Chapter - 1

Introduction

1. Components of data Communication

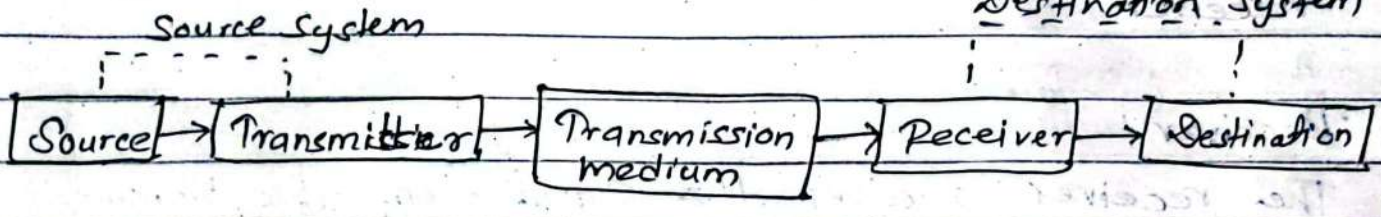


fig: Block diagram of data communication system.

The basic block diagram of typical data communication system consists of source, transmitter, transmission medium, receiver and destination.

1) Source :-

→ The source generate the information or data that will be transmitted to the destination.

→ Popular form of information include text, number, picture, audio, video or combination of any of these.

2) Transmitter:

→ The transmitter is a device which is used to convert the data as per the destination requirement.

→ Eg: A modern (Modulator and Demodulator) convert the analog (Telephone) signal to digital computer signal and alternatively digital to analog.

3) Transmission Medium:

→ The transmission medium is the physical path by which data travels from transmitter to receiver.

4) Receiver:

→ The receiver receives the signal from the transmisson medium and convert it into a form that is suitable to the destination device.

→ For example: a modem accepts analog signal from a transmission channel and transform it into digital signal which is acceptable by computer system.

5) Destination:

→ The destination takes the incoming data from the receiver.

Q. Evolution of Data Communication:

Data Communication:

→ The word "data" refers to information that has been translated into a form that is efficient for movement or processing.

→ In a computer storage, data is series of binary bits that has value 1 or 0 which is processed by the CPU using arithmetic and logical operation.

→ Hence, data communication is the process of using communication technology to transfer data from one place to another.

→ A common example of DC is a computer connected to the internet, through wi-fi connection.

→ The effective data communication depends on these fundamental characteristics:

a) Delivery:
→ Data must be delivered to the correct destination by the communication system and must be received by the desired receiver.

b) Accuracy:
→ The system must delivered the data accurately without any alternation.

c) Timeliness:
→ The system must delivered the data in a prescribed time domain without significant delay in real

time transmission transmitter to receiver.

→ It could be either guided medium (गाइडेड मीडिया) Example: Twisted pair Cabele, Coaxial cable, optical fibre or unguided medium. Exmp^n.' radio or microwave.

Evolution of Data Communication:

→ Data Communication system (using computer) come into existence shortly after the computer became widely used in the organization.

→ DC history include:

(i) The history of telecommunication industry.

(ii) The history of Data communication.

(iii) The history of internet.

→ Modern telecommunication industry began in 1837 with the invention of telegraphy.

→ The development of telephonic communication technology began in 1876 with the invention of telephone.

1837 – Drvention of telegraphy.
1876 – Development of telephonic comm^n & invention of telephone
1950 – Telephone and telegraph company.
1969 – Development of IP (internet protocal)
1991 – 1 million server came online.

→ By 1950, telephone and telegraph company has developed a network of communication facility throughout the industrized world.

→ By 1969, the development of internet protocal (IP) marked a significant milestone in data communication history.

→ By 1991, more than 1 million server had come online using internet protocol technology and the world wide web (www) emerged as the primary component of the internet.

→ Hence, data communication has evolved from the days of telegraph communication and high speed data transfer and is the revolving part of many society today.

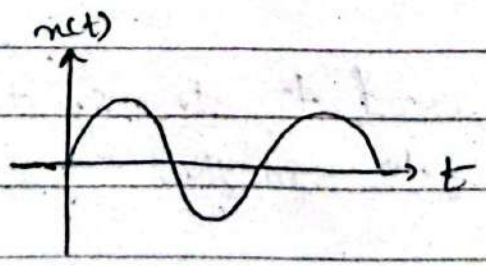
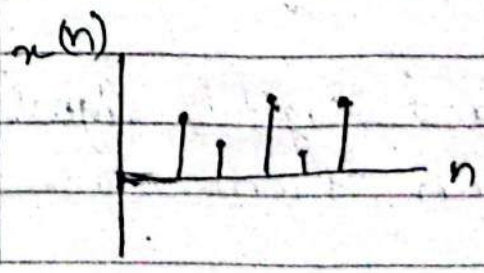
Analog and Digital data transmission

→ Analog and Digital signal are used to transmit the information from one device to another.

→ Analog signal is continuous wave that keeps on changing over a time period.

→ Digital Signal is discrete in nature.

※ Comparision chart of Analog & Digital Signal.

	Analog Signal	Digital Signal
1)	Analog Signal is continuo-usly moving wave that changes over a time.	1) Digital signal is discrete wave that carries info^n in binary forms.
2)	Analog signal is represented by the sine wave.	2) Digital signal is represented by the square wave.
3)	Analog Signal is described by amplitude, frequency & phase.	3) Digital signal is described by bit rate and bit interval.
4)	Analog hardware is not flexible.	4) It is flexible.
5)		

Advantage of Digital Signal over analog Signal transmissi

→ Digital Signals are faster then analog Signal.

→ Digital can be stored and process very easily.

→ Performing Encryption and Decryption is quite easy in digital system. So, it is more secured system.

→ Digital Signal is not corrupted by noise.

→ They enable transmission over a long distance using digital regencrator.

→ Digital Systems are more reliable system.

→ There is minimum electromagnetic interference in digital technology.

→ It is flexible compare to analog.

Disadvantage of Digital Signal transmission:

→ Digital system require greater bandwidth.

→ The detection of digital signal require the communication system to be synchronized.

→ Quantization error may occur during analog signal sampling.

→ Complex circuit is also drawbacks of digital system.

Data Communication Terminology:

→ The transmission mode define the direction of signal flow between two connected devices.

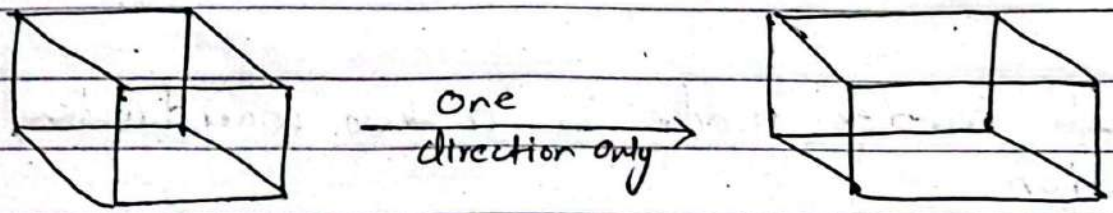
→ There are three types of transmission mode they are:

i) Simplex mode
ii) Half duplex mode
iii) Full duplex mode.

1) Simplex mode:

→ In simplex transmission, sender can send the data but sender cannot receive the data.

→ Hence, simplex mode is uni-directional communication.

