $b_1$ | $c_2$ | $c_1$ |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|

1 frame

$\rightarrow$  8 bit frame

|   |   |   |   |
|---|---|---|---|
| & | C | b | a |
| z | z | z | z |

④ Frame Rate :

Input data rate = 100 kbps

$$\text{output } u \overset{\text{assumption}}{=} 900 \text{ kbps}$$

$$\text{Frame Rate} = \frac{408 \text{ kbps}}{8 \text{ bits}} = 50 \text{ frames/sec}$$

= 50,000 frames/sec

Explaining:  $1 \text{ sec} \rightarrow 900 \text{ kbps}$  transmission speed after 1 sec

$\Rightarrow 8 \text{ bit } \times 2^{12} \text{ frame } \frac{2^7}{1}$

$1 \text{ sec} \rightarrow 5000 \text{ frame}$

Bandwidth  $\Rightarrow$

(+) Here,

5000 frames take  $1 \text{ sec}$

1 frame

takes  $\frac{1}{5000} \text{ sec}$

$$= 0.02 \text{ ms}$$

$$= 20 \mu\text{s}$$

(+) What is the bit duration.

$900 \times 1000 \text{ bits take } 1 \text{ sec}$

$\therefore 1 \text{ bit takes }$

$$900 \times 1000$$

$$= 2.5 \times 10^{-6} \text{ s}$$

$$= 2.5 \mu\text{s}$$

Want of bandwidth

Symbol error

noise



# Data rate matching (Imp)

$[10|10|10|10|10|10]$

28 Nov

5marks in Exam

[TOPIC] slide

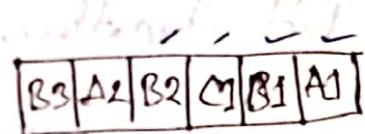
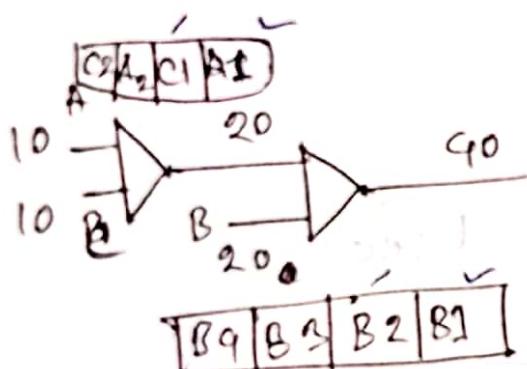
## Data rate Management

Three ways we can input different data into the channel

① Multilevel ②

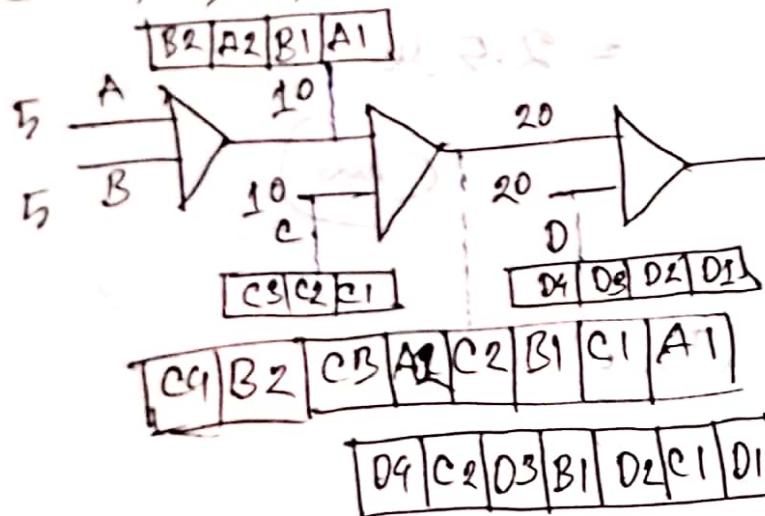
Multilevel:

