TOPIC NAME : C-1 DAY : W-1

TIME : DATE : 3/12/24

DATA Communication

*Fourier Analysis is important

*Mainly the basics of anything communications
(3.2 ⟶ Networks)

*Book : "Data Communications and Networking" ~ Behrouz A. Forouzan
(4th edition is better)

↑ easier
↓ harder

"Data Communications and Networking" ~ William Staling(?)

"Data Communications

*3 Set Questions ⟶ 1 ⟶ Broad; 2 ⟶ Proof; 3 ⟶ Maths } Ans any 5 from 7

*Ch 1→10 Forouzan

*Quiz Questions ⟶ Short Q/A (theory is important)
⟶ Math

TOPIC NAME : DAY : TIME : DATE : / /

Ch – 1

Communication :

(Sharing information)

* Communication System is used to exchange information between two communicable devices

Effectiveness :

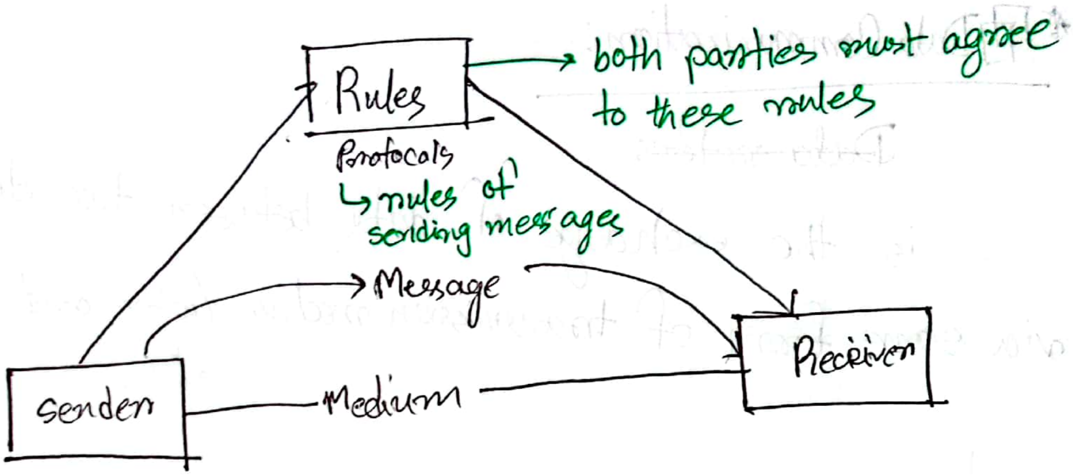
i) Delivery:
information to the correct destination

ii) Accuracy :
unchanged information

iii) Timeliness:
delivery at the right time

iv) Jitters
variation / uneven quality of the information

TOPIC NAME :
DAY :
TIME : DATE : / /



*5 requirements/elements:

i) Message: information to be communicated

ii) Sender : device sending message (Source + Transmitter)

iii) Receiver: device received message (Destination)

iv) Medium : the physical path by which message travels

v) Protocol: rules .

TOPIC NAME :

DAY :

TIME : DATE : / /

Data Communication :

~~Data refers~~

is the exchange of data between two devices via some form of transmission medium (wire and wireless)

guided unguided

Data Representation :

all forms of data (text, numbers, images, audio, video)

→ Text : Sequence of bits

- → ASCII
- → Unicode

CamScanner

TOPIC NAME : W-1

DAY : C-2

TIME :

DATE : 4 / 12 / 24

Communication

- Audio
  - Wire
    - Telephone
  - Wireless
    - Walkie Talkie
    - Radio
    - Cell phone
- Video
  - Wire
    - TV
    - CC TV
  - Wireless
    - IPTV
- Data (Comp. Generated)
  - Wire
    - LAN
  - Wireless
    - Wifi

Based on Data Flow:

1. Simplex → one way
2. Half Duplex → two way but not simultaneously
3. Full Duplex → " "
   - → this actually doesn't exist
   - → Made using two simplex

FDD : Frequency Division Duplexing

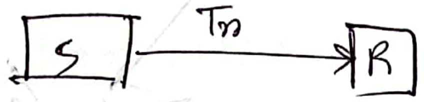
↳ simplex divided

TDD : Time Division Duplexing

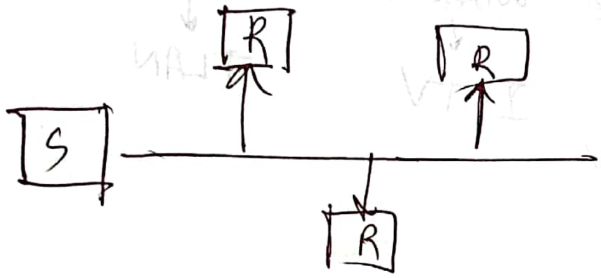
TOPIC NAME :

DAY :

TIME : DATE : / /



Point to Point
(~~Just~~ one direct connection between two users)



Multi point
(One wire to connect them all)

<u>Network Requirements</u>:

1. End Device: Devices that can generate and ~~receive~~ retrieve data
2. Node: Message ~~transfer~~/conveying methods / switching
3. Transmission Medium: Medium through which message is passed

<u>Topology</u>: Graphical representation of network

TOPIC NAME: W-2 DAY: C-3

TIME: DATE: 09 / 12 / 24

NETWORK MODEL

Topology:

Design of network → < 2 miles → is LAN

Layered Task:

Prepping and sending ↓ Carrying data (using Protocol) ↓ Reaches a destination

Higher Layers

Middle Layers

Lower Layers

Processing in destination ↑ Carrying the data (using Protocol) ↑ Receiving the data

- A complex task is divided into several smaller task
- Modular → Each layer can be modified separately

TOPIC NAME | DAY | TIME | DATE / /

Why OSI was needed?

Layered Models

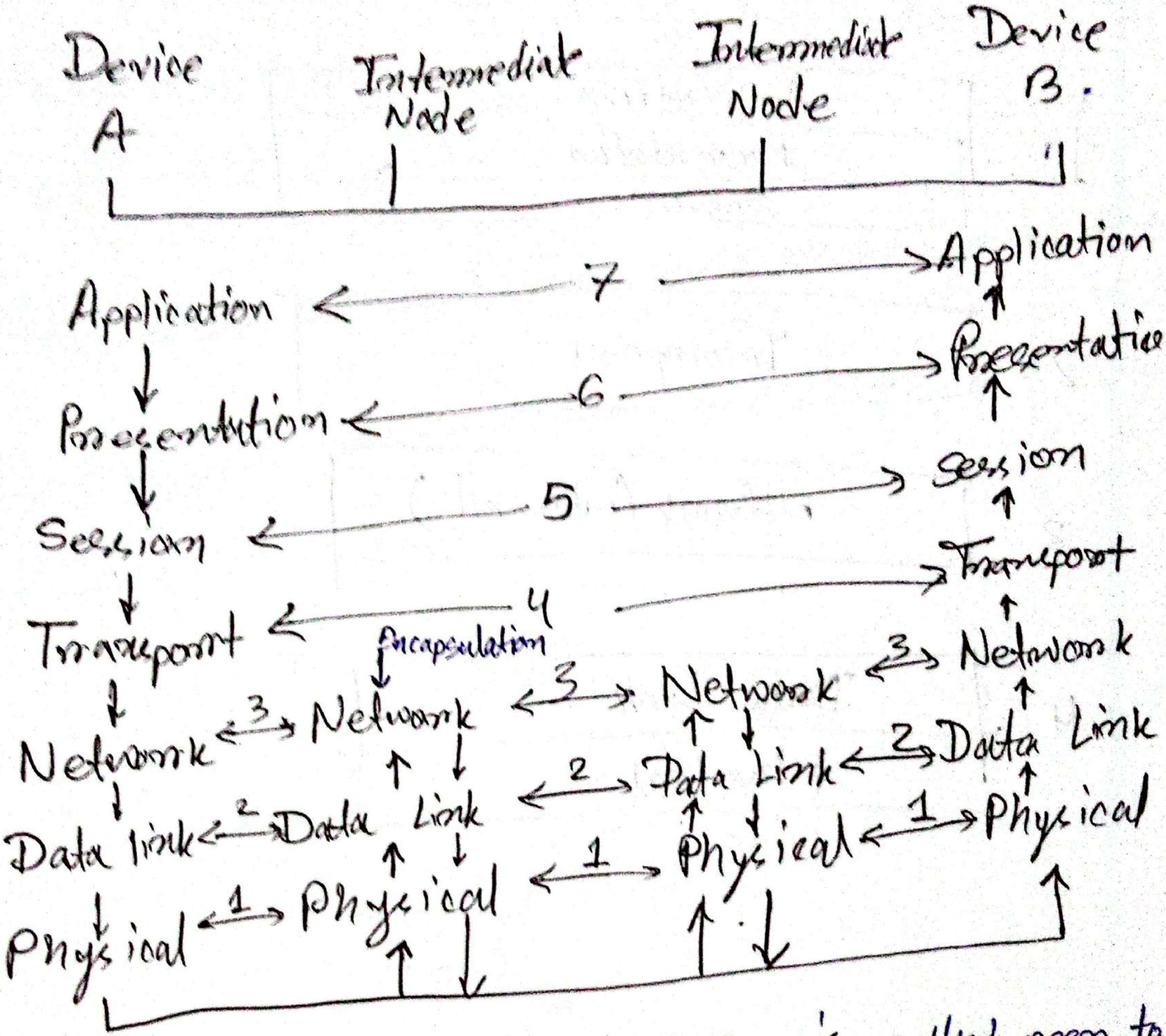
- OSI Model (Open System Interconnection)
  - Theoratically (by) referenced model
- TCP/IP Model

OSI Model → 7 layers

7. Application
   ↑
6. Presentation
   ↑
5. Session
   ↑
4. Transport
   ↑
3. Network
   ↑
2. Data link
   ↑
1. Physical

Only
1
1, 2
1, 2, 3
or 1 → 7

*Devices that follow all 7 layers are called end devices



* This layer to layer propagation is called peer to peer protocol

*For details → Check Slides

TOPIC NAME :
DAY :
TIME : DATE : / /

TCP/IP Model

1. Application / Presentation / Session
2. Transport
3. Network (internet)
4. Data Link / Physical

TOPIC NAME : W-2 DAY : C-4
TIME : DATE : 10/12/24

Signals

Analog → Continuous

Digital → Discrete

Data must be transformed using electromagnetic wave

Analog signal = infinite numbers of values in a range

Digital " = limited " " " " "

- Data
  - Analog → Signal
  - Digital → Signal
- Signal
  - Analog
    - Periodic
    - Non Periodic
  - Digital
    - Periodic
    - Non Periodic

[Self Explanatory]

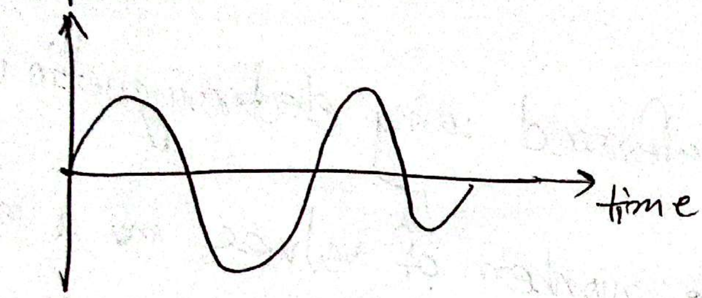
* In DCOM → periodic ~~data~~ analog signal → bandwidth less

  ↳ non " digital " → variation is possible

TOPIC NAME :   DAY :
TIME :   DATE : / /

⊞ Periodic Analog Signal:

$$s(t) = A\sin(2\pi ft + \phi)$$; S = instantaneous amp
t = time
A = peak amp
F = Frequency
ϕ = Phase shift



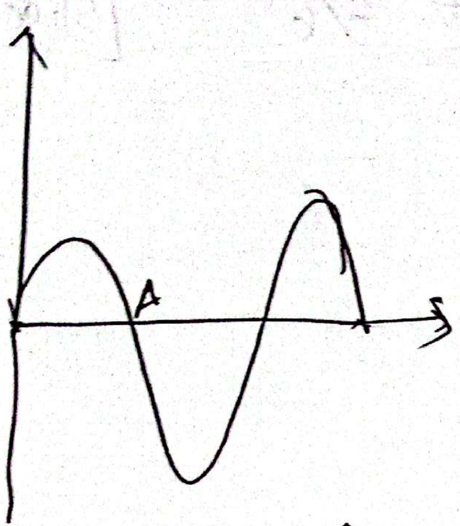
$$\text{Frequency} = \frac{1}{\text{Period}}$$

$$f = \frac{1}{T} \quad \Big| \quad T = \frac{1}{f}$$

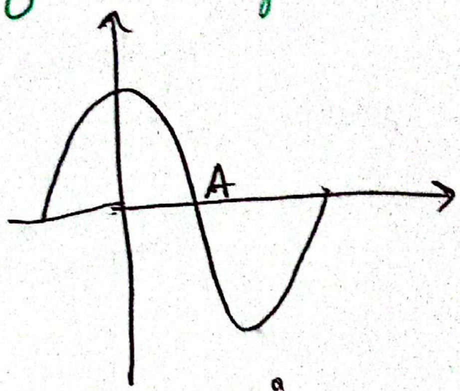
Time	Freq
Mili	Kilo
Micro	Mega
Nano	Giga
Pico	Tera

TOPIC NAME : DAY : TIME : DATE : / /

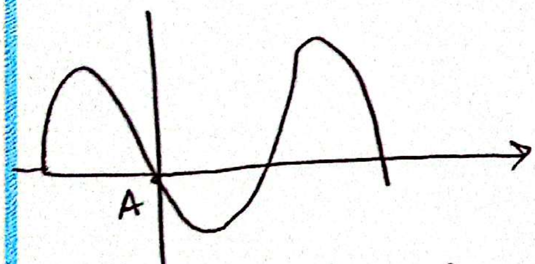
* Phase shift
= moving on the right



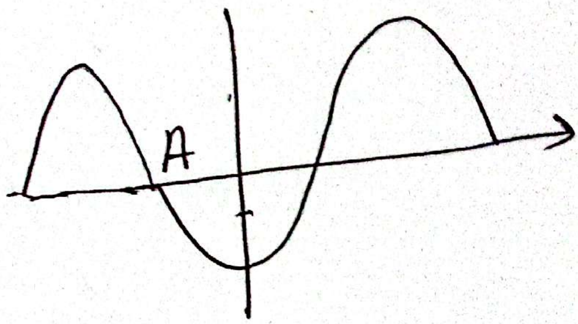
0° sift



90°



180° shif



270°

$\pi^c = 180^\circ$

A sine wave is offset 1/6 [Slide Math]

TOPIC NAME : DAY : TIME : DATE : / /

Wavelength and period :

$$\boxed{\lambda = \frac{c}{f}}$$

λ = wavelength

c = speed in medium

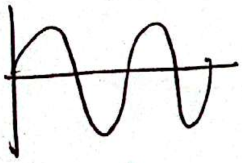
f = frequency

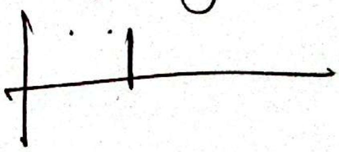
TOPIC NAME: W-3   DAY: 1 C-5
TIME: DATE: 17/12/24

Signal

A signal can be plotted in two domains:

Time Domain   Frequency Domain





One signal does not carry any information

*Fourier Analysis is used to convert time domain graphs to frequency domain and vice versa.

time $\longrightarrow$ frequency
periodic $\longrightarrow$ discrete
non-periodic $\longrightarrow$ continuous

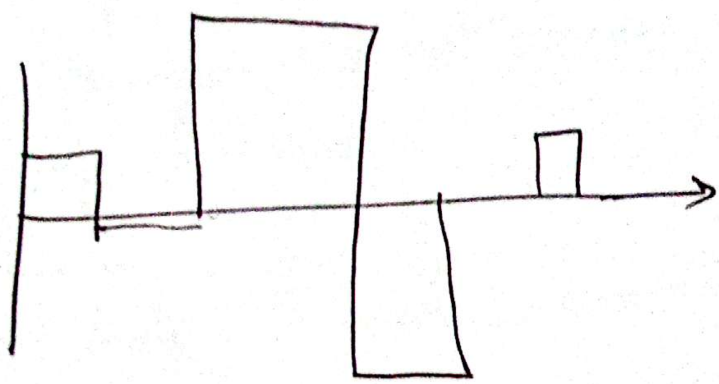
$$\boxed{\text{Bandwidth} = \text{Highest Freq} - \text{Smallest Freq}}$$

* If range of signal $\nleq$ range of medium, signal will not propagate

TOPIC NAME W-3 DAY C-6 TIME DATE 18/12/24

* Something Something Fourier Transform which I DO NOT want to deal with right now.