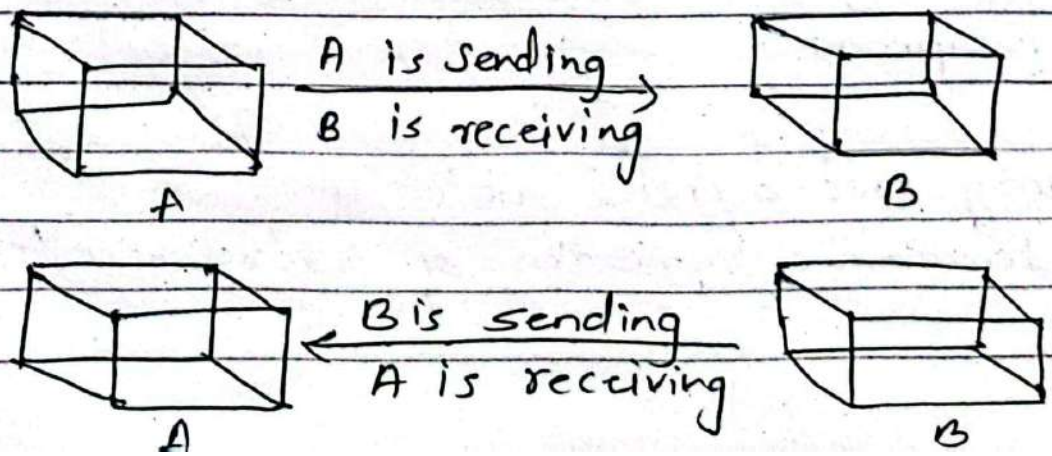


→ Example: FM station, keyboard, monitor.

11) Half duplex mode:

→ In half duplex mode, sender can send the data and also can receive the data but only one at a time.

→ Hence, half duplex is two way directional communicati but one at a time.

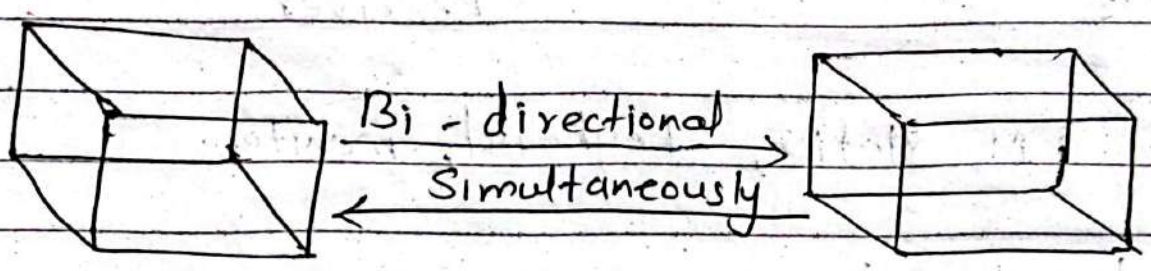


→ Example: Walkie Talkie.

(iii) Full duplex mode:

→ In full duplex mode, sender can send the data and also receive the data at the same time.

→ Hence, full duplex mode is a two way directional communication.



→ Example: Telephone

Standard Organization:

→ Several national and international agency play a strong role in establishing network standard that ensure a ground for communication and network equipment.

→ The key among this agencies are:

1) ISO (International Organization for Standardization):-

→ ~~Is a~~ ISO is ~~an~~ active in developing co-operation in the kingdom of scientific, technological and economic activity.

(i) Internation telecommunication Union (ITU)

→ This comittee was developed for research and establishment of Standard for telecommunication.

(ii) American Nodional Standard Institute (ANSI):

→ ANSI has set the standard for fibre distributed data interface.

→ It also focus on research.

(iv) Institute of electrical and electronics engineer (IEEE):

→ IEEE is the largest professional organization in the world.

→ It is involved in developing Standard for computing and communication.

(v) Electronic Industries Association (EIA):

→ EIA is responsible to develop network cabling standard.

→ It has played a significant contribution in the field of physical connection (wired) as well as electronic signaling (wireless) data communication.

✱ Application of Data Communication:

→

① Electronic Messaging:

→ The most widely used network application is electronic-mail (EMAIL).

→ With Email, it is possible to send a message to remote location.

② FAX:

→ A FAX machine create electronic equivalent of an image on a sheet of paper and then send the image over telephone line.

→ A FAX machine at the other end create the original paper image.

③ Teleconferencing:

→ It allows conference to occur without the participant being in the same place.

→ Teleconferencing ~~includes~~ 'includes':

a) Text conferencing, where participant communicate through their keyboard and computer monitor.

b) Voice conferencing, where participant ~~ha~~ at no. of locations communicate simultenously over

the phone.

c) Video conferencing: where, participant can see as well as talk to one another.

④. Information Service:
- It include data bank allowing free exchange of information.
- A world wide web is providing a free inform service.

⑤ Marketing and Sales:
→ computer network and data are used extensively in both marketing and sales organization.
→ Hence, data communication network have necessary part of business, industry and entertainment.

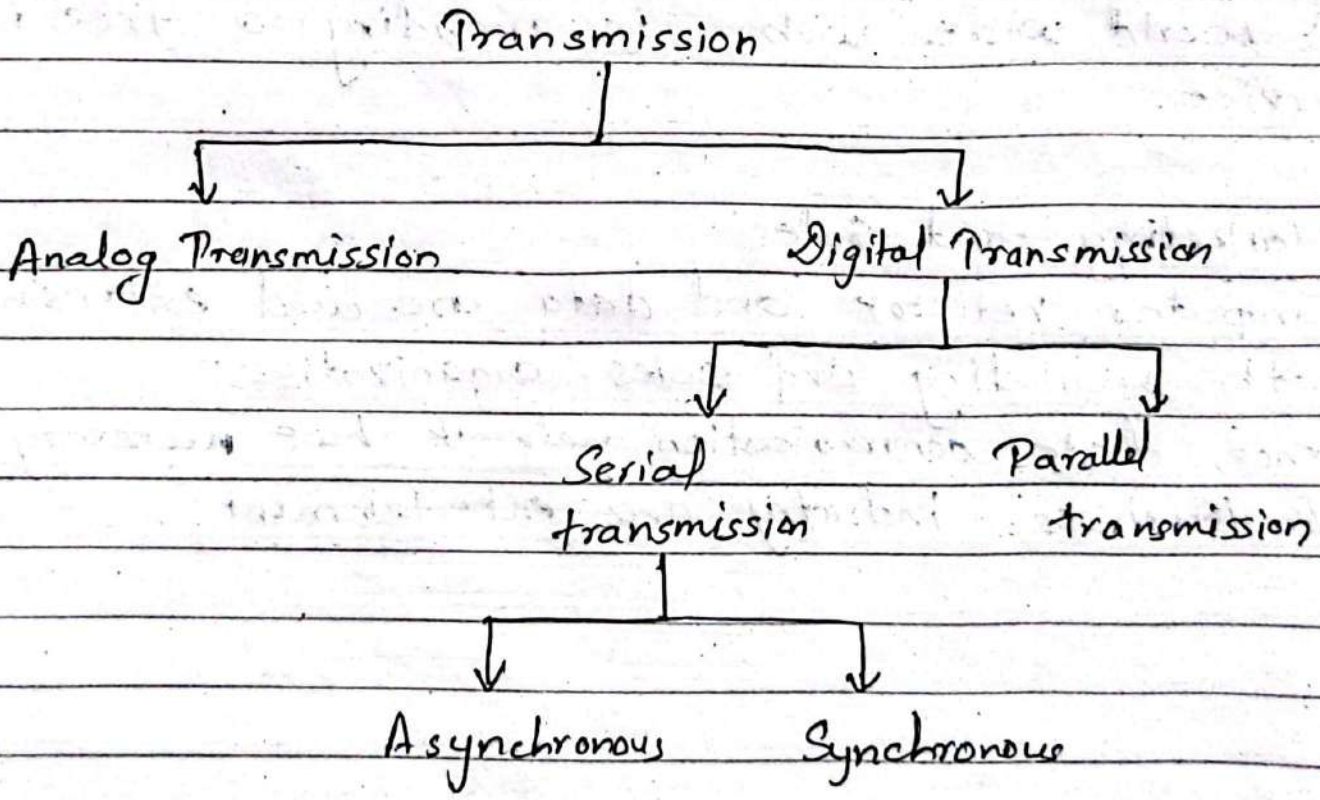
Chapter-2 Monica(L.E.C)