# 10, 20, 10 → 15 bps =



1 bit msg  
with 4 bits

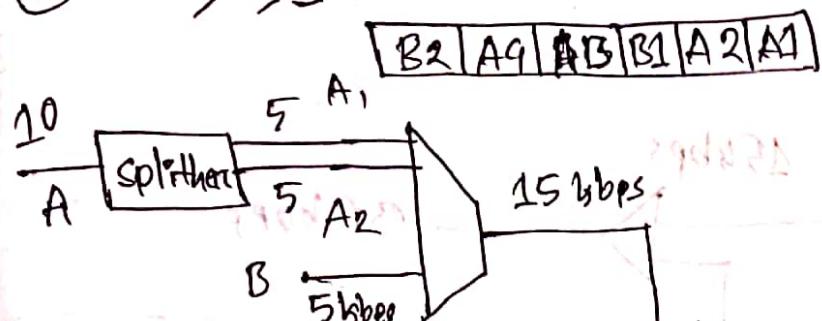
# 5, 5, 10, 20 → 4 bps



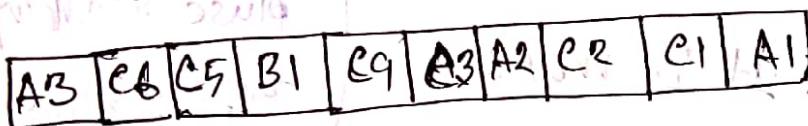
Multiplexing have  
same data  
rate.



# 5, 10, 30



→ common multiple  
→ Splitter can be divided.