Digital Signal



L level,

no. of bits/level = $\log_2 L$

TOPIC NAME : DAY TIME : DATE / /

*Graph is replaced with,

frequency → bit rate

period → bit interval

* idk wtf is going on so just check slide on book ch-3 (0‿0)?

Transmission

- ~~Band~~ Baseband
  - → Bandwidth starts from 0
  - → Passes through low pass filter
  - → Unmodulated
  - →
- Broadband
  - → passes through any bandpass channel
    - → any bandwidth thats not from 0

Transmission Impairment

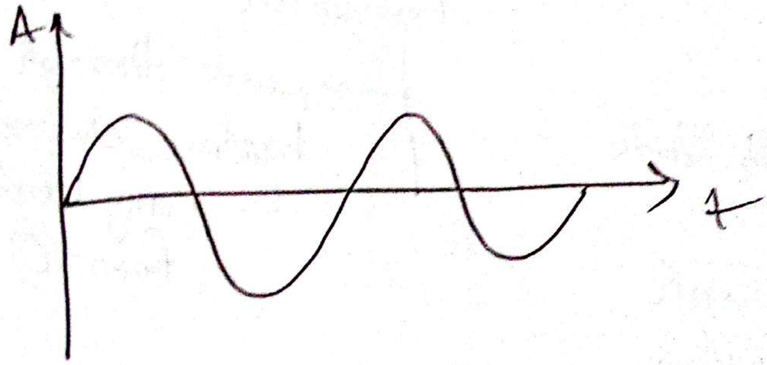
- → Attenuation $dB = 10\log_{10}\left(\frac{P_2}{P_1}\right)$
- → Distortion
- → Noise

TOPIC NAME: W-4 C-7

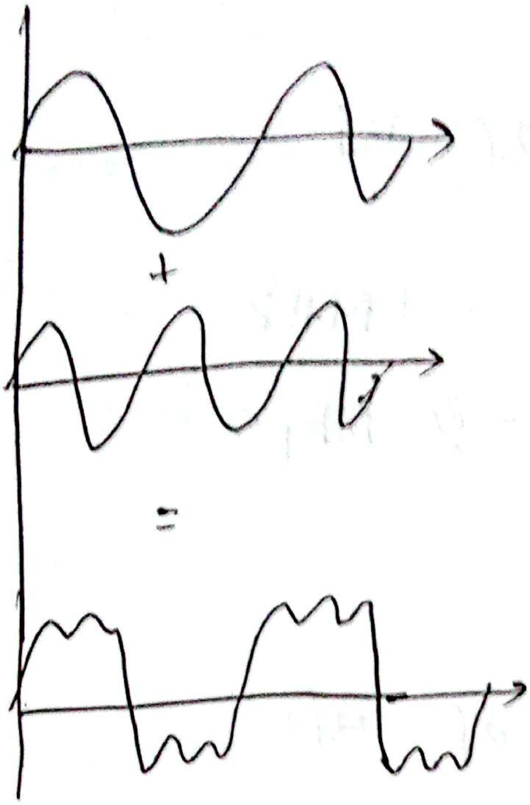
DATE: 23.12.24

Network Performance :

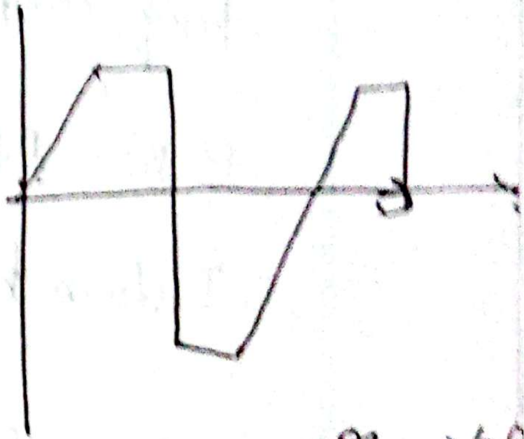
1. BW (Band width)
2. Data Rate
3. Throughput → successfully transmitted data
4. Latency



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



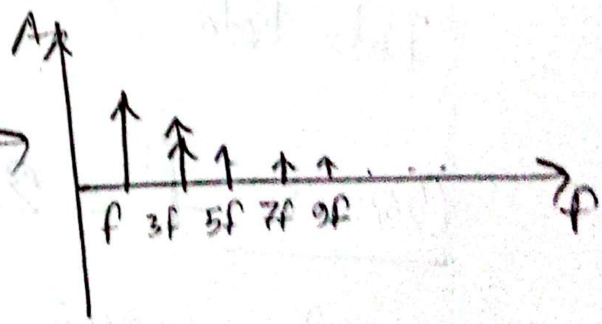
+ infinite sine waves



$$s(t) = A \times \frac{4}{\pi} \sum_{k\,odd,\,k=1}^{\infty} \frac{\sin(2\pi f t)}{k}$$

$$s(t) = A \times \frac{4}{\pi} \sum_{k\,odd\,=\,1}^{\infty} \frac{\sin(2\pi f t)}{k}$$

$$\boxed{\text{Freq Component} \propto \text{Signal Quality}}$$



$$\text{Data rate} = 2f = \frac{2}{T} \text{ bits}$$

TOPIC NAME DAY TIME: DATE: / /

Case 1: f = 1 MHz

freq comp = 1f, 3f, 5f

∴ B.W = 5f − 1f = 4f = 4 MHz

∴ Data rate = 2f bps = 2 Mbps

Case 2: f = 2 MHz

freq comp = 1f, 3f, 5f

BW = 5f − 1f = 4f = 8 MHz

Data Rate = 2f bps = 4 Mbps

Case 3: f = 2 MHz

freq comp = 1f, 3f

BW = 3f − 1f = 2f = 4 MHz

Data Rate = 2f bps = 4 Mbps

TOPIC NAME : DAY TIME : DATE : / /

Analysis :

① Same BW : Same Cost

∴ Preferred

Case 1 and 3 :

Data Rate $\propto \frac{1}{\text{Signal Quality}}$

Data Rate ↑ Signal Quality ↓

② Same Data Rate :

Case 2 and 3 :

~~Ban~~ BW $\propto$ Signal Quality $\propto$ Cost

BW ↑ Signal Quality BW ↑ Cost ↑

③ Same Signal Quality :

Case 1 and 2 :

BW $\propto$ Datarate

BW ↑ Data Rate ↑

TOPIC NAME:

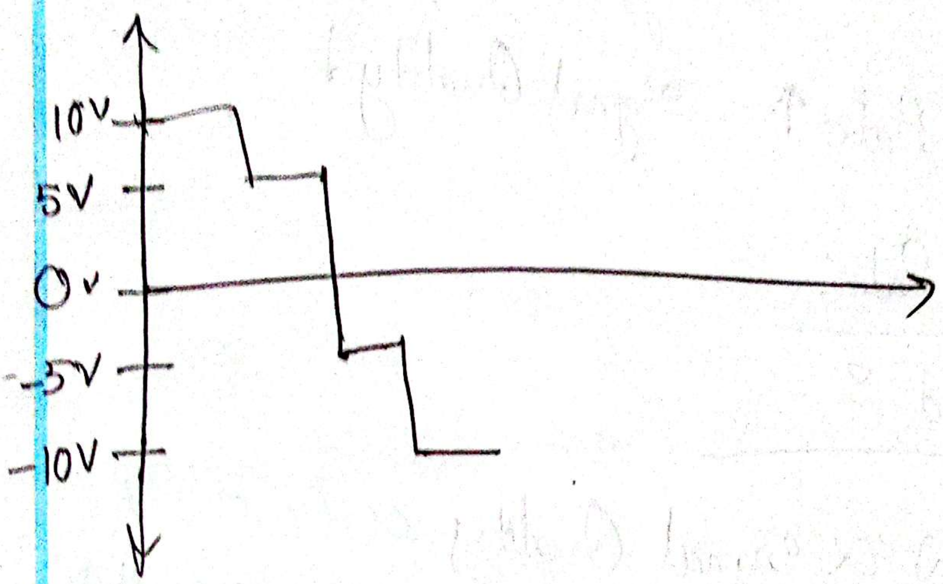
DAY: TIME: DATE: / /

~~Nyqmi~~ Nyquist Noiseless Formula

Capacity, $C = 2B\log_2 M$; B = Bandwidth

M = No. of levels

↳ 2^n



10 V 00

5V 01

-5V 10

-10V 11

Shannon Noisy Formula:

Capacity, $C = B\log_2(1+SNR)$; $SNR = \frac{\text{Signal Power}}{\text{Noise Power}}$

$SNR_{dB} = 10\log_{10}(SNR)$

$SNR = 10^{\frac{SNR_{dB}}{10}}$

GOOD LUCK

CamScanner

TOPIC NAME : DAY TIME : DATE : / /

Latency
- → Propagation Delay
- → Transmission Delay
- → Queuing Delay
- → Processing Delay

Propagation Delay, Transmission Delay } Measurable

Latency → Sends data late

$$\text{Propagation Delay} = \frac{D}{S} \text{ sec}$$

D → distance between Tx and Rx

S → Speed in Transmission medium

$$\text{Transmission Delay} = \frac{L}{R} \text{ sec}$$

L → Length of message

R → bps

Quiz - 1: 30/12/24
Ch - 1, 3
SQ + Math

TOPIC NAME: W-~~8~~ 4 DAY: C-8

TIME: DATE: 24/12/24

Conversion

Analog info → Signal → Digital

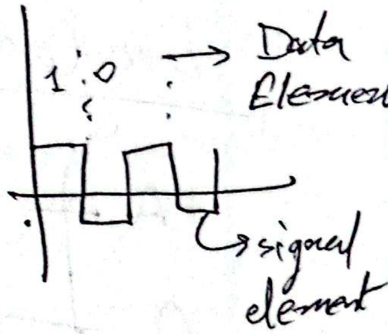
Digital → Signal

Digital Info → Digital Signal:

- → Line coding
- → Block coding

Line Coding :

Digital Data → Sequence of bits



Data rate → bps

Signal rate → baud

~~r =~~

$$r = \frac{\text{Data Element}}{\text{signal Element}}$$

$$\boxed{S = c \times N \times \frac{1}{r}}$$; N = data rate

c = case factor → worst/best etc

↳ ~~0<c<1~~ $0 < c < 1$

$$B_{min} = S = c \times N \times \frac{1}{r}$$

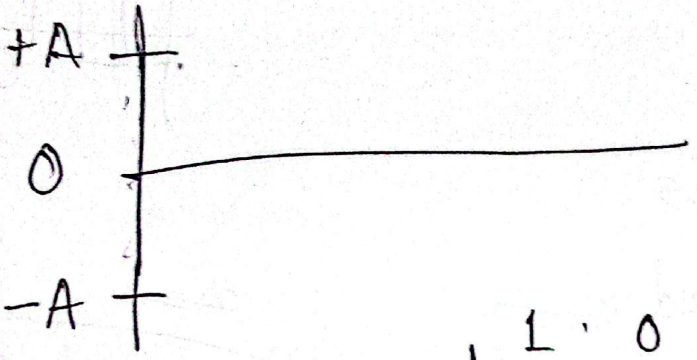
$$N_{max} = \frac{1}{c} \times B \times r$$

$B = S$

Problem: Error detection becomes hard

Line Coding : Unipolar : NRZ

→ Non return to zero
→ does not go to 0 at mid

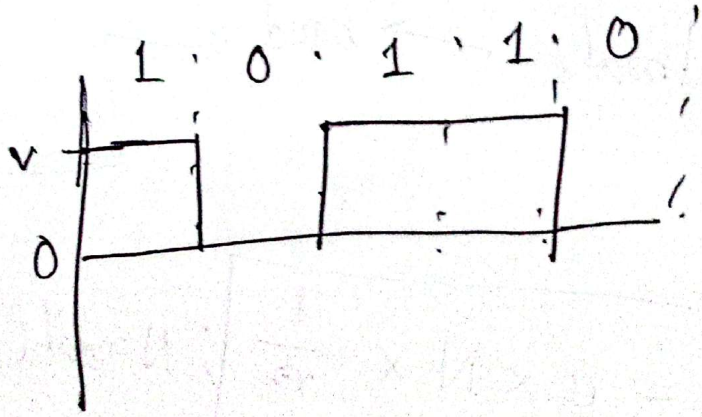


Either +ve/-ve or 0

Let,

1 = +ve

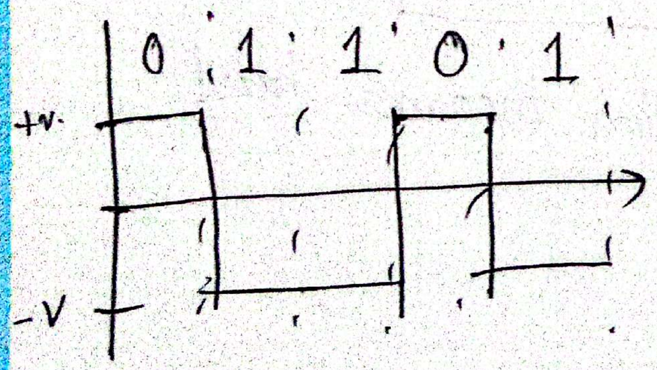
0 = 0



Line Coding : Polar : NRZ-L

→ Either +ve or -ve

→ 1 = -ve
0 = +ve



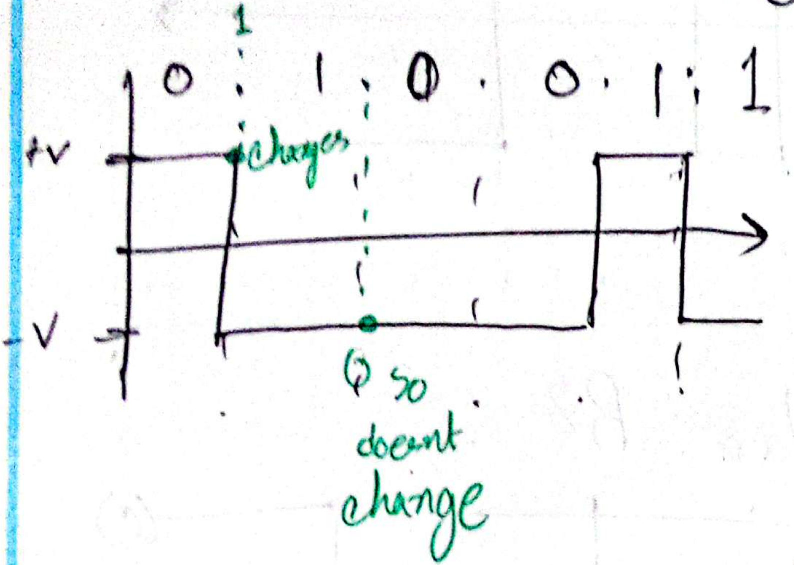
TOPIC NAME: DAY: TIME: DATE: / /

Linear Coding : Polar : NRZ - I :

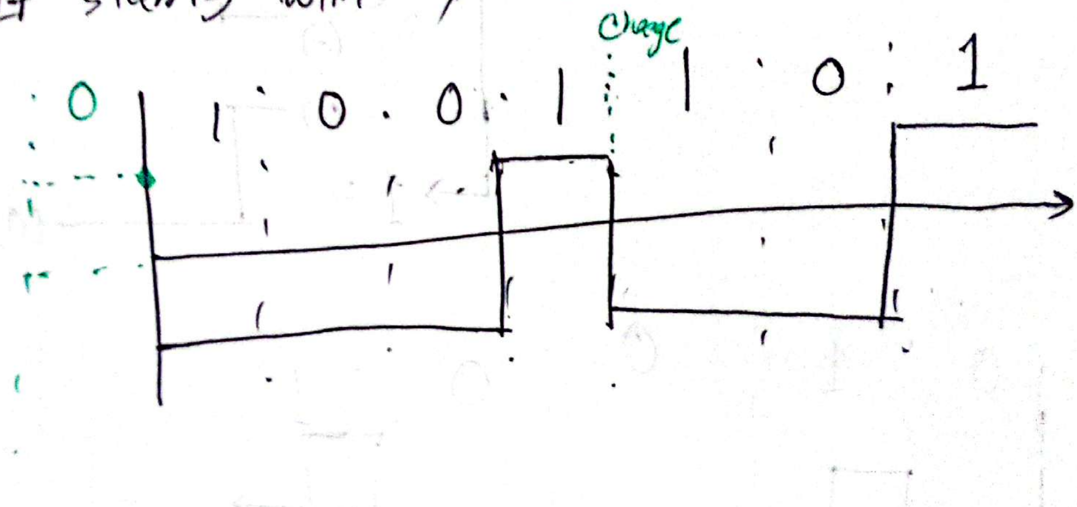
→ 1 = change/transition

→ 0 = no change/transition

Wat???