Data Transmission

※ Data Transmission:

→ The process of transmission data from sender to the receiver is called data transmission

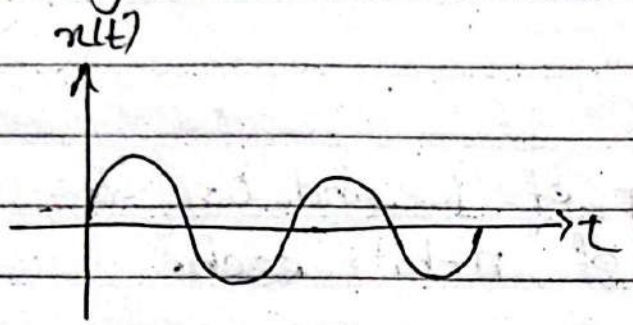
→ Transmission takes place by the propagation of a signal.



※ Analog transmission:

→ Analog signal is ~~is~~ one in which the signal intensity varies with respect to time.

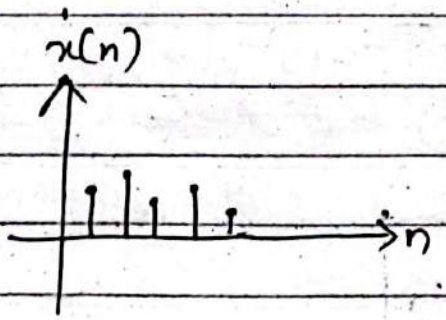
→ In other words, there are no breakes or discontunity in the signal.



⁂ Digital Transmission:

→ Digital signal is a wave that carries information in a binary form (i.e. 0 & 1).

→



→ A digital signal can be transmitted only a limited distance but to achieve greater distance, repeater are used.

→ A repeater receives the digital signal, recorer the pattern of 0's and 1's and retransmit a new signal.

→ Thus, attenuation (weak signal) is overcomed.

→ Again, digital transmission is divided into Serial and Parallel transmission.

A) Parallel Transmission:

→ Binary data consisting of 1's and 0's are organized into group of 'n'-bits each.

→ By grouping, n-bits data can be send at a time instead of 0.1.

→ The figure of parallel transmission is given below:

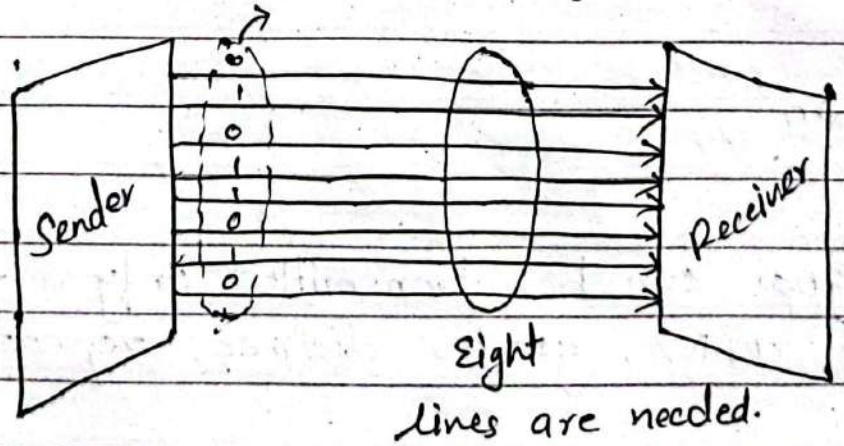


fig: Parallel transmission for n=8

→ n-wire are used to send n-bit at a time.

→ The advantage of parallel transmission is speed.

→ Parallel transmission can increase the transfer speed by factor n over serial transmission.

→ It is impractical for long distance transmission, since cost for large no. of line increases.

→ Hence, n-bits of data can be sent from sender to the receiver, in each clock pulse.

B) Serial transmission

→ In serial transmission, one bit follows another.

→ Hence, only one communication channel is needed rather then 'n' to transmit data between two communication device.

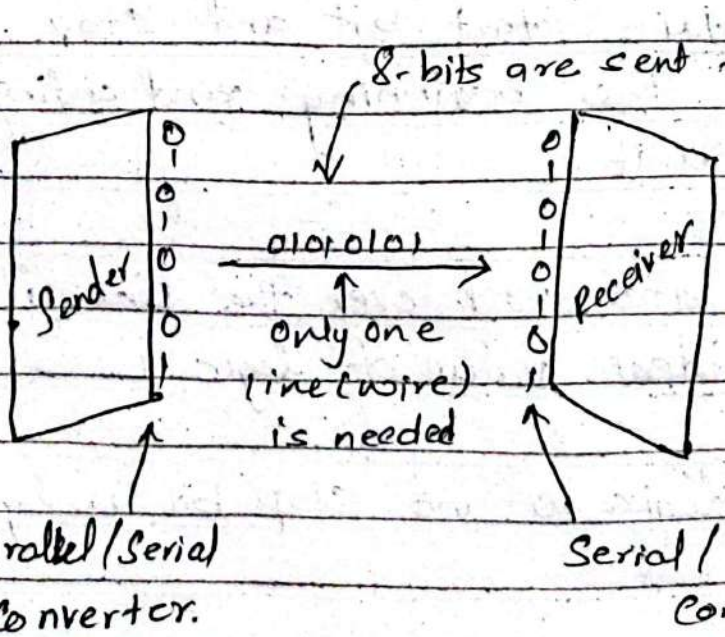


fig: Serial data transmission.

→ Parallel to serial converter is used to convert the incoming parallel data to serial form.

→ The advantage of serial communication over parallel communication is that only one communication channel data is transmitted and reduces the cost of transmission by factor n.

* Types of Serial Transmission:
i) Asychronous Serial data transfer.
ii) Synchronous " " "

i) Asynchronous Data transfer: (Text एडिटर active और्को अफ इन पति पाने

→ In asynchronous data transmission each data most contain start bit and stop bit indicationg the beginning and ending of each data unit.

→ When no data are send over the line, it is maintained ideal value of logic 1.

→ Start bit is logic 0 and stop bit is logic 1.

→ start and stop bit carries no information.

→ Both transmitter and receiver are given a seperate clock signal.

→ The asynchronous transmission is generally used in low speed transmission (less than 20 kb/s).

→ In this type of transmission, the receiving device does not need to be synchronized with a transmitting device.