→ common multiple,

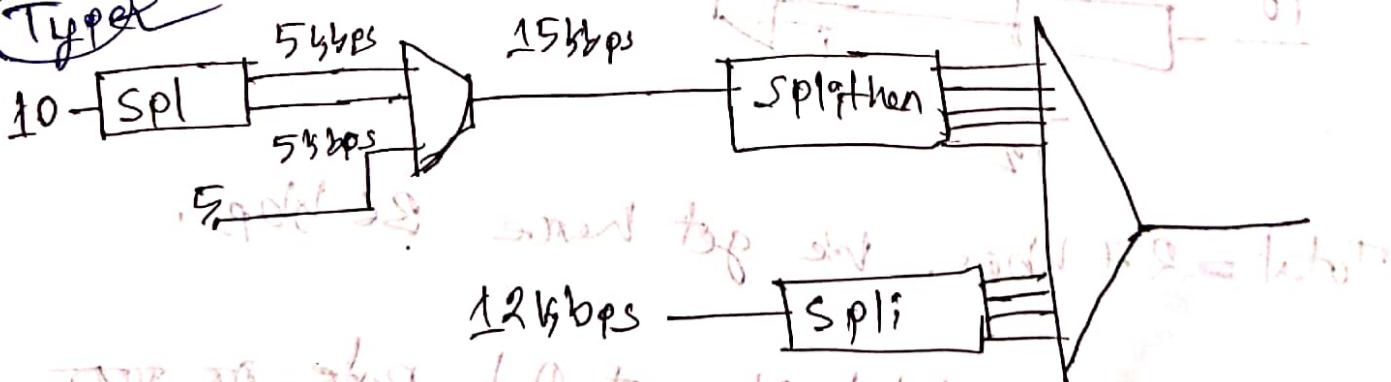
# 5, 10, 12

pulse stuffing

$$001 = 001 / 0001 / 01$$

Type 0 add 001

Type



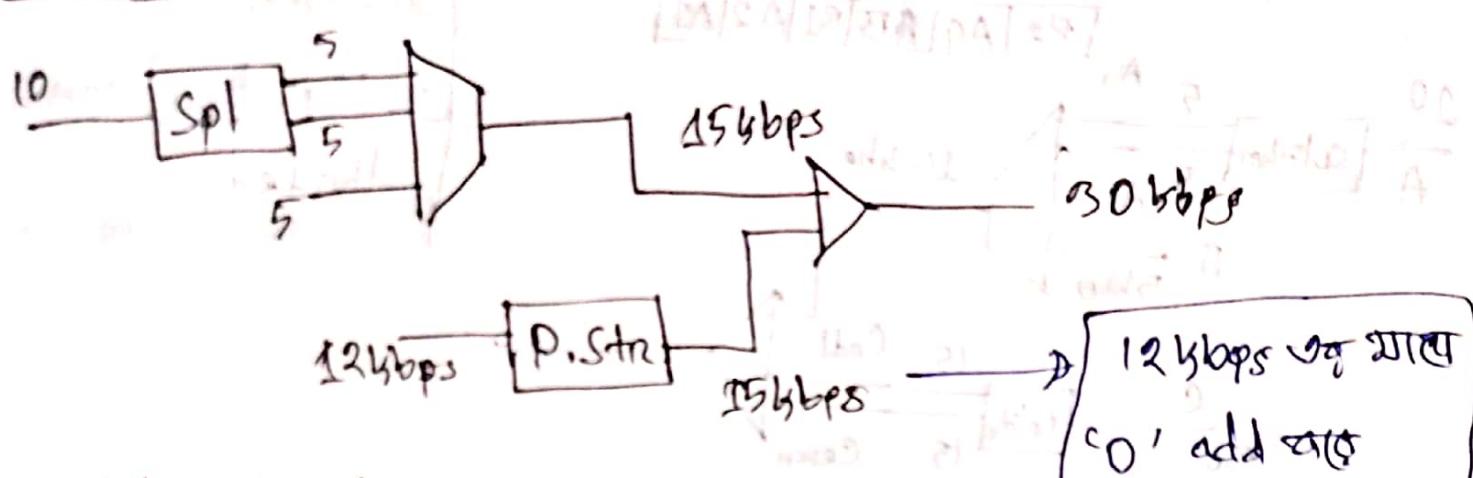
$$001 = 1$$

$$098 = 98$$

↓ of Type 0 not IC REQUEST, the off time is not available & no time pre-pointing is up

↓ DPLL is not up

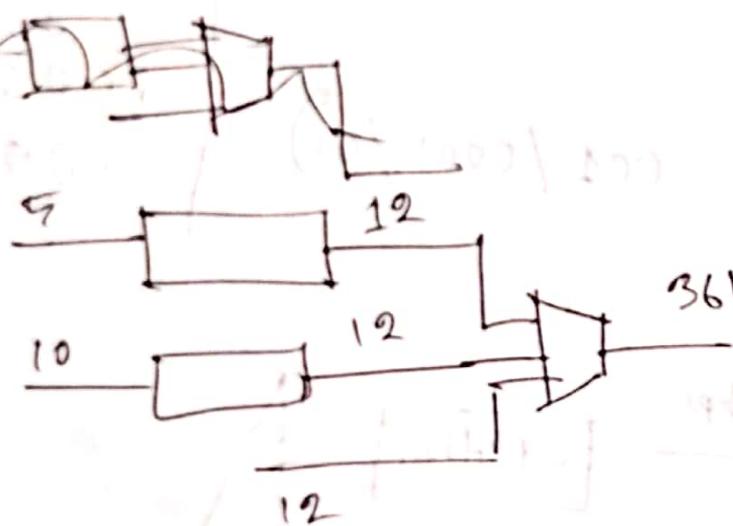
### Step-2



$$\text{Total} = 27 \text{ kbps}$$

∴ but we get 30 kbps. It is more efficient than others.