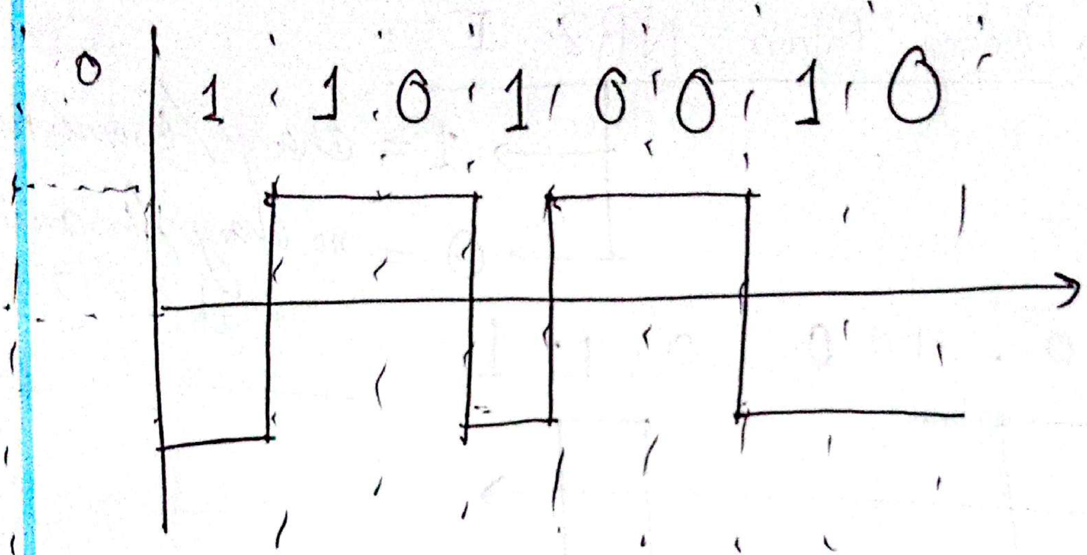
If starts with 1, take a hidden 0



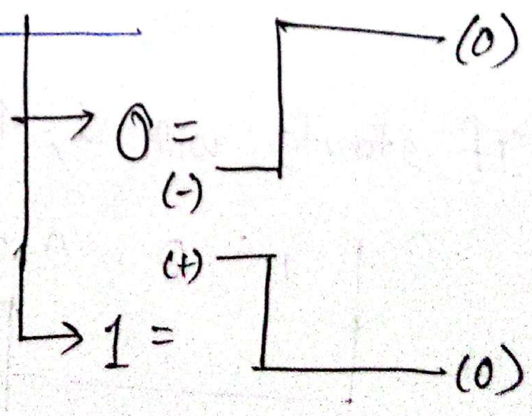
TOPIC NAME :

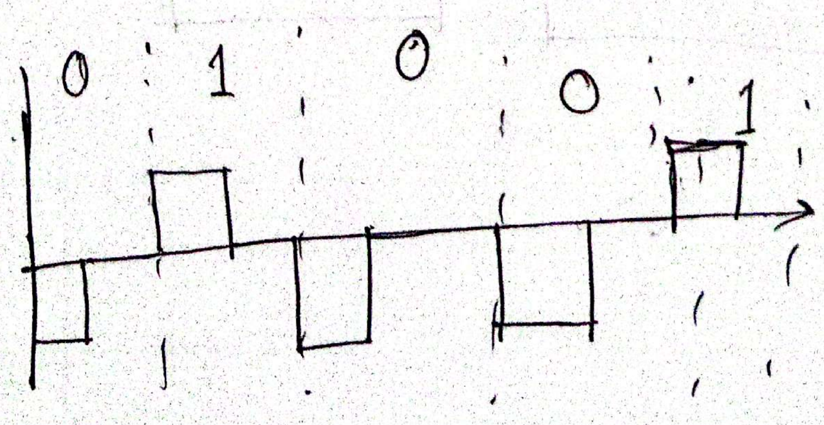
DAY

TIME : DATE : / /



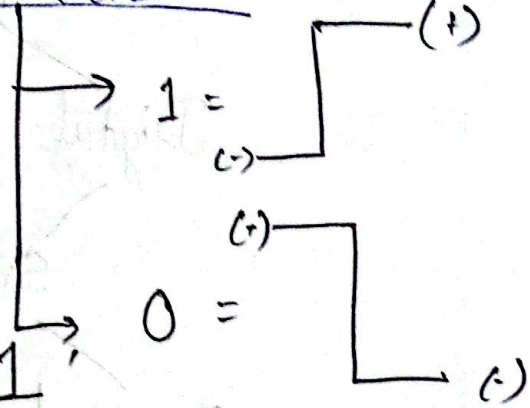
Linear Coding : Polar : RZ :

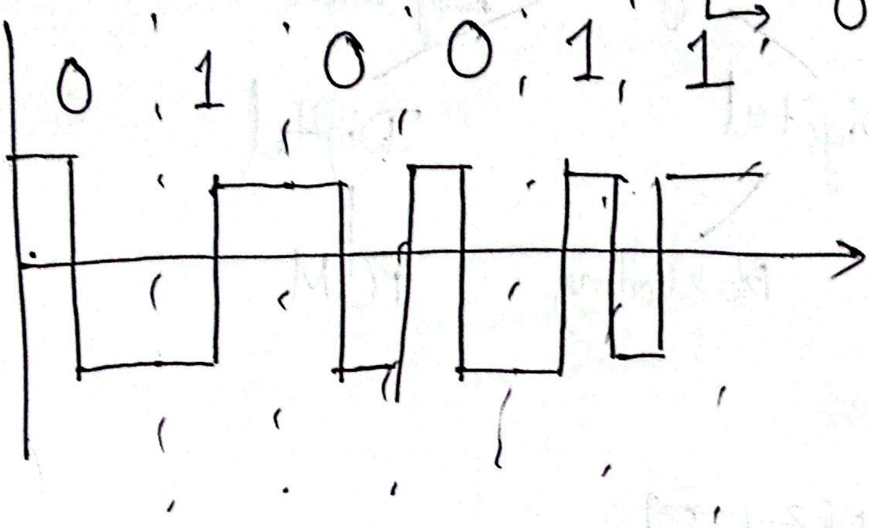




TOPIC NAME : DAY : TIME : DATE : / /

Linear Coding : Polar - Biphase : Manchester

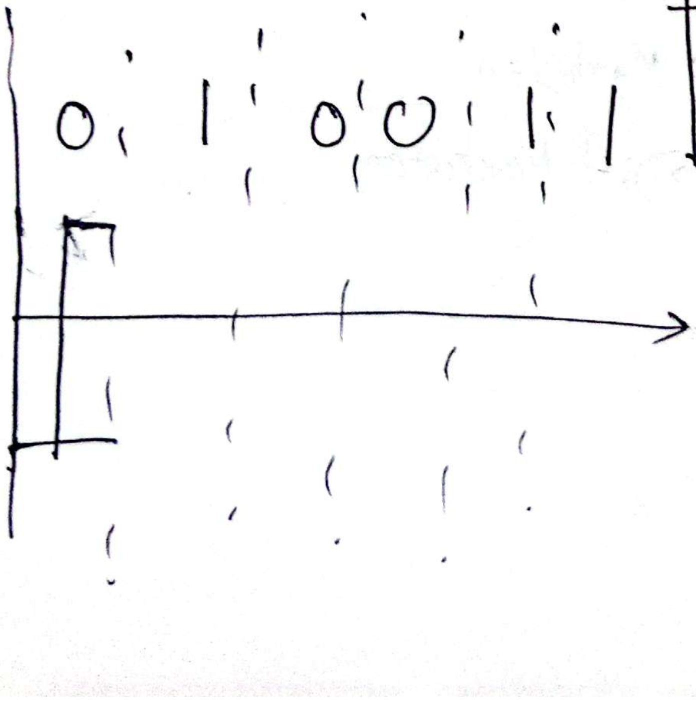




Differential Manchester :

0 = Transition

1 = No Transition



TOPIC NAME : W-5

DAY : C-10 (9 uas quiz)

TIME : DATE 31/12/24

Data

- Digital
- Analog

Signal

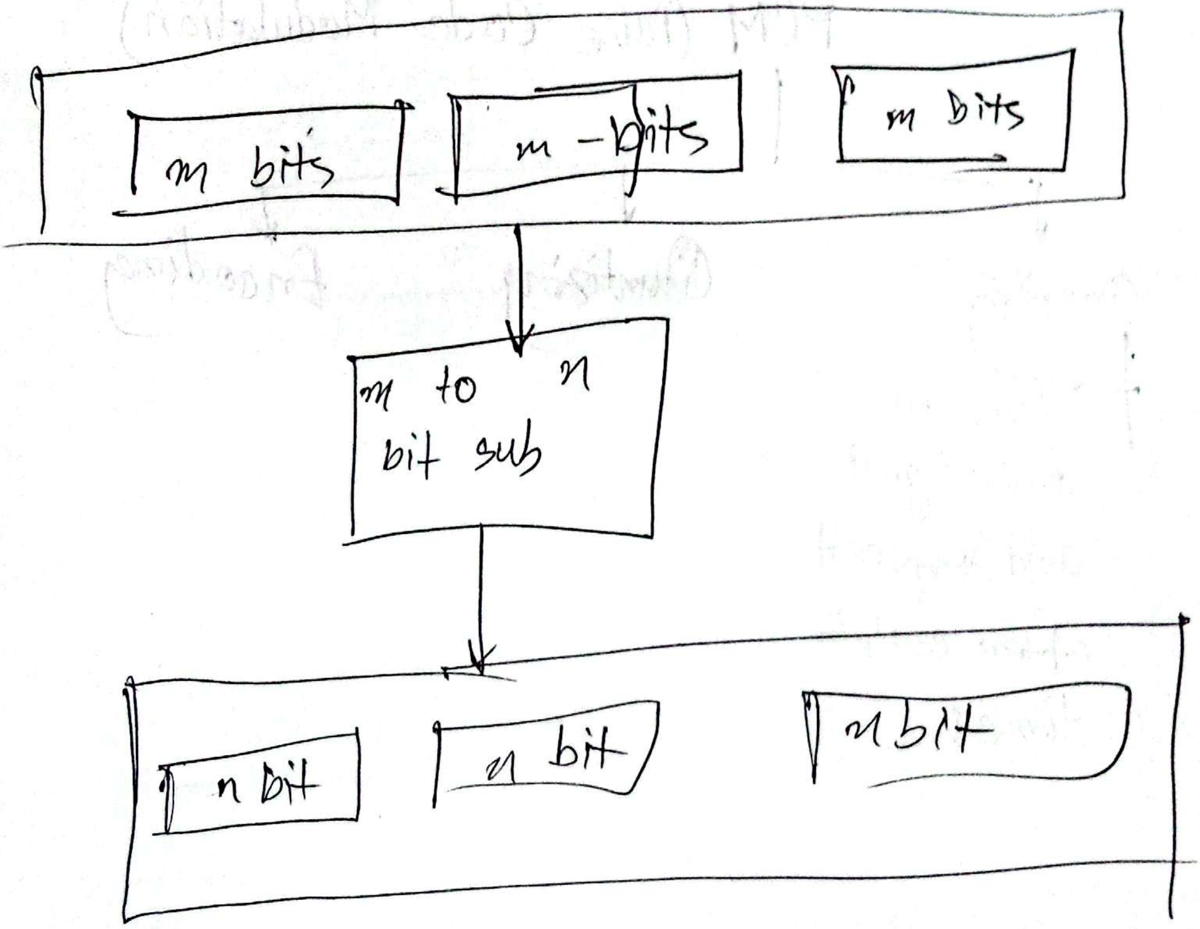
- Digital
  - Line coding
    - Unipolar NRZ
    - Polar
      - NRZ-L
      - NRZ-I
      - ~~Biphase Manchester~~
      - RZ
        - Manchester
        - Diff Manchester
  - Block Coding
- Analog Data → Digital
  - PCM

TOPIC NAME : DAY : TIME : DATE : / /

Block Coding

* Redundant bits ~~ad~~ are added for error detection and synchronization

* mB/nB ; $m < n$



* In Exam : Show Division
Substitution
Combination

CamScanner

TOPIC NAME: W-5 DAY: C-11

TIME: DATE: 01 / 01 / 25

Transmission

Analog Data

↓

Digital Signal

↓

PCM (Pulse Code Modulation)

- Sampling
  - → Takes an analog signal and samples it after certain times
- Quantizing
- Encoding

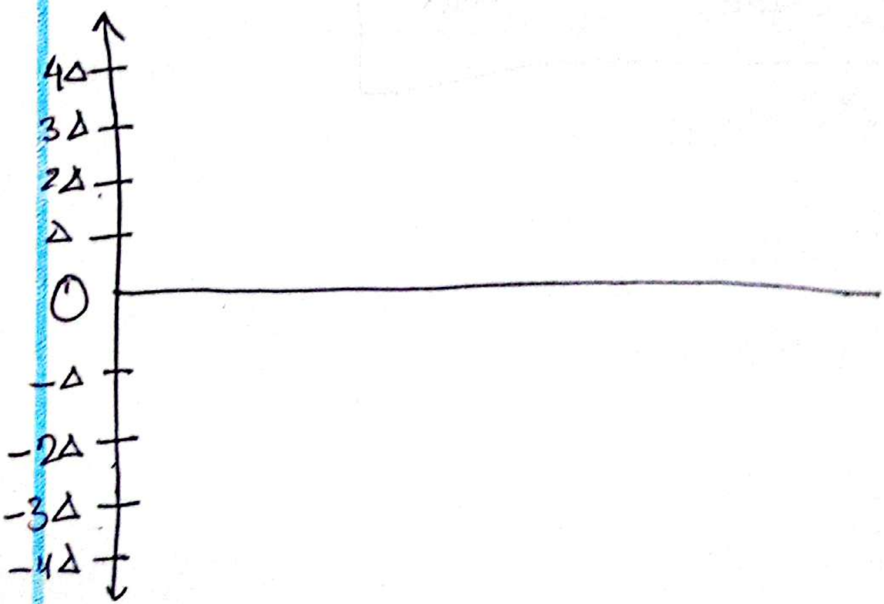
TOPIC NAME : DAY :
TIME : DATE / /

$\boxed{3}$ Sampling :

According to Nyquist, sampling rate must be at least 2 times the highest freq in signal

Dear Future me
Good luck
I have no idea
what is happening
anymore

$\boxed{4}$ Quantization :



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

$V_{max} \rightarrow +20V$, $V_{min} \rightarrow -20V$, $L \rightarrow$ No. of levels

+ find mid values between $n\Delta$ and $(n-1)\Delta$
* * Those will be levels
* * Then plot them in the graph.

$$NPAM_{value} = \frac{value}{\Delta}$$

$$\boxed{NQ_{value} = \frac{\text{Mid points}}{\Delta}}$$

$$\cancel{N_{Error} = \quad NQ}$$

$$\boxed{N_{ERROR} = NQ_{value} - N{\cdot}PAM_{value}}$$

TOPIC NAME: W-6 DAY: C-12
TIME: DATE: 6/1/25

Digital Data ⟶ Digital Signal
- Line Coding
- Block "

Analog Data ⟶ Digital Signal
- PCM

Ch-4

Digital Data ⟶ Analog Signal
- ASK, FSK, PSK

Analog Data ⟶ Analog Signal
- AM, FM, PM

Ch-5

Ch-5

Why? Idk
How? Idk that either

Digital Signal: $s(t) = A\frac{4}{\pi}\sum_{k\ \text{odd},1}^{\infty}\frac{\sin(2\pi k f t)}{k}$

∴ If lowpass ⟶ we use digital
bandpass ⟶ " " analog

TOPIC NAME : DAY : TIME : DATE : / /

Dig to Ana Conv :

* In order to make a digital signal pass through the ~~base~~ bandpass channel, a signal is passed through to ~~a~~ called 'carrier signal' → analog signal

* Dig to Ana signal is changing ~~one~~ of the characteristics → A, f, φ of the sine wave

Dig to Ana Conv

- Amplitude Shift Keying (ASK)
- Frequency ~~Key~~ Shift~~ing~~ Keying (FSK)
- Phase Shift Keying (PSK)

ASK + PSK → Quadrature Amplitude Modulation (QAM)

TOPIC NAME: DAY: TIME: DATE: / /

Data Elements → No. of bits required

Signal " → No. of voltages required per bit

$$r = \frac{\text{Data Elements in a Clock Pulse}}{\text{Signal Element is a Clock Pulse}}$$