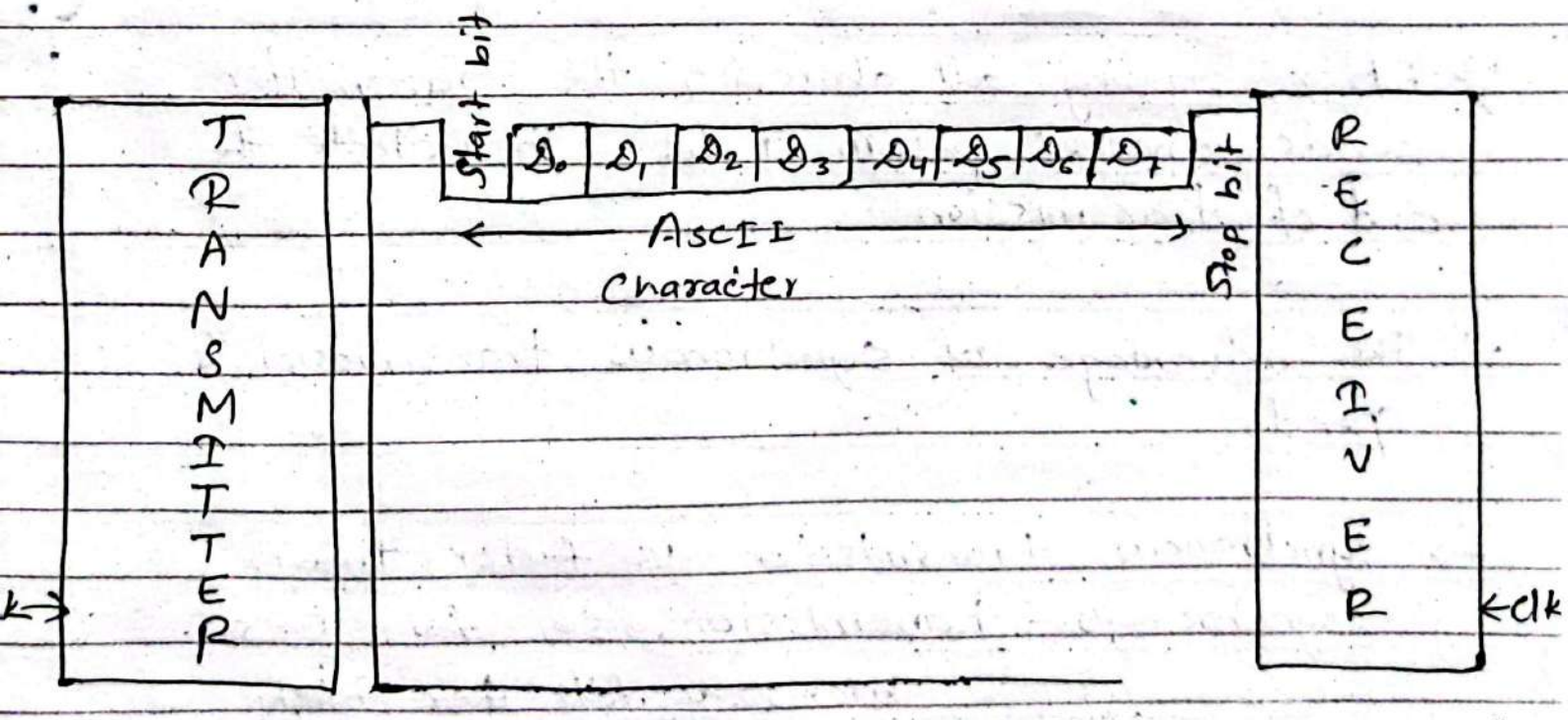


fig: Transmission formate for asynchronous transmission.

↗ phone call एकैचोटी काम गर्ने।

ii) Synchronous Transmission:

→ In synchronous trans^{s}, transmitter and receiver are synchronized by a master clock i.e. depend upon the same clock signal.

→ In this transmission, bits are send one after another without start / stop bit.

→ Usually synchronizing character (sync) are used to indicate the start of each synchronous data stream.

→ After sending all character, the transmitter sends another pattern of bit, to indicate the end of transmission.

→ The advantage of synchronous transmission is speed.

→ Synchronous transmission is faster then asynchronous transmission. so, for this reason it is more usefull for high speed application.

Q. Difference between asynchronous and synchronous data transmission.

Asynchronous D.T.	Synchronous D.T.
1) Data is sent in the form of byte or character.	1) Data is sent in the form of blocks or frames.
2) Asynchronous transmission is slow.	2) Fast.
3) Asynchronous transmission is economical.	3) Costly
4) Time interval of transmission is not constant, it is random.	4) Constant
5) Gap is present between the data.	5) No Gap
6) Start and stop bit are required for communication.	6) Synchronous (Sync) bit are required for the transmission.
7) low efficiency.	7) High Efficiency.

8) Asynchronous transmission are used in low speed transmission.

8) Synchronous trans^{s} are used in high speed transmission.

9) No need of synchronize clock.

9) clock needs to be synchronized.

** Efficiency in data transmission in asynchronous mode.

→ The efficiency to transmission is defined as the ratio of ~~total~~ no. of message bit to the total no. of ~~data bit~~ transmitted bit.

→ Mathematically.

$$\text{Efficiency} = \frac{\text{data bit}}{\text{Total bit}} \times 100\%$$

Q. On a transmission channel six hundred character message using ASCFI 7-bit code is used for synchronous data string, there are two synchronization character and single error detection character is used. In case of asynchronous data transmission, there is one start bit

Synchronous → efficiency ~~कम~~ ज्यादा
asynchronous → " ~~ज्यादा~~ कम

and one stop bit and a single error detection character is added. Calculate the efficiency of transmission in the help of two types of transmission mode.

Soln:

a) For synchronous mode of transmission.

→ Total no. of character transmitted

$= 600 + 2 + 1 = 603$ Character

(2 → synchronization character
1 → Error detection character)

$\Rightarrow 603 (603 \times 7)$ bits

$\Rightarrow 4221$ bits

But no. of bits carrying actual msg = 600 ch.

$= (600 \times 7)$ bits

$= 4200$ bits.

Therefore;

$$\text{Efficiency} = \frac{\text{data bits}}{\text{Total bits}} \times 100\%$$

$$= \frac{4221}{4200} \times 100\%$$

$$= 99.5\%$$

b) For asynchronous mode of transmission,

→ For every character in this mode there is start and stop bit.

→ So for each character it is need to send

$= 7 + 1 + 1$

$= 9$ bits

(1 → start bit , 1 → stop bit)

→ Hence the total no. of character to be send

$= 600 + 1$

↳ Error detection character.

$\Rightarrow$ 601 character $\Rightarrow (601 \times 9)$ bits

$\Rightarrow$ 5409 bits

But no. of bits carrying actual message

$= (600 * 7)$

$= 4200$

Efficiency

$= \frac{4200}{5409} \times 100\%$

$= 77.65\%$

Hence, efficiency of synchronous serial communication is better than asynchronous serial communication.

✱ Line configuration:

→ The way two or more communication devices at to a link is reffered as line configuration.

→ The two forms of line configuration are:
a) Point to point line configuration
b) Multi-point line configuration.

a) Point to point connection
→ A dedicated link is provided by point to point configuration betⁿ two devices.
→ It is simple to set up and connect it through cable or wires. Also the link through the satellite or microwave is possible.
→ The entire capacity of the link is reserved for transmission betⁿ those two devices.

→ Examples: (1) point to point connection betⁿ remote and television.
2) Computer connected by telephone.

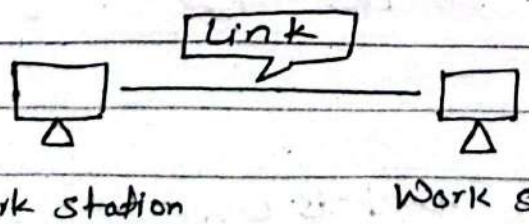
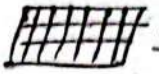


fig a): point to point wired connection



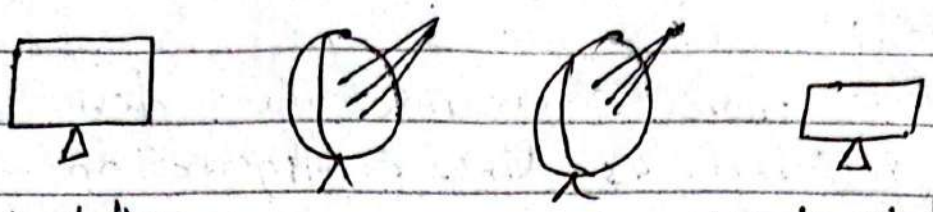


fig (b): Point to point wireless connection.

b) Multi-point line configuration.