### Step-3



$$\text{Total} = 36 \text{ kbps}$$

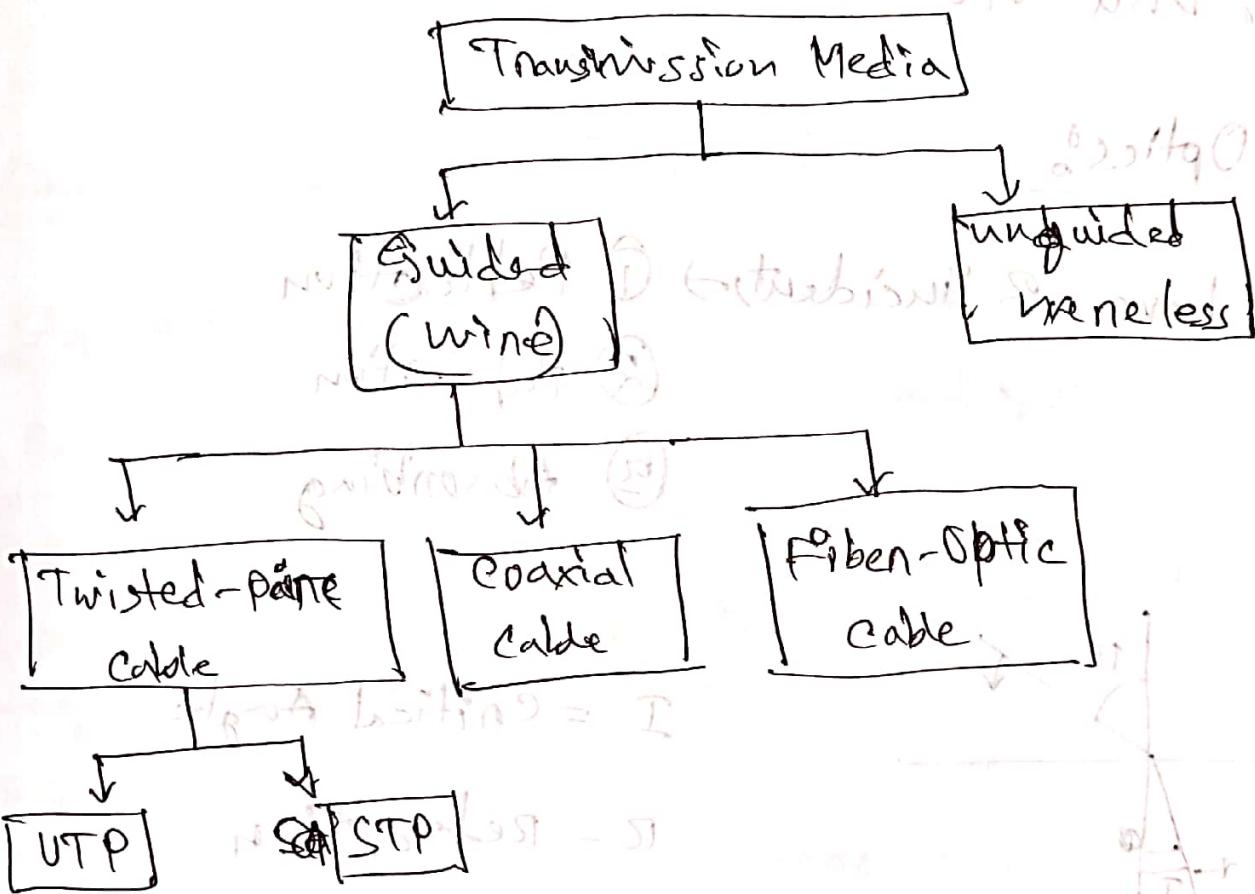
Note: মানে সেখানে কোন প্রক্রিয়া নেই। Total Available Data Rate = মানে  
multiplex data rate কেমন করে Difference আসতে,  
IC কোন কার্য করে নাই। Problem 20, তাই  
আমি IC করিব।

# Transmission Medium

Transmission medium in Wire.

→ Transmission medium (cable) to transmit Data

medium ATM, AT, ISDN, DSL, VDSL



## Coaxial cable →

→ Capacitor अ॒ गति इन्हें ताप्ति,

# PPT 9 for B Ant. (बहु एश्या रुप, अंतर्राष्ट्रीय)  
# WIRELESS or (class) without modulation

BNC connector: connector द्वितीय उपकरण,

स्लिम; Dish अ॒ Connect ताप्ति जैसे,

## Fiber Optics:

Light / wave  $\rightarrow$  incident)