For ch-5, Signal Element = 1

$$\boxed{S = N \times \frac{1}{r} \text{ baud}}$$

$\therefore S \le N$

$$\boxed{r = \log_2 L}$$

Quiz-2 ; Ch-2 Transmission Impairment + ch-4

on 13/01/25

TOPIC NAME: 10-6

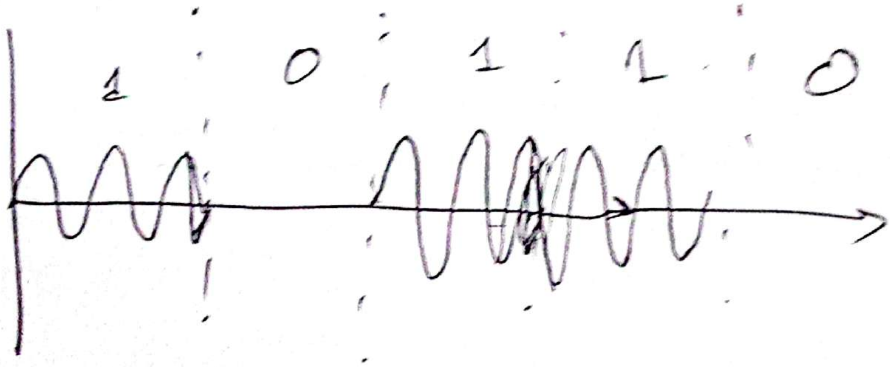
DAY: C-13

DATE: 7 | 25

Amplitude Shift keying:

↓

f and φ are constant

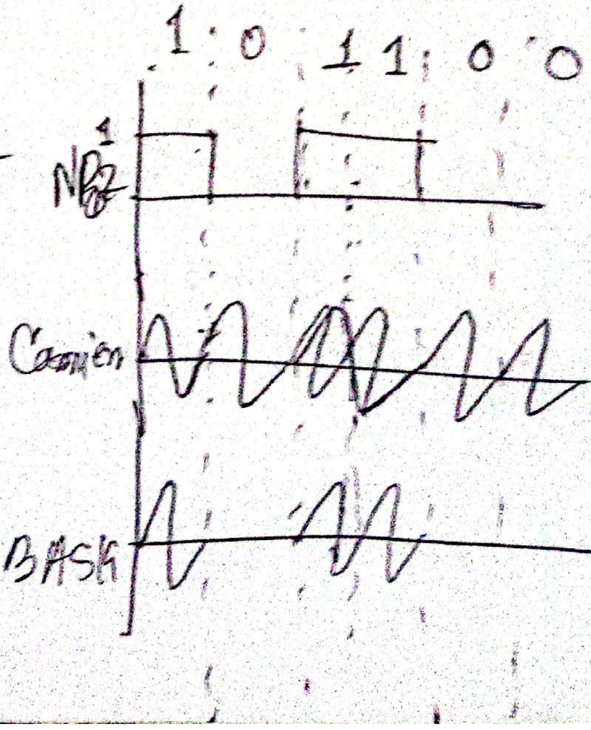


Binary ASK
↓
BASK

variation occurs in Bits !

Implementation:

* Similar to unipolar NRZ
* Sends unipolar NRZ and Carrier



Non periodic Composite Signal

TOPIC NAME : DAY TIME DATE : / /

Bandwith & Signal Rate

$B = (1+d)S$; d = Modulation and filtering

$0 \leq d \leq 1$

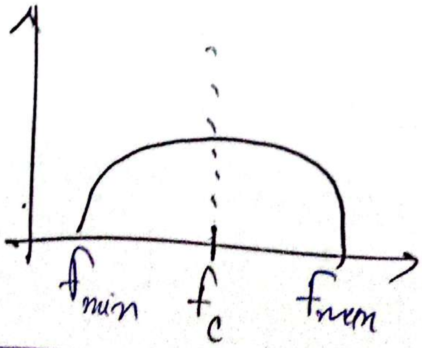
1 → max bandwidth

0 → min bandwidth

$B = (\cancel{\phi}\,1+d)N \cancel{R} \frac{1}{r}$

Carrier freq is always the mid point of the range.

$\boxed{\text{In BASK, } r = 1}$



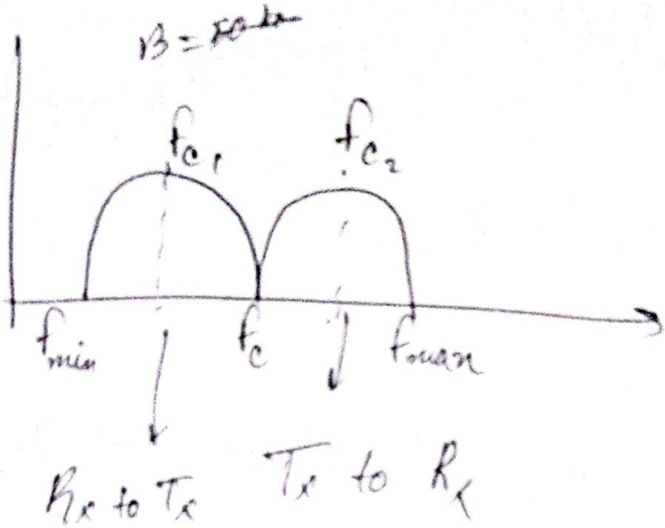
$$\boxed{\begin{aligned} f_{min} &= f_c - \frac{S}{2} = f_c - \frac{N}{2} \\ f_{max} &= f_c + \frac{S}{2} = f_c + \frac{N}{2} \end{aligned}}$$

$r = 1$

in $S = N \times \frac{1}{r}$

GOOD LUCK

For full duplex



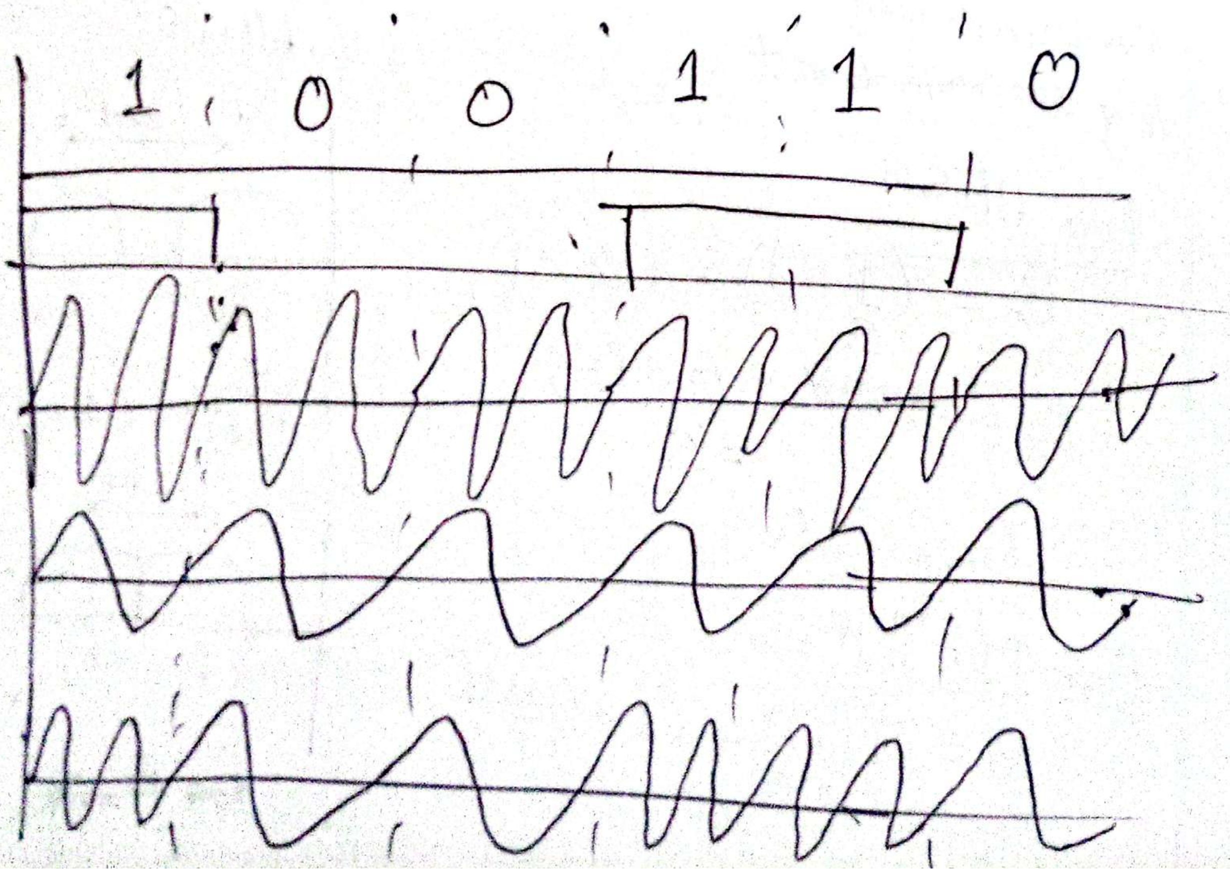
Frequency Shift Keying: (FSK)

Frequency changes
└→ Bit duration frequency same
↓
freq (1) ≠ freq(0)
freq (1) = freq(1)

For BFSK: $f_1 = freq(1) = f_c + \Delta f$

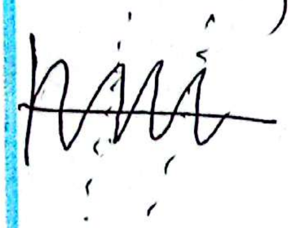
$f_2 = freq(2) = f_c - \Delta f$

$f_1 = 7$ Hz
$f_c = 5$ Hz
$f_2 = 3$ Hz

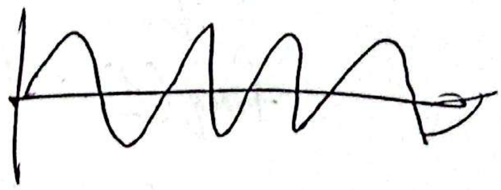


BFSK

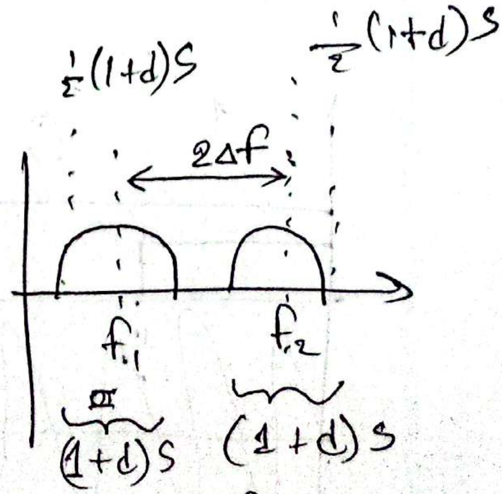
Non coherent → discontinuity



Coherent → continuity



↳ If two side by side waves are discontinued, they are non-coherent



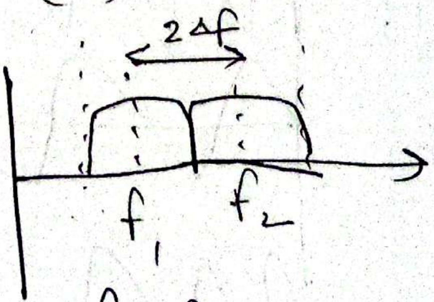
For BFSK

$$B = (1+d)S + 2\Delta f$$

$$\cancel{B_{min} = 2\Delta f = (1+d)S}$$

$$= S$$

$$B_{min} = 2S$$



For MFSK:

$$B = (1+d)S + (L-1)2\Delta f$$

$$B_{min} = L \times S$$

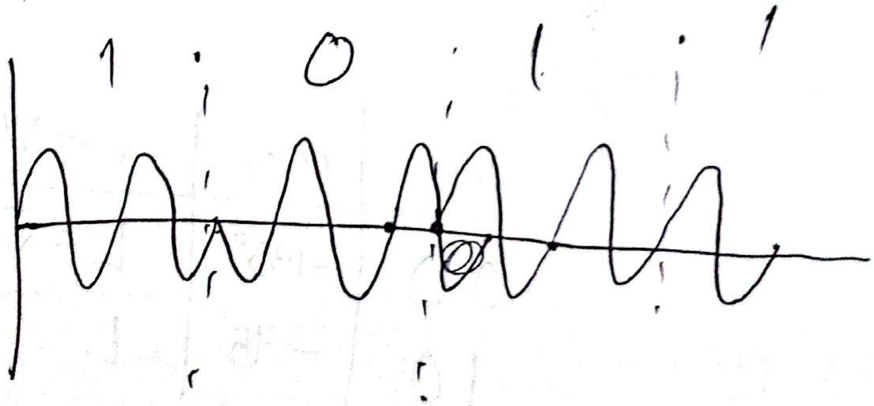
TOPIC NAME: W-8 DAY: C-16
TIME: DATE: 27/1/25

* We use analog signal in bandpass channel
* We use 1 signal element in bits

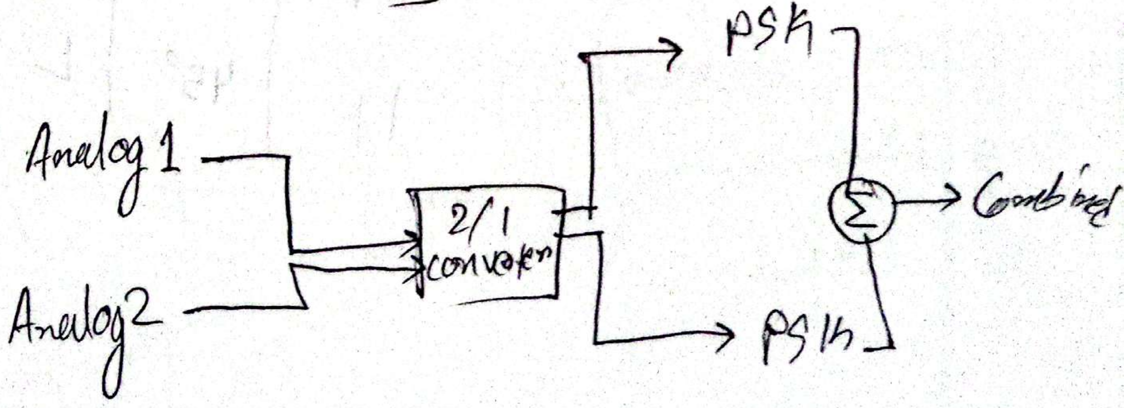
Phase Shift Keying

1 carrier Signal → 0° shift for 1
180° " " 0

Uses NRZ-L



QPSK: Takes bits separately and then combines later



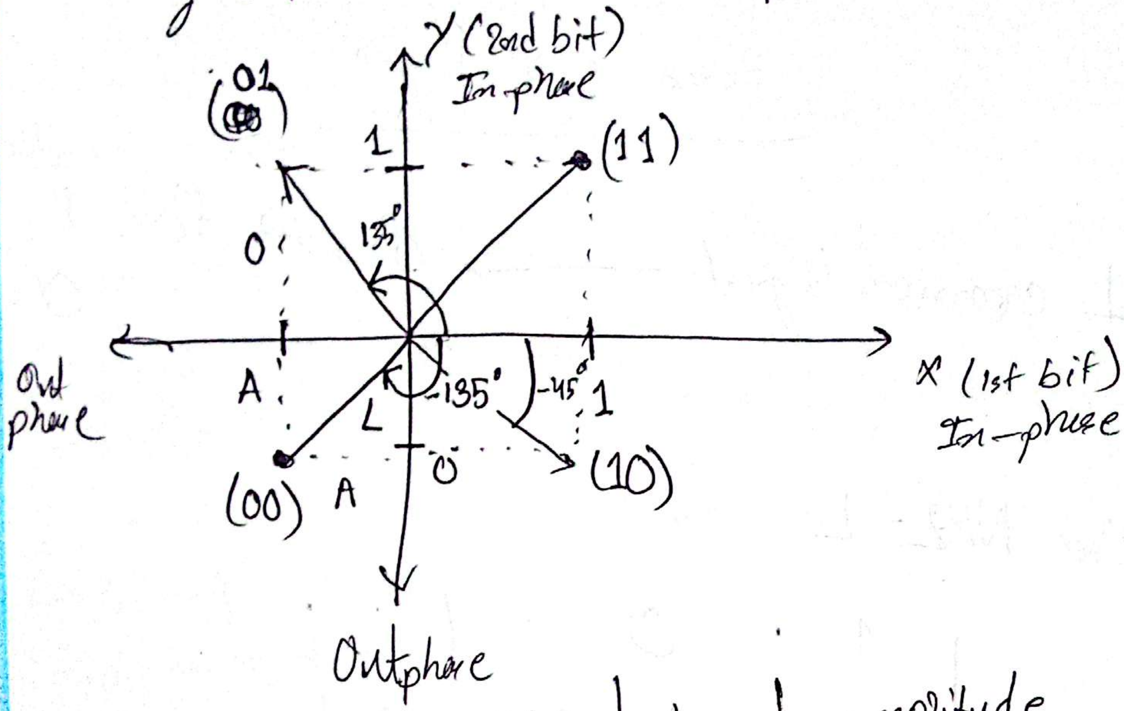
TOPIC NAME :