→ In this connection, more than two computer are connected through a single link.

→ It is also called multi drop configuration.

→ There are two types of multi-paint connection -

→ If the links are used simultaneously bet^n many devices, it is reffered to as shared line configuration.

→ If the user takes turns while using the link, then it is reffered to as time shared line configuration.

→ Hence, it allows broadcasting packets over the network & also each device is able to communicate

with each other.

→ Example:
A radio station, video conference.

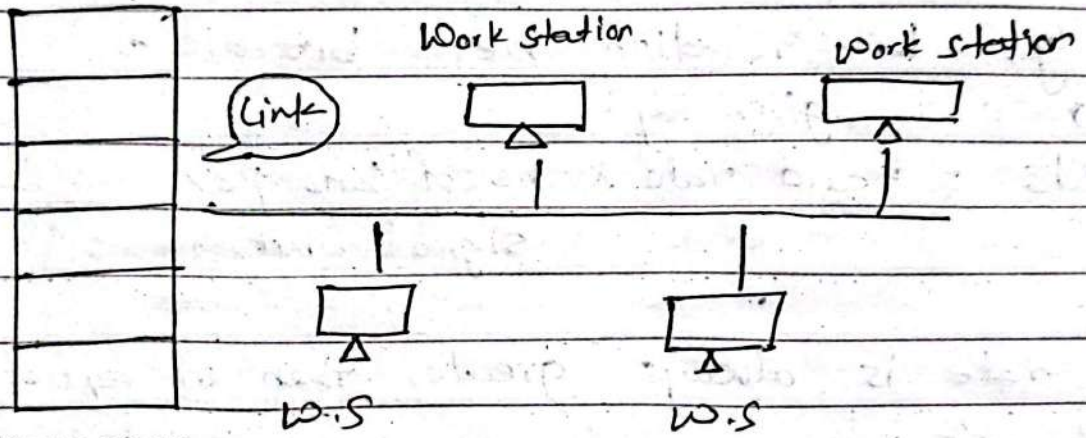


fig: Multi-point line conf^{n}.

Bit rate
→ The mast basic digital symbal used to represent information in the binary digit or bit.
→ Hence bit rate is the number of bits transmitted in one second.
→ It is expressed in bits per second (bps).

** Baud Rate:

→ Baud Rate is the no. of signal per second

→ Signal unit is able to represent one or more bit.

→ It is expressed in Bauds per second.

Mathematically, bit relation bet^n bit rate & baud rate is given by:

bit rate = baud rate x no. of bits per signal unit.

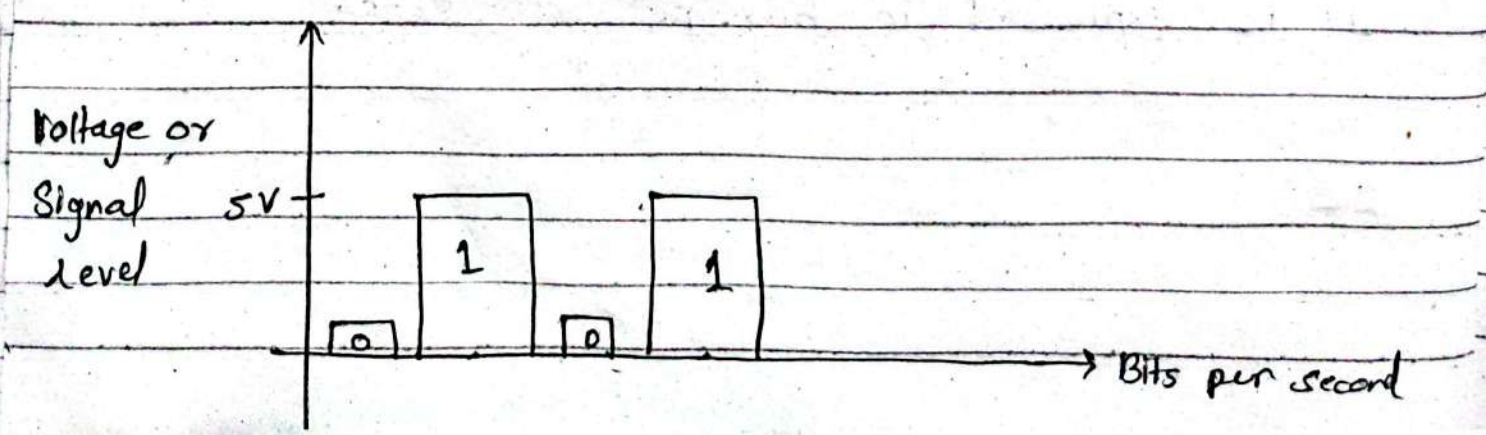
→ Hence, bit rate is always greater then or equal to baud rate.

i.e. bit rate $\geq$ baud rate

eg:

Let us consider a wave-form where two different level are used to represent the data.

2 level = $\begin{bmatrix} 0 \\ 1 \end{bmatrix}$ [Each level is represented by 0 or 1]



→ Assume 9600 bits are transmitting then;
bit rate = 9600 bits/second.

→ then by formula:

bit rate = baud rate × no. of bits per signal unit

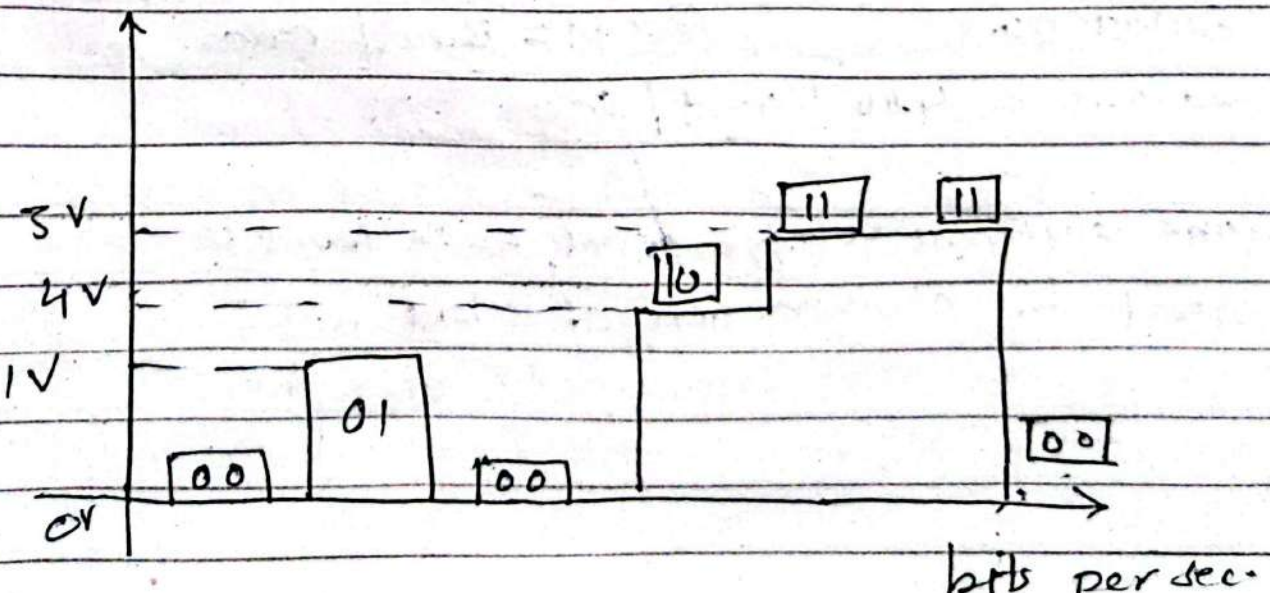
9600 = Baud rate × 1

∴ Baud rate = 9600 baud/sec

→ Hence it may be noted that for two level signal, the bit rate and baud rate are same.