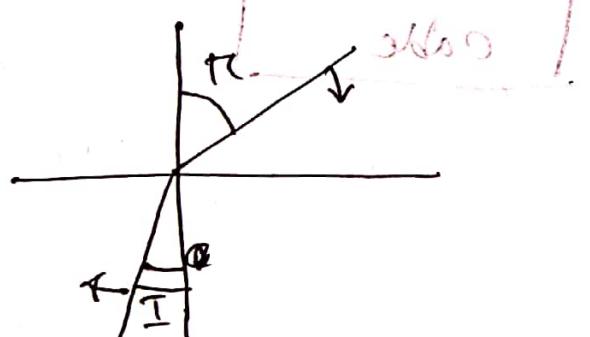
① Reflection

② Refraction

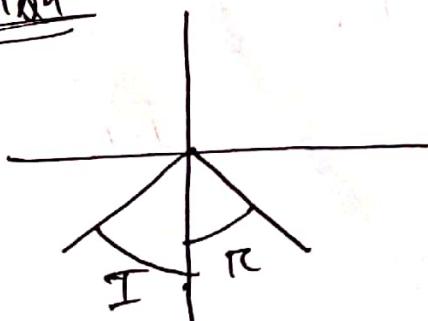
③ Absorbing

I = Critical Angle

R = Refraction



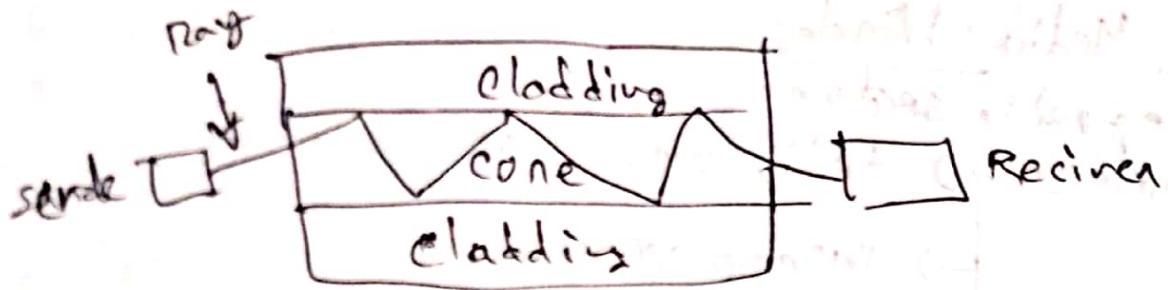
reflection



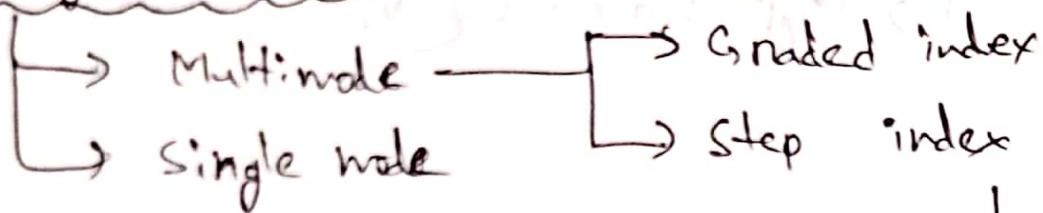
Reflection अ॒,

I = R

30 Nov



## Propagation Modes



Single: Cone আবৃত হিলে রেইন করে।

Step index: Constant reflective index (Fixed),  $n_1$  ও  $n_2$  স্থিতি রাখে।

Graded index:  $\rightarrow$  গ্রেডেড বেণ্ট (গ্রেডেড) হস্ত পাস,

$\rightarrow$  বোল্ড রেফেল,

$\rightarrow n$  জো আবৃত গ্রেডেড রয়েছে, ( $0.1, 0.2, 0.3$ )

Example: - Moved wave on reflect.

## Fiber Construction

Fiber robust (কানামাটু হী গাছে পাহ ক্ষেত্রে) রেট,

প্রথম এবং দ্বিতীয় ইন্ডেক্স (= ভাস্টিন)

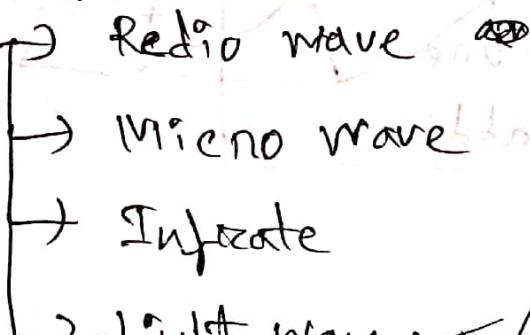
ST connector

MT-RJ :: (Joint ও usc ২৫)

## Unguided Media & Wireless

Electromagnetic spectrum

Wireless  $\rightarrow$  Radio wave



## Propagation

Ground propagation

Sky (atmosphere) (reflect on ionosphere)

Line-of-sight (direct ray)

(most suitable)

\* \* **From**

Broadcast  $\rightarrow$  Store, Access (OTT, Netflix)

Multicast  $\Rightarrow$  different access range (OTT, for ex.)

different requests from different users

(OTT, YouTube)

Exam

- ④ Radio wave have used for multicast. They can  
Penetrate through walls. Highly regulated (তোমার  
মান করা যাবে নির্বাচিত মান) .  
→ Use Omni directional antennas.

- ④ Microwave ⇒ Unicast communication.

→ Higher frequency ranges can't  
penetrate walls.

- ④ Infrared ⇒ Used for short range communication.