DAY :

TIME : DATE : / /

Constellation Diagram :

Diagram to decide which phase to take



bits	phase	amplitude
0 0	-135°	$L = \sqrt{2}A$
1 0	-45°	L
0 1	135°	L
1 1	45°	L

TOPIC NAME: W-8 DAY: C-17
TIME: DATE: 29/ 1 / 25

Analog → Analog

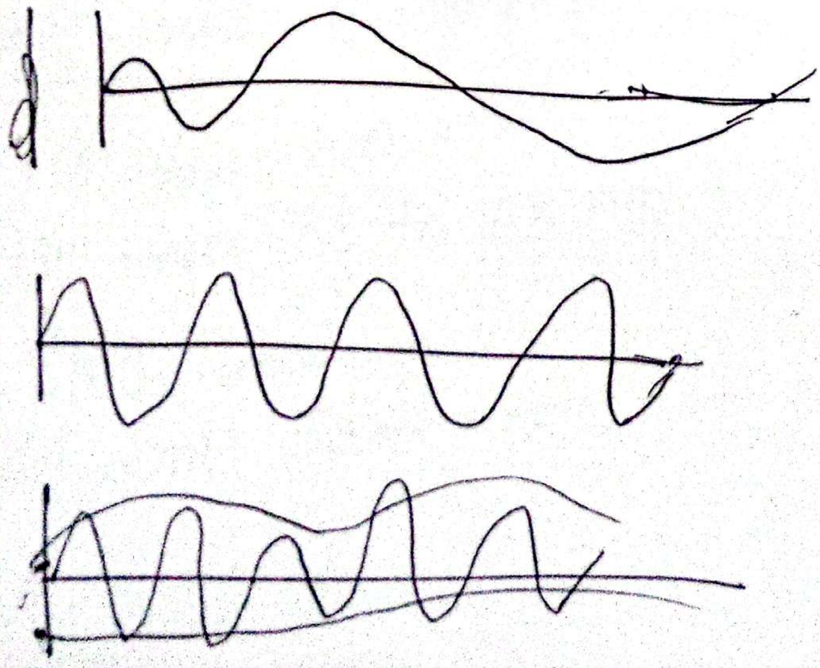
Quiz -3 on 10/02/25
Ch — 5

* we do this to modulate a ~~bandpass~~ baseband into a bandpass

A to A
Conversion

- Amplitude Modulation
- Frequency Modulation
- Phase Modulation

Amplitude Modulation: Envelopes



If ~~a~~ modulated signal is positive, amp is greater
If not ~~modul~~ amp is smaller.

TOPIC NAME : DAY : TIME : DATE : / /

* AM Radio:

* FCC decides channel

FCC has set 530 − 1700 kHz

$\therefore B_{AM} = 2B = 2 \times 5 = 10\ kHz$

$\therefore$ Channel Number $= \dfrac{1700 - 530}{10}$

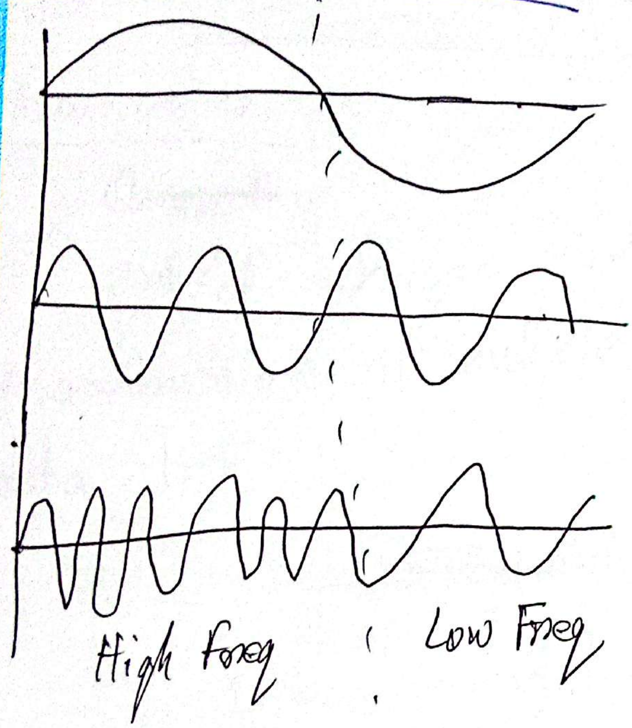
$= 117$ channels

* Implementation + Channel

GOOD LUCK

TOPIC NAME : DAY : TIME : DATE : / /

Frequency Modulation :



$B_{FM} = 2(1+\beta)B$ → Usually 4

Quality of FM > Quality of AM

*FM Radio: $B = 15\ kHz$

FCC allows 200 kHz

FCC ranges 88 to 108 MHz = 88×10^3 to 108×10^3 kHz

∴ 100 stations

But, only 50 are useable for guard bands (alternate ones are skipped)

TOPIC NAME :

DAY :

TIME : DATE : / /

[4] Phase Modulation :

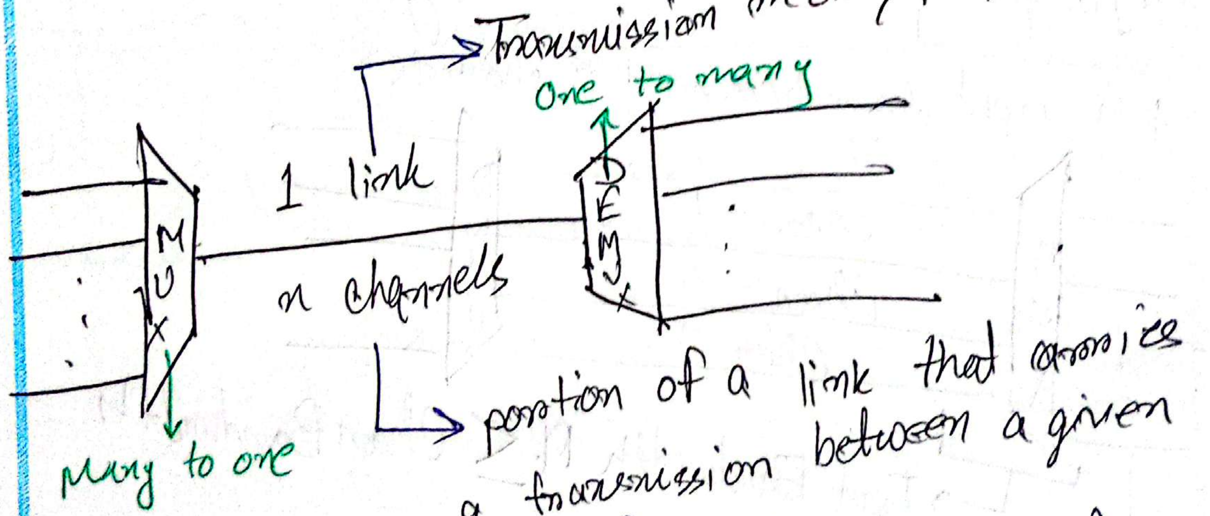
TOPIC NAME : W-9 DAY : C-18
TIME : DATE : 4/02/25

Ch - 6

Multiplexing:

~~Connecting~~

Set of techniques that allows the simultaneous transmission of multiple signals across a single data link



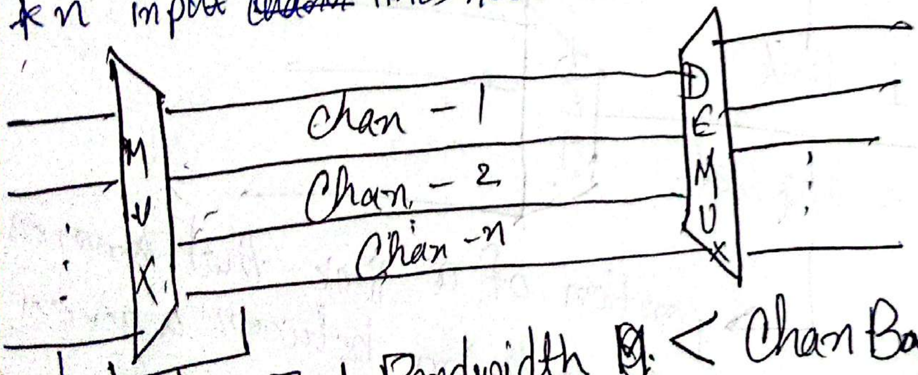
portion of a link that carries a transmission between a given pair of lines.
↳ when created using freq

Multiplexing

- Frequency Division (Analog)
- Wavelength Division (Analog but not imp)
- Time Division (Digital)

Frequency Division Multiplexing:

* n input ~~chann~~ lines need n channels



Input Bandwidth ≤ Chan Bandwidth

if analog → enters directly (Hz)
if digital → convert to analog → enter (Data Rate → Hz)

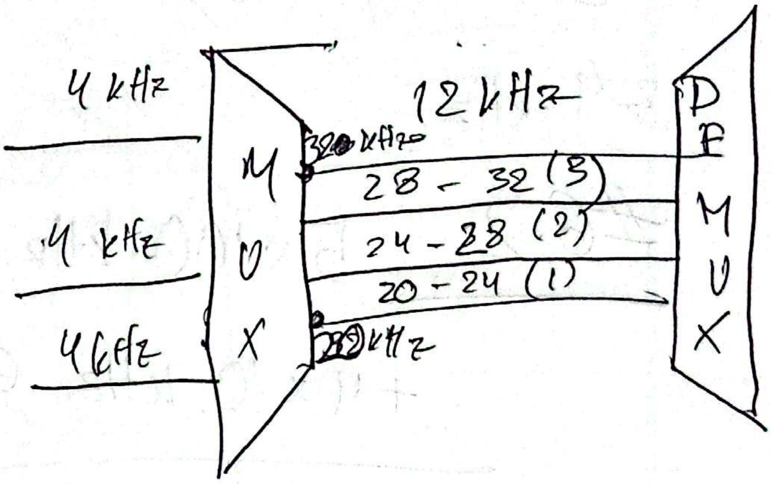
Inputs are baseband (starts from 0)
Channels are bandpass (Does not start from 0)

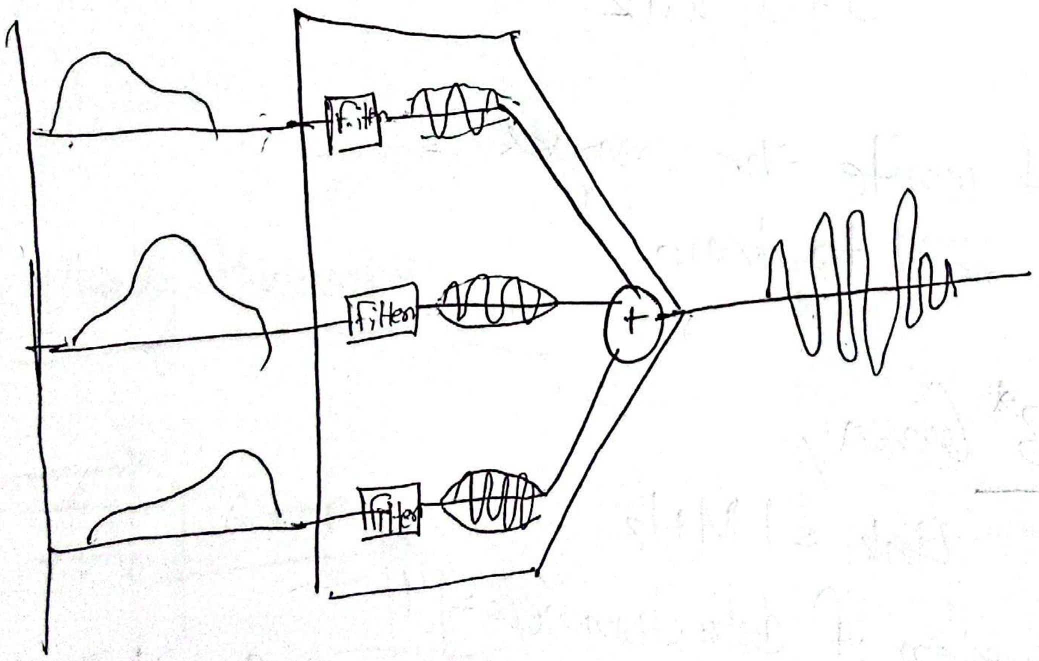
TOPIC NAME : DAY : TIME : DATE : / /

#6.1

$n = 3$

$\text{inp } b = 4 \text{ kHz}$





TOPIC NAME : W-9 DAY : C-19 TIME : DATE : 5/2/25

*If not specified, we consider voice width as 3-4 kHz.

#6.2. 5 × 100 kHz signals

+ 4 × 10 kHz Guard Bands

540 kHz

*Just write the ranges
No need to draw

#6.3* Given,

Link = 1 MHz

Number of data channels = 4

$\therefore$ Range $= \frac{1000 \text{ kHz}}{4} = 250$ kHz

For taking QAM,

$B_{min} = S$; [d = 0]

$= N \times \frac{1}{r}$

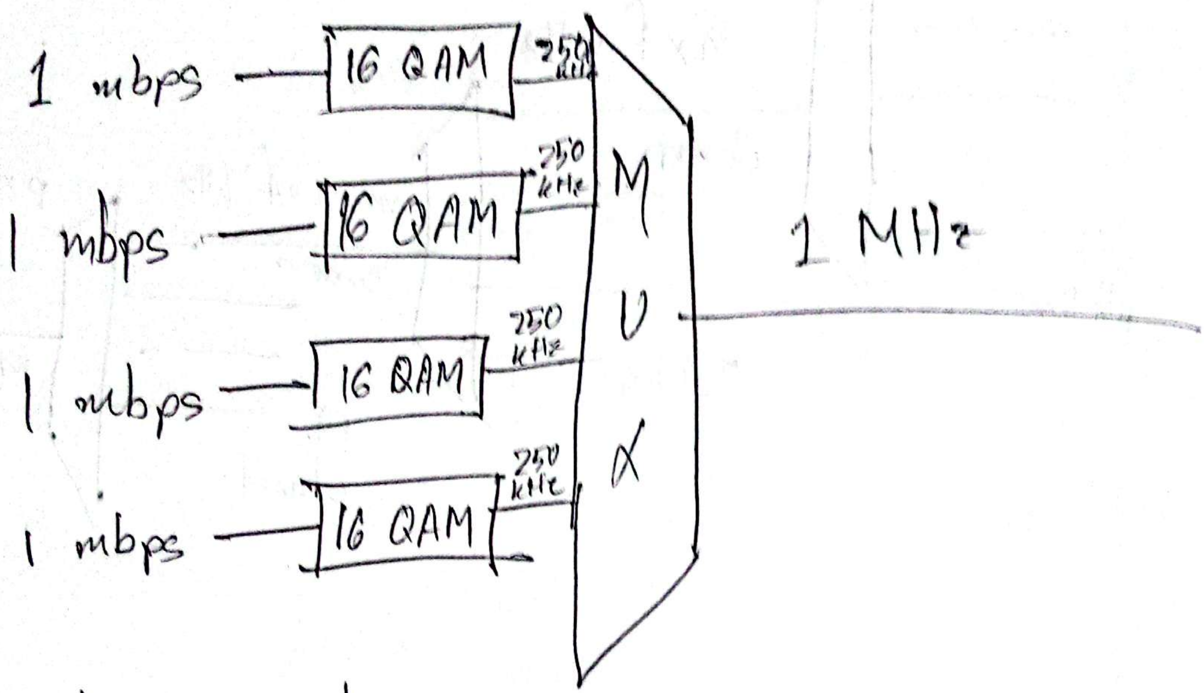
$\therefore r = \frac{N}{B_{min}} = \frac{1000}{250}$