Q^n Let us consider waveform where four different levels are used to represent the data.

4 level = $\begin{bmatrix} 0 & 0 \\ 0 & 1 \\ 1 & 0 \\ 1 & 1 \end{bmatrix}$ Each level is represented by a combination of two bits.



→ Assume 9600 bits are transmitting then;
bit rate = 9600 bits/second.

→ then by formula:
Bit rate = Baud rate x no. of bits per signal unit.

9600 = Band rate x 2

∴ Baud rate = 4800 baud/sec

→ Hence it may be noted that for four level signals, Bit rate and baud rate are different. This illustrates that Baud rate can be lower than the bit rate.

2 level theorem

Q) If system sends a signal that can assume 8 different voltage level. It sends 400 of these signals per second. what are the Baud rate and bit rate.

Note:- unit signals per second = Baud rate.

→ Solution:-

Baud rate = 400 baud/sec.

for eight different voltage level each level is represented by combination of 3 bit.

8-level =

0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

Now,

Bit rate = Baud rate * no. of bits per signal unit.

Bit rate = 400 * 3

= 1200 bits per sec

Transmission.

→

* Channel Capacity :

→ To represent the max. amount of information that can be transmitted by a channel per second.

* Noisy channel : (Shannon Capacity) :

→ In information theory, the shannon hartley theorem tells the max. rate at which the information can be transmitted over a communication channel of a specified band width in

the presence of noise.

→ Hence, shannon theorem states that "the channel capacity is given by $C = B\log_2\left(1+\frac{S}{N}\right)$".

where,

C = Channel capacity in bits per second.

B = Bandwidth of the channel in hertz (Hz).

S = Total received signal power measured in watt.

N = Total noise or interference power measured in watt.

→ The signal to noise ratio (S/N) is usually expressed in decibel (dB) and is given by;

$$SNR_{dB} = 10\log_{10}\frac{\text{Signal Power (S)}}{\text{Noise power (N)}}$$

Q^n: Find the capacity of a telephone channel with the bandwidth of 3000Hz and signal to noise ratio of 39 dB.

Soln:

Given,

Bandwidth (B) = 3000Hz

SNR = 39dB

Channel Capacity $C = ?$

Now,

$$C = B \log_2\left(1 + \frac{S}{N}\right)$$

Also,

$$SNR_{dB} = 10 \log_{10} \frac{S}{N}$$

$$39 = 10 \log_{10} \frac{S}{N}$$

or, $3.9 = \log_{10} \frac{S}{N}$

or, $\frac{S}{N} = 10^{3.9} = 7943.28$

Now,

$$C = B \log_2\left(1 + \frac{S}{N}\right)$$

$$= 3000 \log_2 (1 + 7943.28)$$

$$= 3000 \log_2 (7944.28)$$

$$= 38867.10 \text{ bits per sec}$$

Q: The spectrum of a channel is between 3 MHz to 4 MHz and the SNR is 24 decibel. (24 dB). Calculate the maximum channel capacity.

→ Soln:

Bandwidth $= (f_2 - f_1)$

$= (4 - 3)$ MHz

$= 1$ MHz $= 1 \times 10^6$ Hz

$SNR = 24\,dB$

Now,

$$SNR_{dB} = B\log_2\left(\frac{S}{N}+1\right)$$

or, $24 = 1\times10^6 \log_2\left(1+\frac{S}{N}\right)$

or, $2.4\times10^{-5} = \log_2\left(1+\frac{S}{N}\right)$

$$SNR_{dB} = 10\log_{10}\left(\frac{S}{N}\right)$$

$$24 = 10\log_{10}\left(\frac{S}{N}\right)$$

$$2.4 = \log_{10}\left(\frac{S}{N}\right)$$

$$251.18 = \frac{S}{N}$$

Again,

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

$$= 1\times10^6 \log_2\left(1+\frac{S}{N}\right)$$

$$= 1\times10^6 \log_2 (1+251.18)$$

$$= 1\times10^6 \log_2 252.18$$

$$= 7978310.052 \text{ bits/s}$$

3. Consider an additive white Gaussian noise channel (AWGN) with 4kHz bandwidth and the noise power spectral density $\frac{\eta}{2} = 10^{-12}$ w/Hz. The signal power required at the receiver is 0.1mW. Calculate the capacity of this channel.

→ Soln:

Given,

Bandwidth (B) = 4kHz = 4000 Hz

$S = 0.1$ ~~MW~~ mw $= 0.1 \times 10^{-3}$ W

$\frac{\eta}{2} = 10^{-12}$ w/Hz.

We know,

$N = \eta B$ → Formula

$= 2 \times 10^{-12} \times 4000$

$= 8 \times 10^{-9}$ W

$$C = B \log_{10}\left(1 + \frac{S}{N}\right)$$

$$= 4000 \log_{10}\left(1 + \frac{0.1 \times 10^{-3}}{8 \times 10^{-9}}\right)$$

$= 5.4 \times 10^4$ bits/sec

Q. Determine the maximum bit rate for a channel having bandwidth equal to 1600 Hz if (S/N) ratio is 0 dB.

Soln:

Bandwidth (B) = 1600 Hz

$S/N = 0\ dB$

Now,

$$SNR_{dB} = 10 \log_{10} \frac{S}{N}$$

$$0 = 10 \log_{10} \frac{S}{N}$$

$$0 = \log_{10} \frac{S}{N}$$

$$\frac{S}{N} = 10^0 = 1$$

Again,

$$C = B \log_2 \left(1 + \frac{S}{N}\right)$$

$$= 1600 \log_2 (1 + 1)$$

$$= 1600 \text{ bits per sec}$$

Formula: Bitrate = 2x bandwidth x $\log_2 L$

where L ⇒ no. of signal level used to represent the data.

2. Consider a noiseless channel with a bandwidth of 3kHz transmitting data with two signal. Calculate bit rate.

soln:

Given,

B.W = 3kHz = 3000 Hz

L = 2

bit rate = ?

Now,

Bit rate = $2 \times B.W \times \log_2 L$

$= 2 \times 3000 \times \log_2 2$

$= 6000$ bits/sec.

n: The bandwidth of data channel is 2MHz and its signal to noise ratio is 63. Determined the appropriate bit rate and signal level.

soln:

Given,

B.W = 2MHz = 2×10^6 Hz

SNR = 63

bit rate = ?

signal level (Channel capacity) (L) = ?

Now,

Bit rate = $2 \times 2 \times 10^6 \times \log_2 L$

Bit rate = $2 \times B.W \times \log_2 L$

$C = B \log_2 \left(1 + \frac{S}{N}\right)$

$= 2 \times 10^6 \log_2 (1 + 63)$

$= 12000000$ bits per second

✻ RS-232C

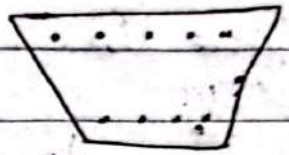


Fig: DB-9P connector.

→ It is used for serial communication.

→ RS-232C works in negative logic.