$= 4$

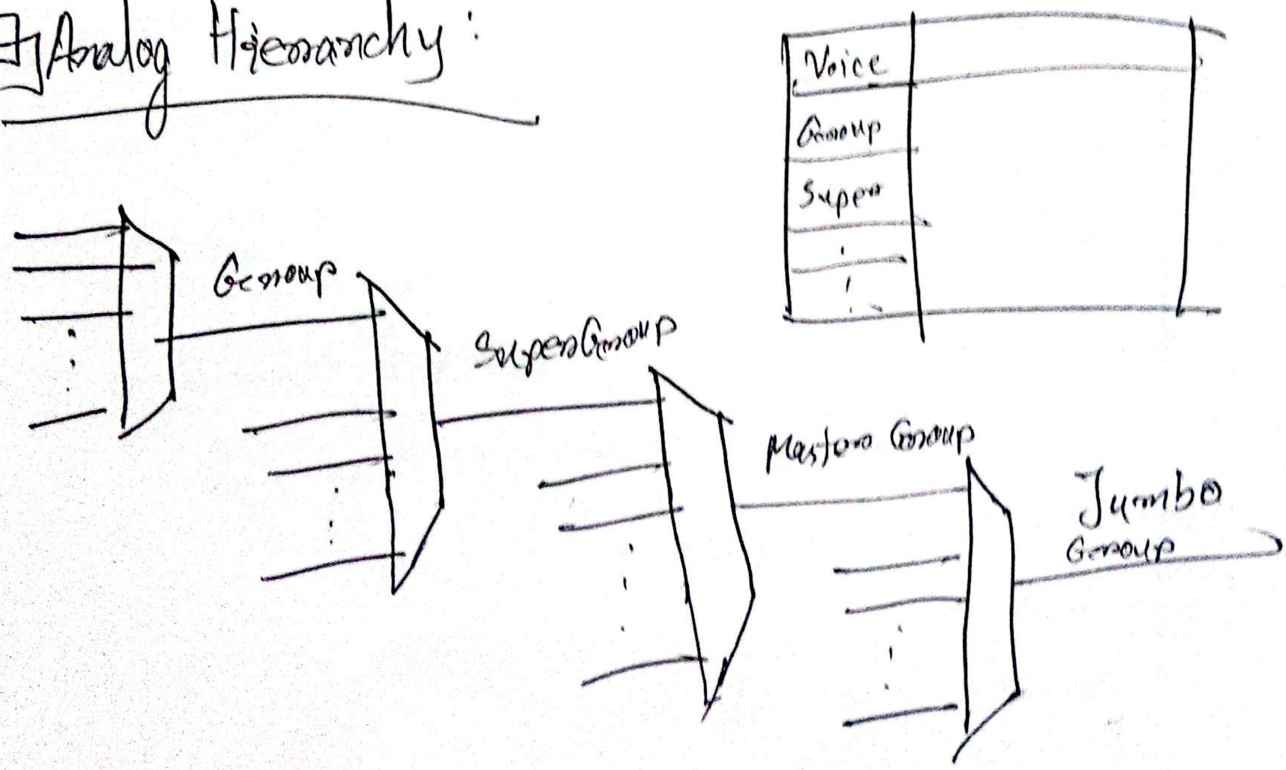
$\therefore r = \log_2 M$

$\therefore M = 16 \; (2^4)$

∴ Required ~~value~~ modulation :



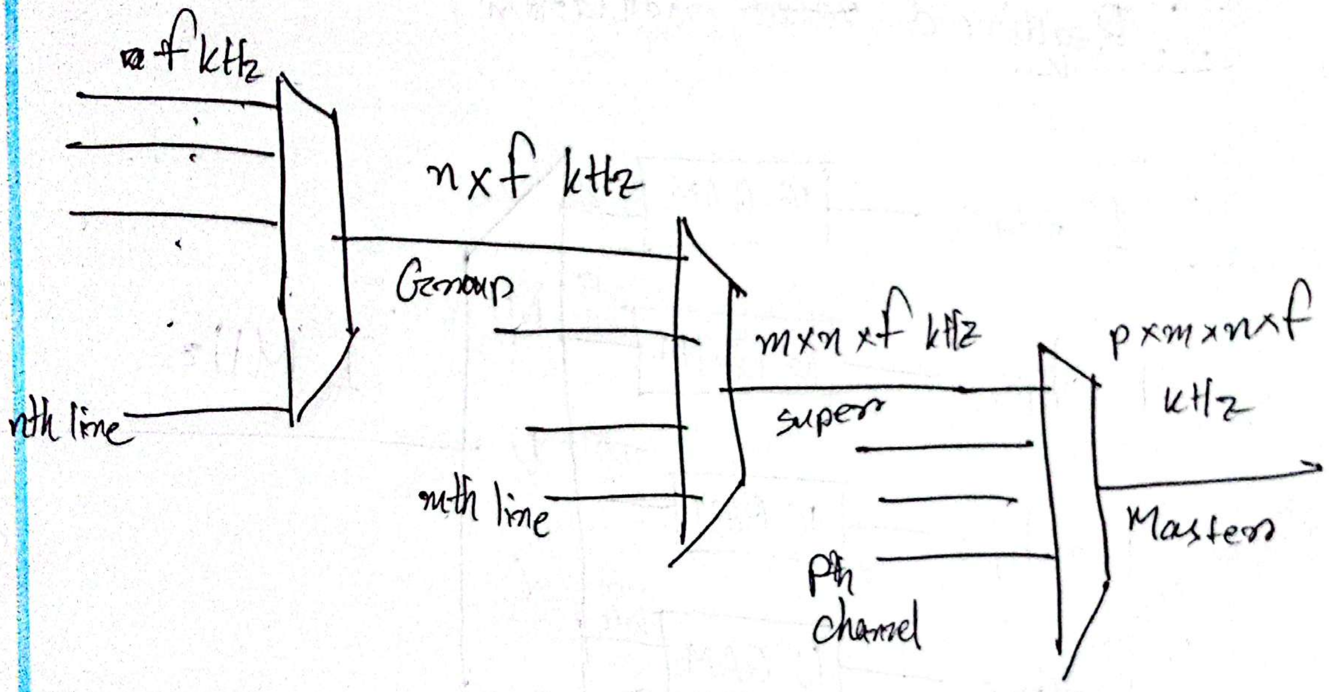
Analog Hierarchy :



TOPIC NAME :

DAY :

TIME : DATE : / /



TOPIC NAME: W-10

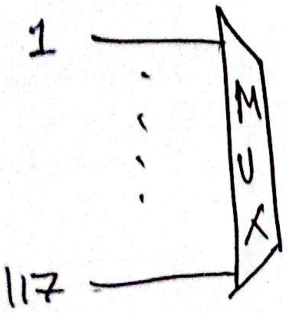
DAY: C-21 (20 was Quiz)

TIME:

DATE: 11/02/25

Application of FDM:

- Used in AM and FM



* * For exam:

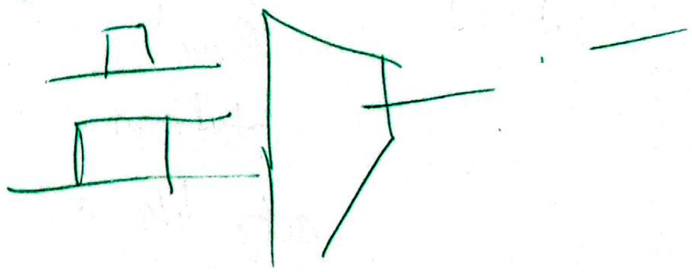


fig.

- Used in TV Broadcasting:
  - Each TV has 6 MHz band

- Used in cellular telephone
  - Each gen increases bandwidth
    - 824 - 849 MHz used for receiving (Uplink)
    - 869 - 894 MHz " " transmitting (Downlink)

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

$= 10 \times 3 \text{ kHz} = 30 \text{ kHz}$

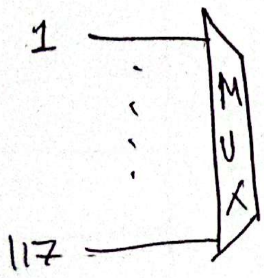
$Ch = \dfrac{849 - 824}{30 \times 10^3}$ 790 channels

TOPIC NAME : W-10 DAY : C-20 (20 was Quiz)

TIME : DATE : 11 / 02 / 25

Application of FDM :

- Used in AM and FM



* For exam :

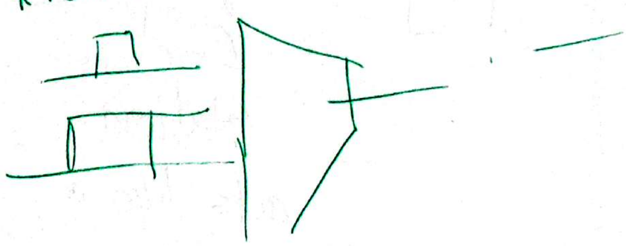


fig.

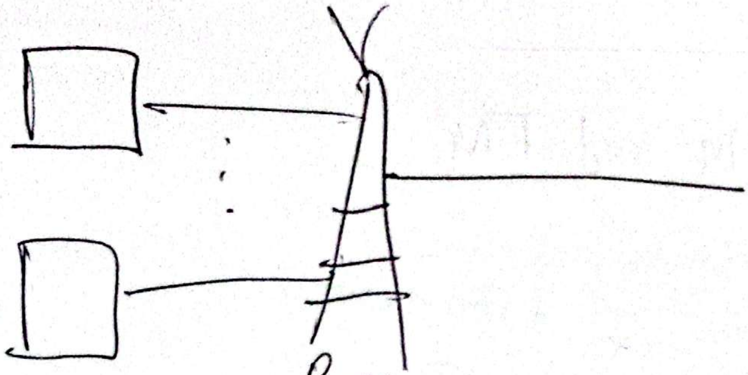
- Used in TV Broadcasting :
  - Each TV has 6 MHz band

- Used in cellular telephone
  - Each gen increases bandwidth
  - 824 – 849 MHz used for receiving → Uplink
  - 869 – 894 MHz " " transmitting → Downlink

$B_{FM} = 2(1+\beta)B$
$= 10 \times 3 \text{ kHz} = 30 \text{ kHz}$

$Ch = \frac{849 - 824}{30 \times 10^3}$ 790 channels

TOPIC NAME : DAY : TIME : DATE :



* for wireless, we use FDMA
↳ Multiple Access

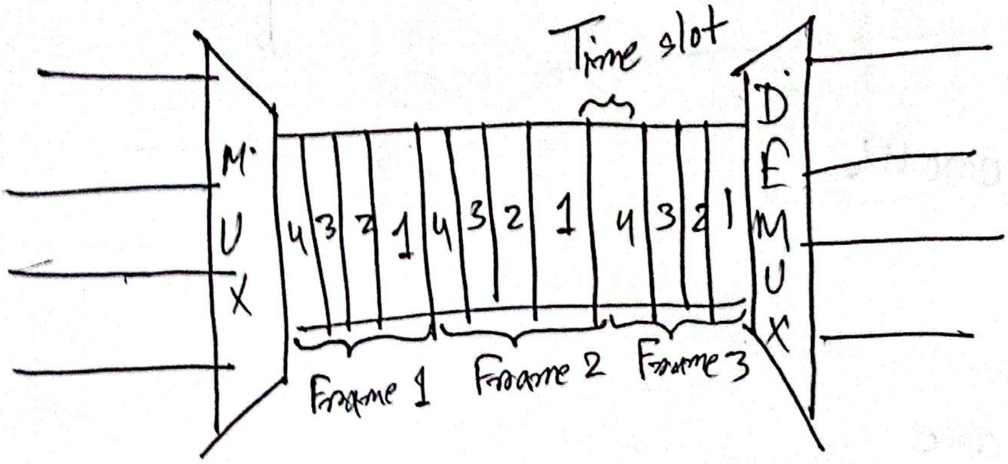
GOOD LUCK™

CamScanner

TOPIC NAME : DAY : TIME : DATE : / /

Time-Division-Multiplexing:

— Entire bandwidth, limited time



input * time slot = frame

*Digital signals

If analog ⟶ use PCM

TOPIC NAME

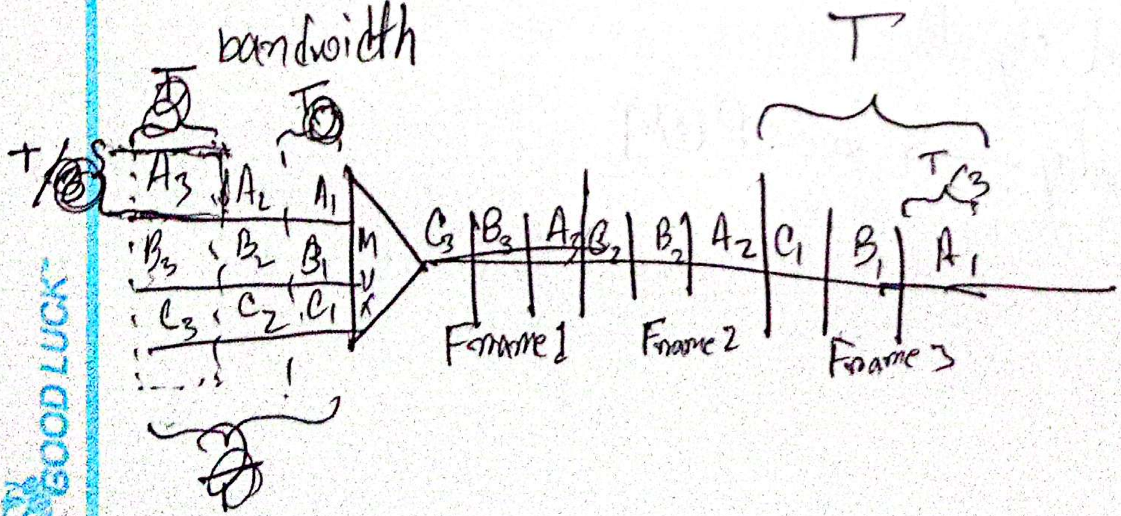
TDM

Synchronous

~~1st bits~~

All bits are sent at once

└→ wastes bandwidth



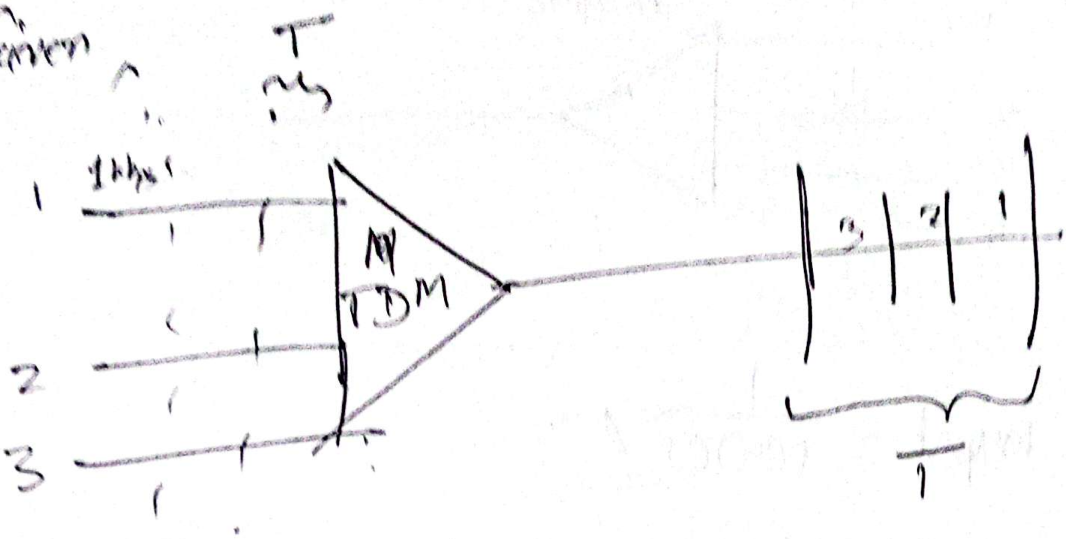
TOPIC NAME

DAY

TIME DATE / /

#6.5

Given



Here,

1000 bits are sent in 1s

1 " " " $\frac{1}{1000}$ bits

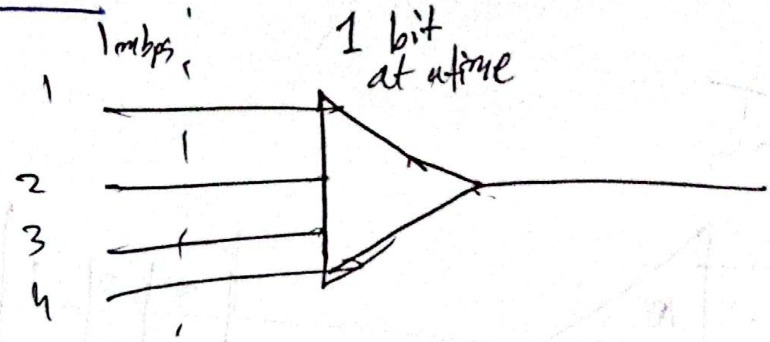
$\therefore T = 0.1$ ms

$\therefore$ Frame duration = input duration = 1 ms

$\therefore$ Output duration = $T/3 = \frac{1}{3}$ ms

TOPIC NAME : DAY TIME : DATE :

#6.6



$\therefore$ input $= \frac{1}{1000}$ s

$= 1\,\mu s$

$\therefore$ output $= \frac{1}{4}\,\mu s$

$\therefore$ output bitrate $= 4 \times 1$ mbps (no. input + bit

$= 4$ mbps

$\therefore$ output frame rate $=$ input frames / second

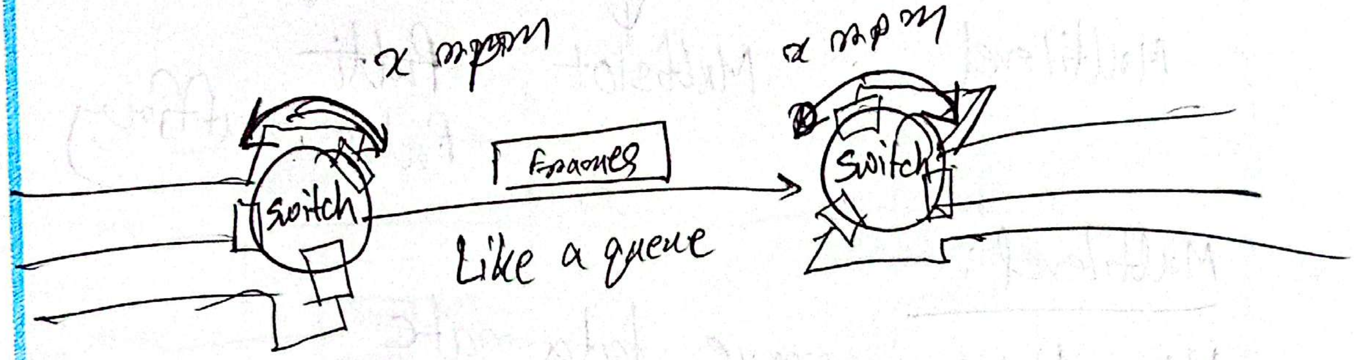
$= \cancel{1000} : 10^6/1$

$= 10^6$

GOOD LUCK™

TOPIC NAME : W-10 DAY : C22 TIME : DATE : 12 / 2 / 23

Synchronization :



This process is interleaving

→ two switches connected to ~~oppo~~ input lines which send bits synchronously

TOPIC NAME : DAY: TIME: DATE: / /

Data Rate Management

Multilevel — Multislot — Pulti Pulse Stuffing

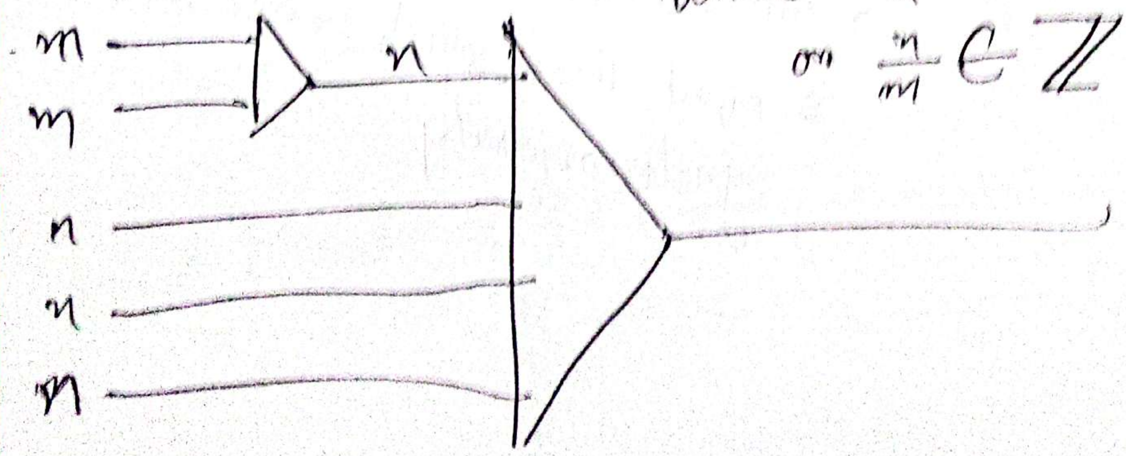
Multilevel:

Using MUX to improve data rate

* Has to be multiple of others.

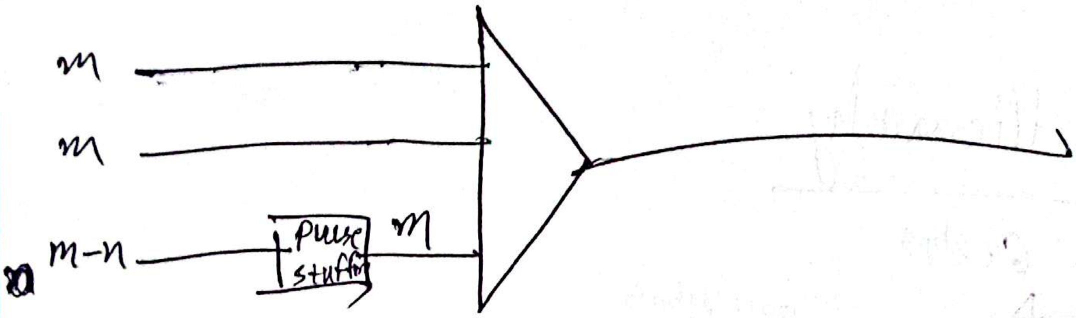
where $\frac{m}{n} \in \mathbb{Z}$

or $\frac{n}{m} \in \mathbb{Z}$



Pulse Stuffing:

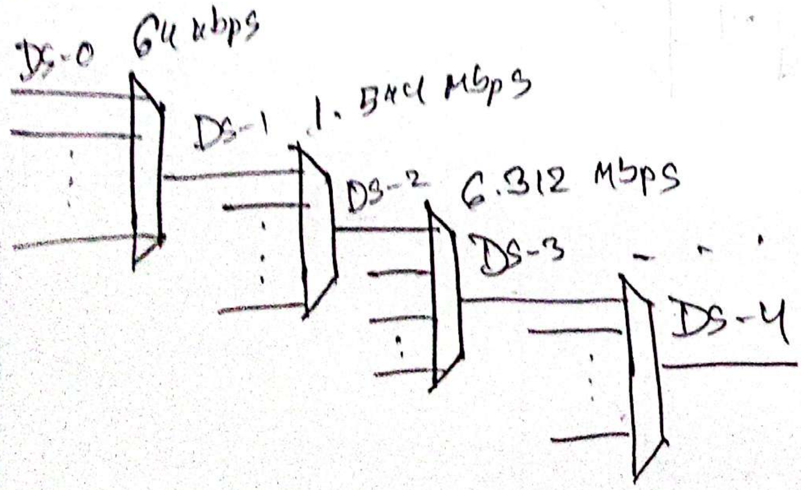
Adding bits to make them equal



Frame Bit:

Bit sequence that maintains synchronization

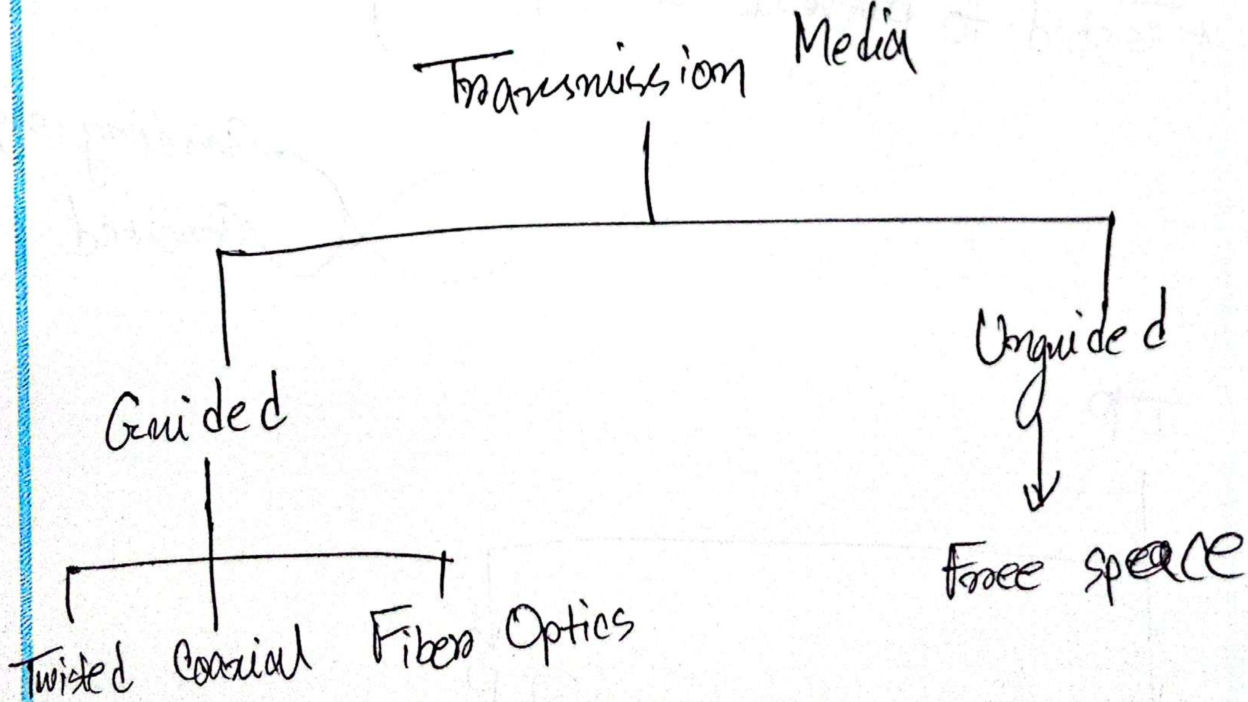
DS Hierarchy:



TOPIC NAME: 10-11 DAY: C-23
TIME: DATE: 8/2/25

Ch-7: Transmission Media

* Transmission medium is the physical path between two



TOPIC NAME:

DAY:

TIME: DATE: / /

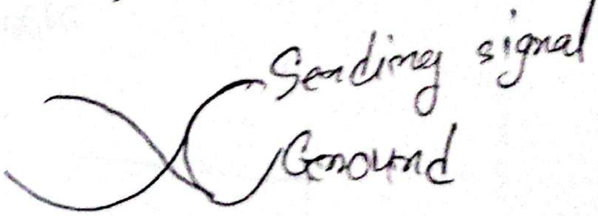
Guided Media

→ Conductors or ⓑ Fiber Optic Cable

↓

Twisted Pair Cable:

* four pairs of cables twisted together
* Twisted to prevent noise spreading



TP

UTP
Unshielded

STP
Shielded
(cost higher)

* Used in : i) Telephone lines
  ii) DSL → Broadband
  iii) LAN (10 base T
  mbps baseband. distance

TOPIC NAME :

DAY :

TIME : DATE : / /

Coaxial Cable :

* Higher freq than Twisted
* Used in :i) Telephone

ii) :

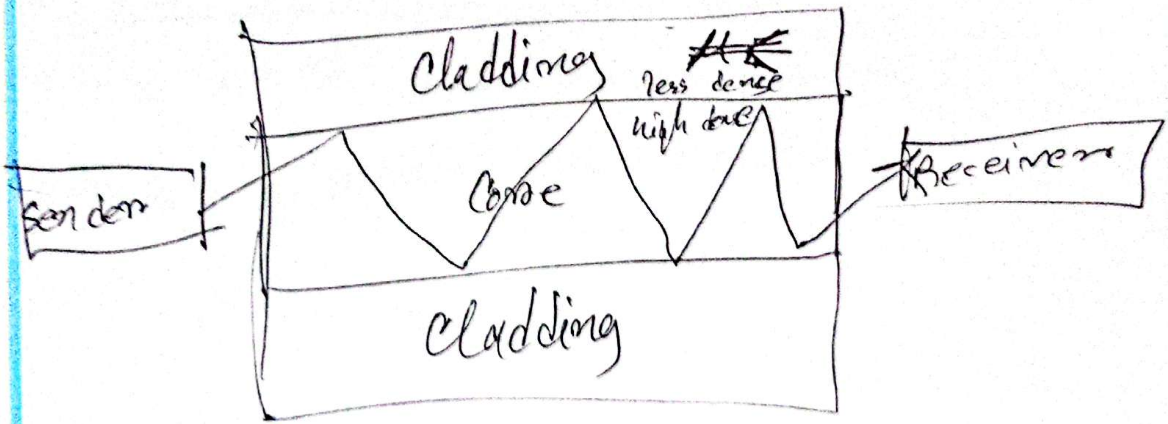
:

TOPIC NAME : DAY :
TIME : DATE : / /

Fiber Optic Cable

* Passes ~~through~~ light

* Total internal reflection



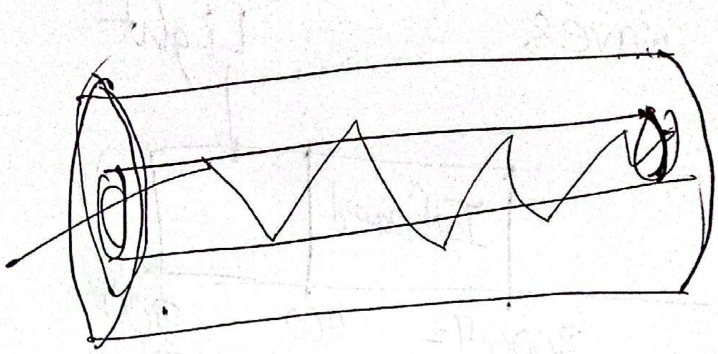
Sending Method
= Mode

- Multi
  - Step
  - Graded
- Single

TOPIC NAME : DAY : TIME : DATE : / /

Multimode core > Single Mode core

Multimode step :



Multimode Grade :

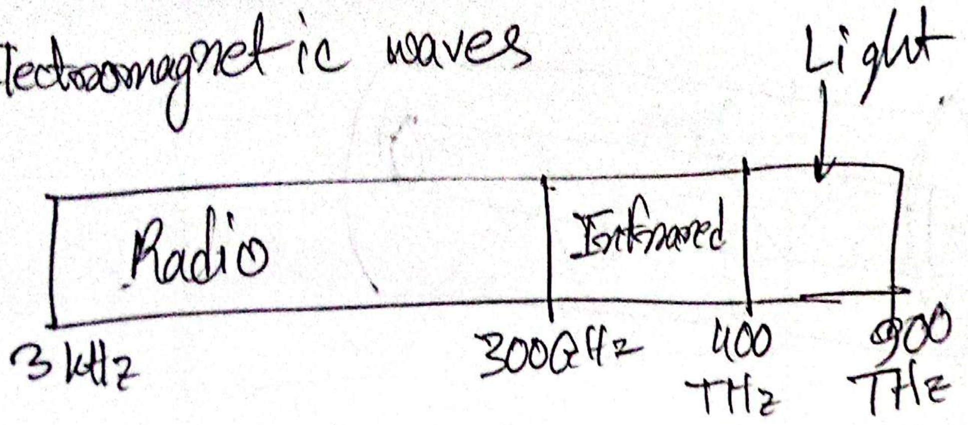
[Check slide.]