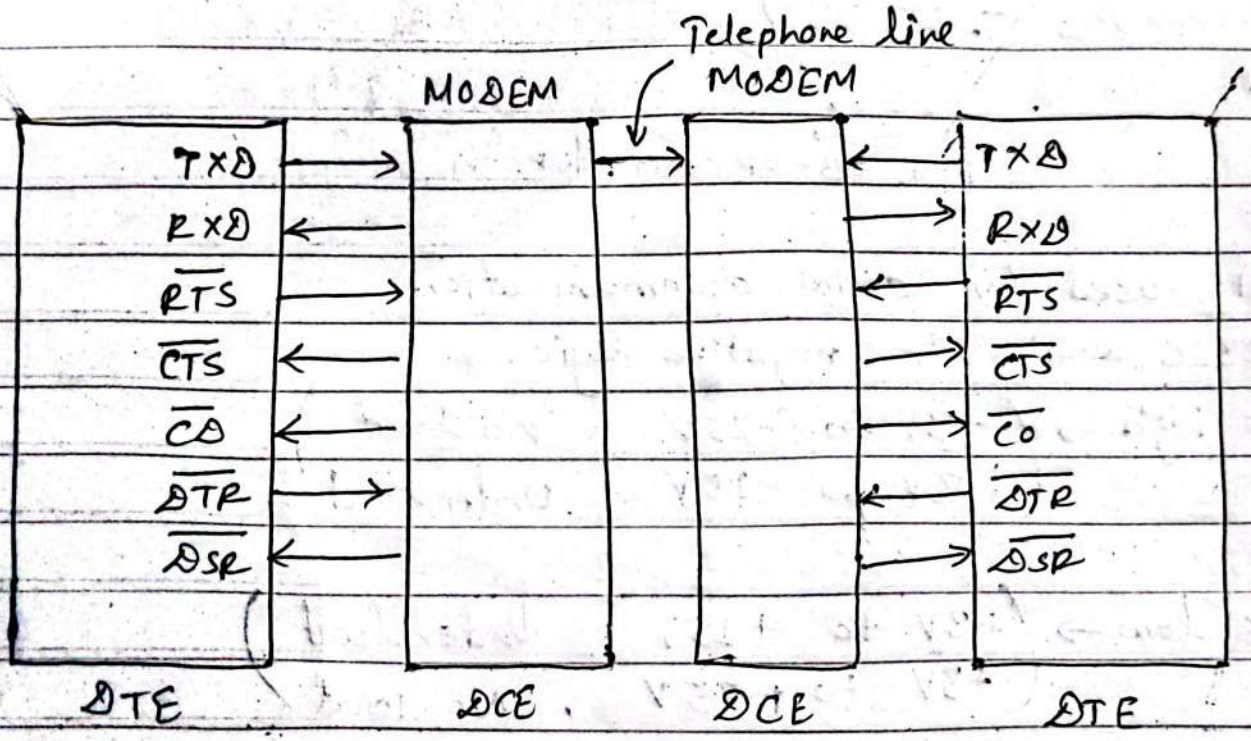
logic high → (-3V to -25V no load; -3V to -15V under load)

logic low → (+3V to +15V under load; +3V to +25V, No-load)

Pin no	Pin	Description
1	$\overline{DCD}$	Data carrier Detect.
2	RXD	Receive data
3	TXD	Transmitted data
4	$\overline{DTR}$	Data terminal ready
5	GND	Signal ground
6	$\overline{DSR}$	Data set ready
7	$\overline{RTS}$	Request to send
8	$\overline{CTS}$	clear to send
9	RI	Ring indicator.

Table ~~fig~~: Pin description for DB-9P connector.

Data-transmission and Reception of RS-232 C.



Chapter-3 Signals and System

Signals!

⇒ A signal may be function of time, temp^r, position, distance, etc.

→ Thus, a function of one or more independent variable which contains some informations is called signal.

→ The signal can be one dimensional or multi-dimensional.

1. One Dimensional signal.

→ When a function depends upon a single variable, the signal is called as one dimensional signal.

→ The example of one dimensional signal is speech signal whose amplitude varies with time.
i.e.

example $x_1(t) = 10t$

$x_2(t) = 2t^2$

2. Multi Dimensional signal

→ When the function depends upon two or more variable, the signal is said to be multi-dimensional.

→ The example of multi-dimensional signal is image signal.

Example: $g(x,y) = 3xy + 2y^2$

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** Classification of signals:

→ Based upon nature on characteristics in time domain, the signal may be classified as

i) Continuous time signal (Analog)
ii) Discrete time signal (Digital)

i) Continuous time Signal ~~Discrete~~

→ Continuous Signal is continuously moving wave that changes over a time.

→ Continuous signal is represented by the sinc wave.

→ It is also called as analog signal.

→ It is described by amplitude, frequency & phase.

→ Continuous hardware is not flexible.

→

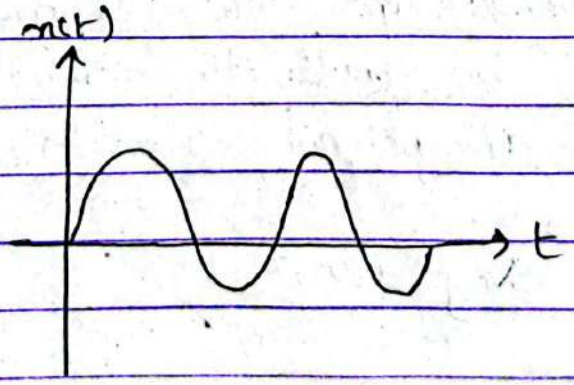


fig continuous time signal.

→ Analog circuit like opamp, amplifier, filter process continuous time signal.

ii) Discrete time signal:

→ Discrete time signal is discrete wave that carries information in binary forms.

→ Discrete signal is represented by the square wave.

→ Discrete signal is described by bit rate and bit interval.

→ It's hardware are flexible.

→ It is also known as Digital signal.

→ The circuits like microprocessor, counters, flip-flops works on discrete time signal.

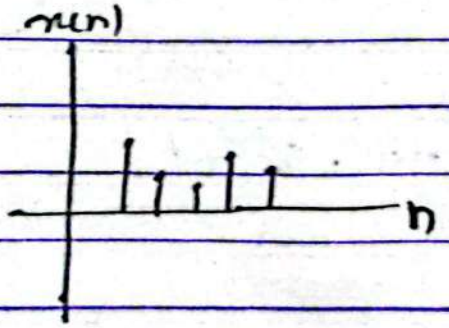


fig: Discrete time signal.

• Further, both continuous and discrete time signals are classified as deterministic and non-deterministic, periodic and non-periodic, even and odd, energy and power signal.

a) Deterministic Signal

→ It can be defined as the signal which pattern is regular and can be determined.

→ It can be completely represented by mathematical equation at any time.

→ The nature of signal can be predicted.
example: Sine wave, square wave, exponential wave, etc.

→ Let $x(t) = A\sin\omega t$, then this signal is represented as

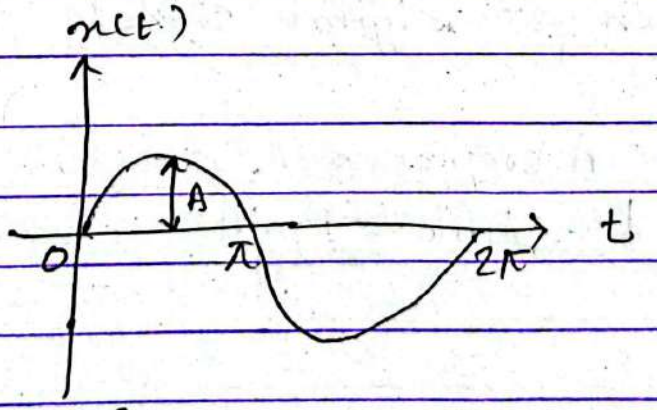


fig: Deterministic signal

b) Non-deterministic (random signal):

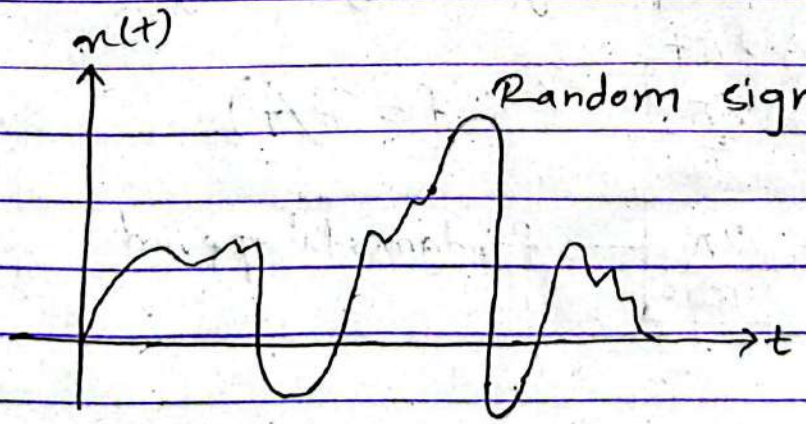
→ A signal which cannot be represented by any mathematical equation is called random signal.