TOPIC NAME: W-11 DAY: C-24
TIME: DATE: 19/2/25

Ch-7

Transmission Media (Unguided)

* Electromagnetic waves

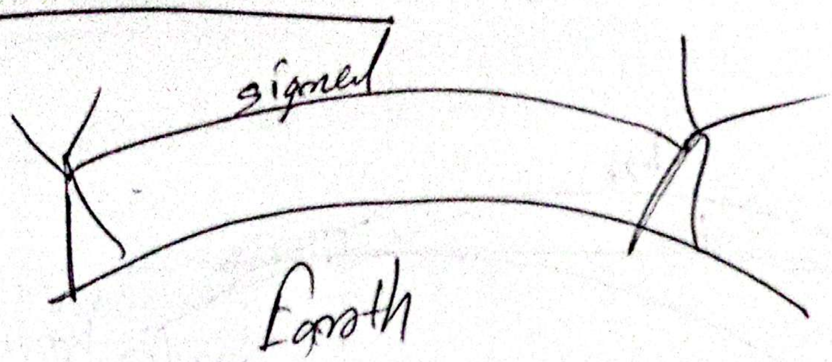


Antennae sends waves
└→ receives "

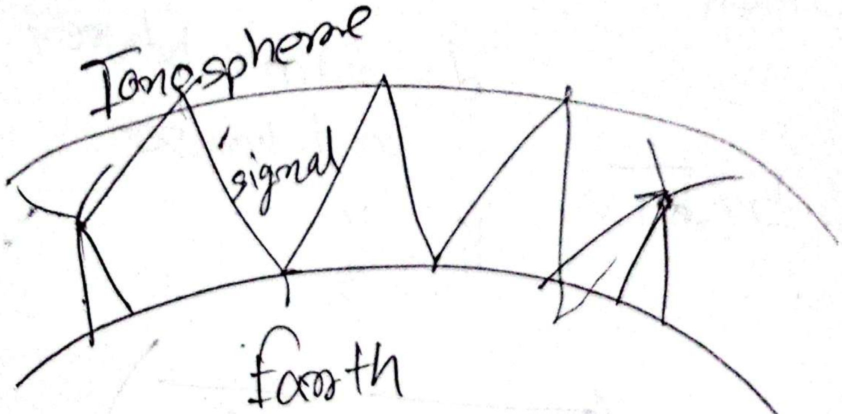
Propagation Methods:

Ground wave → < 3 MHz
Sky wave → 3 MHz → 30 MHz
Effective Line of Sight → > 30 MHz

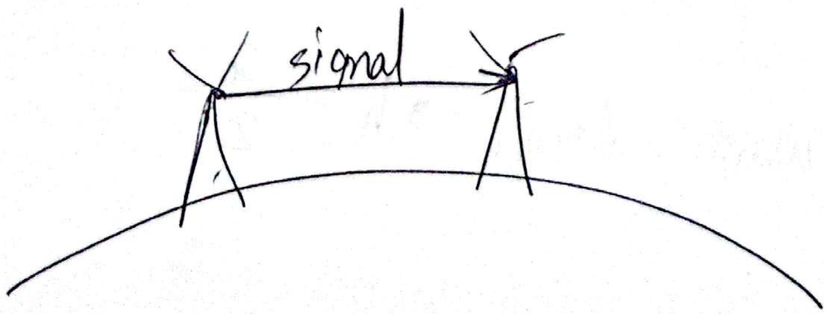
Ground wave 30 Hz → 30 MHz



Sky Wave 3 – 30 MHz

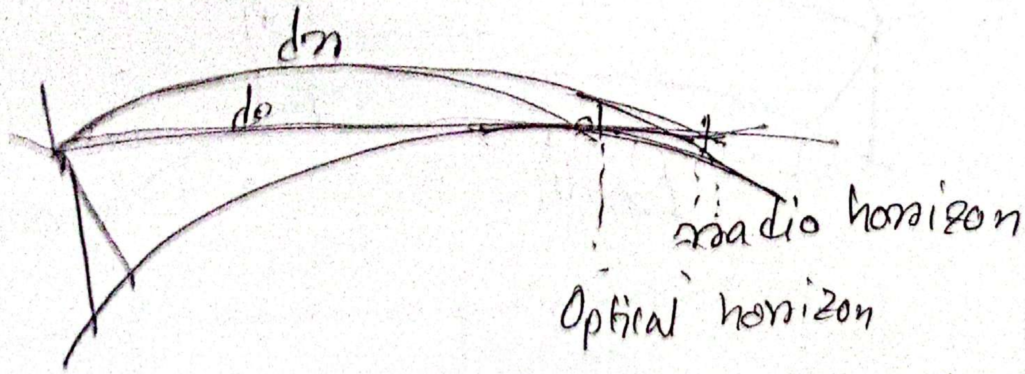


Line of sight: 30 MHz → 900 THz



TOPIC NAME DAY : TIME : DATE : / /

LOS dist calculation :



$d_o = 3.57\sqrt{h}$

h = antenna height

d = distance between antenna and horizon

$d_r = 3.57\sqrt{Kh}$

$K = \frac{4}{3}$

$$d_{max} = 3.57\left(\sqrt{Kh_1} + \sqrt{Kh_2}\right)$$

Half wave antenna $\rightarrow h = \frac{\lambda}{2}$

TOPIC NAME :
DAY :
TIME : DATE : / /

4. Radiowaves : 3 kHz → 1 GHz

* Omnidirectional antennas

5. Microwaves : 1 GHz and 300 GHz

* Unidirectional antennas

6. Infrared : 300 GHz → 400 THz

TOPIC NAME: W-12 DAY: C-23

TIME: DATE: 24/2/25

Ch-8
Switching

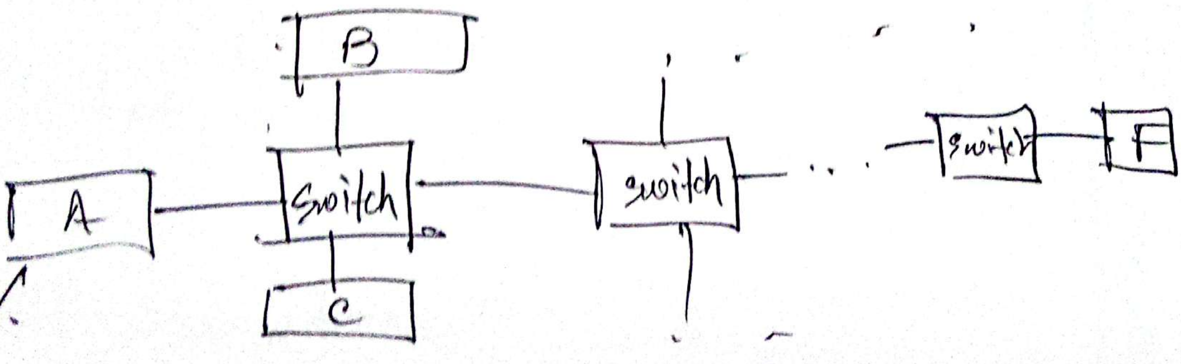
* Usual topologies are not recommended for large scale networks

* Switching networks are necessary for large scale networks

Switching Networks:

Using switches to make topologies

Connect switches instead of devices



End Device : → follow 7 layers of OSI and Devices that can generate and read ~~devices~~ messages.

TOPIC NAME : DAY : TIME : DATE : / /

* Switches ~~follow~~ work upto three layers

Home Devices → Routers → ISP → Regional ISP → Others Regional ISP → Internet

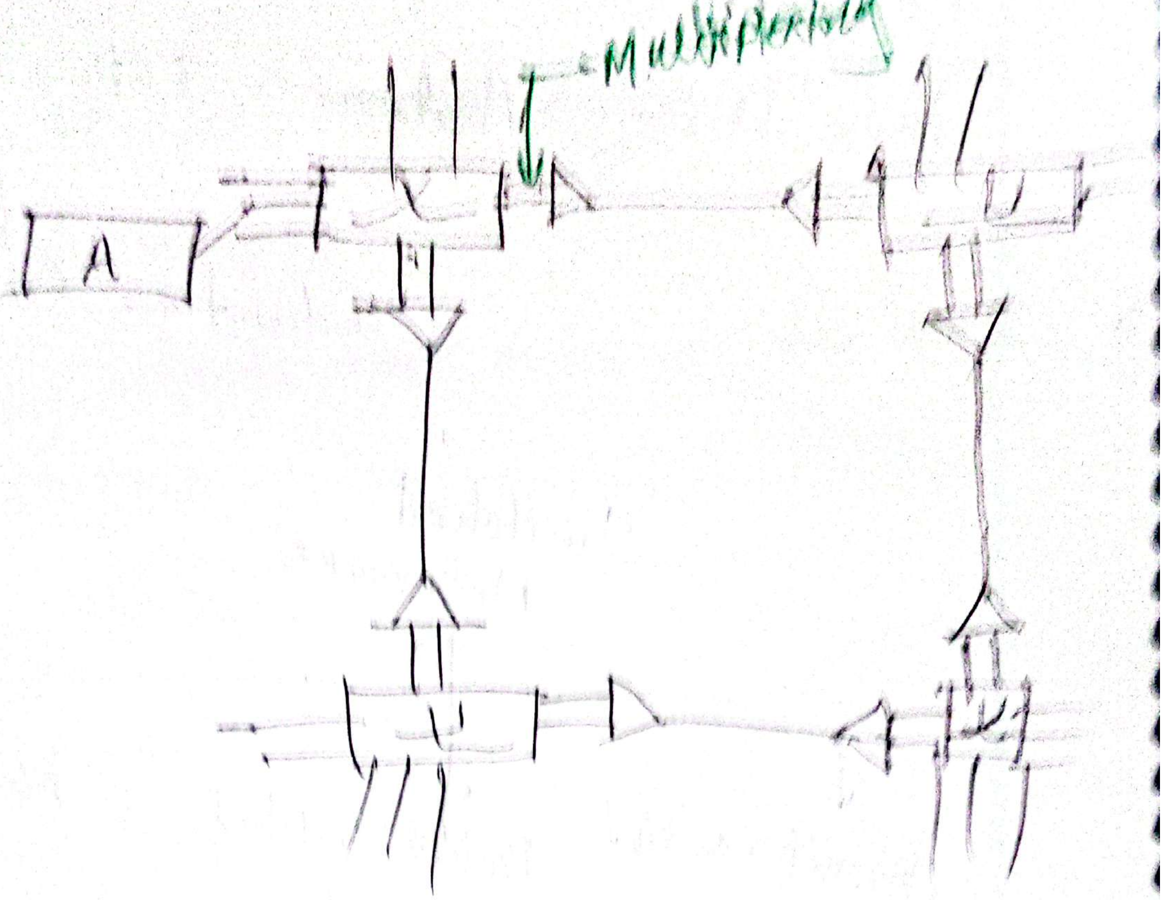
Switched Networks

- Circuit-switched Network (landlines)
- Packet-Switched Network (Usually what we use)
  - Datagram network
  - Virtual Circuit network
- Message-switched Network (not used anymore)

TOPIC NAME

Circuit Switching

* Physical Links



* Three phases:

i) Setup Phase : A Making a dedicated connection/ circuit → dialing the other party
Allocates some reserved resources so there is no delay

TOPIC NAME

ii) Data Transfer Phase: Transferring the data using the allocated resources

iii) Teardown Phase: Disconnecting, and, thus, releasing the resources

Taken from slide

* Efficient but wasteful

* Delay: → Forouzan uses total distance ~~if not mentioned~~, don't do that and use individual delay

* Propagation delay between points in setup phase

Transmission " " " "

× 2

* Propagation delay only once } in data transfer phase

Transmission " " "

* Delay as in ~~Dat~~ Teardown Phase

TOPIC NAME: 10-12 DAY: C-26
TIME: DATE: 5/2/25

* LTE uses VOIP which uses packet switching network

Message Switching:

* destination address is appended with message
* uses store-and-forward network

↳ stores until full message

* Not used because it needs the whole message.
* If total message is big it gets deleted → buffers needs to be beeg
* If next hop and link are not available it remains stored indefinitely

TOPIC NAME : DAY : TIME : DATE : / /

Packet Switching:

* Message is broken into packets
    * Packets are smaller than switch Buffers
* Messages are sent using whichever switch is available
* If network is overloaded, they are discarded

Datagram Networks:

* Packets are treated independently
* Packets are called datagrams
* Also called connectionless network
* IP is part of datagram
* Each switch contains address with port
    * Multiple addresses can have same port

* ~~Efficient~~ Less wasteful but may not be instant
* Delay : $\underbrace{\text{Total Delay} = 3T + 3\tau + w_1 + w_2}_{\text{only for data transmission phase}}$

For n switches, Total Delay $= (n+1)T + (n+1)\tau + \sum_{i=1}^{n} w_i$

TOPIC NAME: DAY: TIME: DATE: / /

→ Virtual - Circuit Network:

* Cross between circuit switching and datagram network
  - → has setup and teardown phase
  - → " packets

* Setup phase : * Updates routing table
  * Temp address/ called VCI
    ↓
    Virtual Circuit Identification

  * At first a req, message is sent to update ~~routing table~~ incoming VCI
  * After acknowledgement from the receiver, it updates the outgoing VCI using same path

* Data Transfer : * Just follow the previously established path

* Teardown Phase : * Removes all VCI

GOOD LUCK

CamScanner

TOPIC NAME : DAY :
TIME : DATE : / /

* Can check availability of resources.
* Same ~~that~~ delay as before without waiting time.
* Divide delay in each phase for each.

GOOD LUCK

TOPIC NAME: W-13 DAY: C-27

TIME: DATE: 3/ 3 / 25

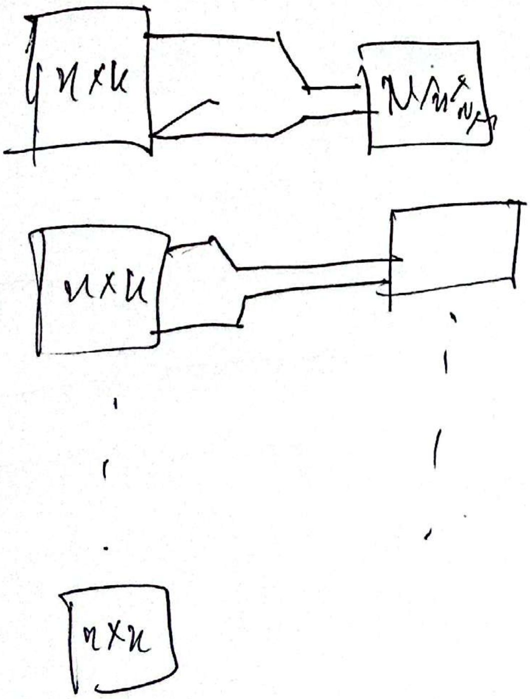
Crossbar switch:

~~multip~~

input × output points

but this is inefficient

so we set multi stage



TOPIC NAME :

DAY

TIME DATE / /

Clos Criteria for non-blocking:

$$n = \left(\frac{N}{2}\right)^{\frac{1}{2}}$$

$$k \geq 2n-1$$

for 200×200 switch,

$$n = \left(\frac{200}{2}\right)^{\frac{1}{2}} = 10$$

$$k = 2n - 1 = 19$$

GOOD LUCK™

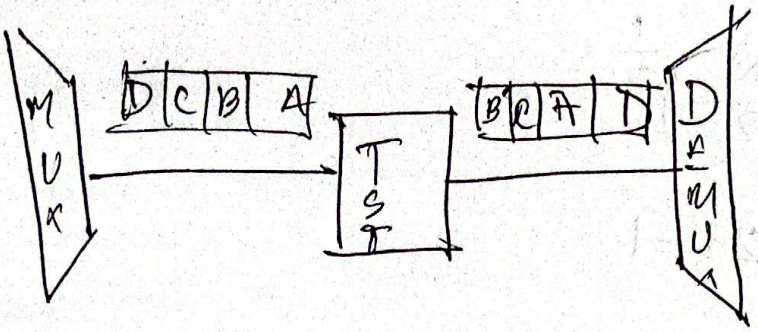
CamScanner

TOPIC NAME :

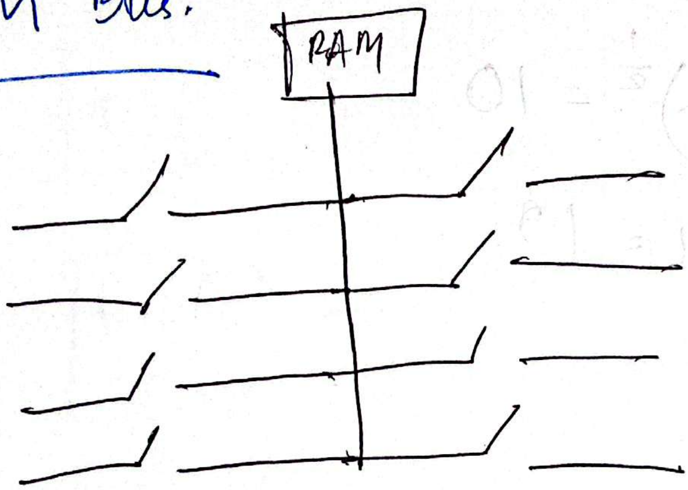
DAY :

TIME : DATE : / /

Time Slot Interchange :



TDM Bus :



GOOD LUCK

CamScanner

TOPIC NAME :
DAY :
TIME : DATE : / /

TST:

Banyan Switch:

Packet switch

for n inputs n outputs

$$\text{stages} = \log_2 n$$

$$\text{microswitches} = \frac{n}{2}$$

TOPIC NAME: 10 - 13 DAY: C-28
TIME: DATE 04/03/25

Error

Error → Single bit error

Error → Burst

Ch - 10

Error Detection and Correction

Detection:

Redundant bits are sent

if same → no error

else → error

TOPIC NAME:

DAY

TIME DATE: / /

Error Detection Methods

- Parity Check
  - ~~Add~~ Even (Makes even number of 1s)
  - Odd (Makes odd number of 1s)
- Cycle Redundancy Check
  - Divides by divisor and takes remainder after (divisor)bits − 1
  - ~~-1~~
- Checksum

Vertical Redundancy Check

- Can only check for a single bit error
- Can detect if even changes for odd parity and odd changes for even parity

Two dimensional Parity

- can't detect for even/even
  odd/odd

TOPIC NAME :

DAY :

TIME : DATE : / /

Hamming Code :