→ It is a signal whoose occurrance is always random in nature.

→ The pattern of such signal is quite irregular

example: A typical example of non-deterministic signal is thermal noise generated in electric circuit, transmission channel cables, etc.

→



c) Periodic signal:

→ A signal which repeats itself after a fixed time period is called periodic signal.

→ Conditions for periodicity of continuous time signal is:

$$x(t) = x(t+T_0) \text{ for all } t$$

ie. for $-\infty < t < \infty$

where T_0 is called as the period of signal $x(t)$

→ example of periodic signal are sinewave, cosine wave, etc.

→ The reciprocal of fundamental period is called fundamental frequency.

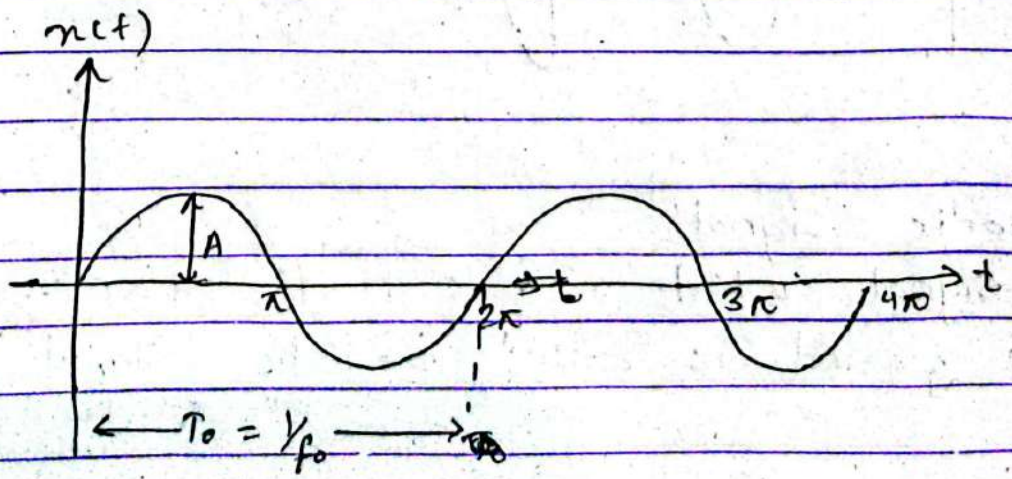
$$f = \frac{1}{T}$$

→ The angular frequency is given by:

$$\omega = 2\pi f$$

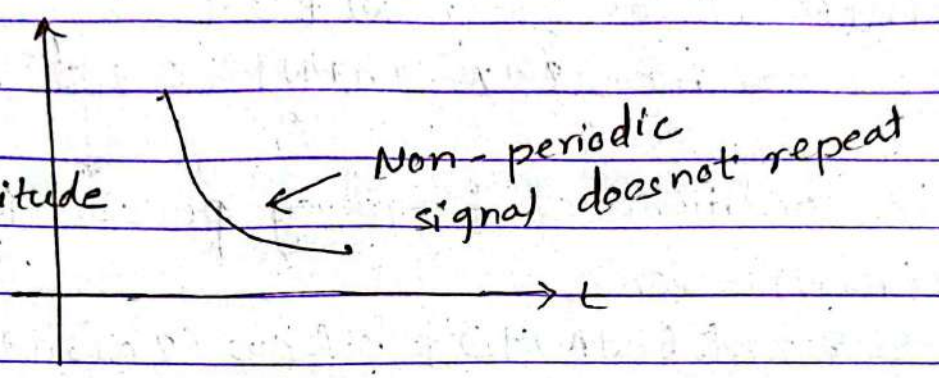
$$\omega = \frac{2\pi}{T} \quad (\because f = 1/T)$$

$$\boxed{T = \frac{2\pi}{\omega}} \rightarrow \text{fundamental period.}$$



rational = ratio of two integer.

d) Non-periodic signal



→ A signal which doesnot repeat itself after a fixed time period is called as non-periodic or aperiodic signal.

→ Hence, it doesnot satisfy the condition of periodicity.

→ ⓚ Condition of periodicity of discrete time signal:

→ A discrete time sinusodial signal is periodic only if its frequency 'fo' is rational.
i.e. The freq" 'fo' should be in the form of ratio of two integers.

→ Forward a discrete time signal, the condition of periodicity is given by:

$x(n) = x(n+N), \quad -\infty < n < \infty$ for all integer n

where N is the fundamental time period.

→ Let x(n) be the cosine wave and it can be expressed as

$$x(n) = A\cos(\omega n + \theta)$$

where A = Amplitude $\quad \theta$ = phase shift.

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Note:-
$\omega = 2\pi f$ — *
$f = 1/T$ — *

Now,

$$x(n+N) = A\cos\{\omega(n+N) + \theta\}$$
$$= A\cos\{2\pi f_0(n+N) + \theta\}$$

Acc. to conditions of ~~frequency~~ periodicity.

$$x(n+N) = x(n)$$

or, $A\cos\{2\pi f_0(n+N)+\theta\} = A\cos(2\pi f_0 n + \theta)$

or, $A\cos[2\pi f_0 n + 2\pi f_0 N + \theta] = A\cos(2\pi f_0 n + \theta)$

To satisfy the eqn, $2\pi f_0 N$ is integer multiple of 2π.

$\therefore$ $2\pi f_0 n + 2\pi f_0 N + \theta = 2\pi f_0 n + \theta$

Now,

Acc. to condition,

$$2\pi f_0 N = 2\pi k$$

where k is the integer and relatively prime and N is also an integer.

$$\boxed{f_0' = \frac{k}{N}}$$

~~Numerical~~

(*) Periodicity condition for $x(n) = x_1(n) + x_2(n)$

→

Let $x_1(n)$ and $x_2(n)$ be the both periodic discrete time signal. Acc. to condition of periodicity

$f_1 = \frac{k_1}{N_1}$ and $f_2 = \frac{k_2}{N_2}$

→ The resultant signal x_n is periodic if $\frac{N_1}{N_2}$ is ratio of two integers.

→ The period of x_n will be L.C.M of N_1 and N_2.

Similarly,

→ If continuous time signal $x(t) = x_1(t) + x_2(t)$ then the resultant signal $x(t)$ is periodic if $\frac{T_1}{T_2}$ is ratio of two integers.

→ The fundamental period of $x(t)$ will be L.C.M of T_1 and T_2.

Q.n. Determine wheather the signals are periodic or not?

i) $\cos(0.01\pi n)$

→ Comparing with $\cos(\omega n) = \cos(2\pi f n)$

where,

$$\omega = 0.01\pi$$

or, $2\pi f = 0.01\pi$

$$f = \frac{0.01}{2} = \frac{1}{200} = \frac{k}{N}$$

→ Here, f is expressed in ratio of two integers with $k=1$ and $N=200$.

→ Hence, the signal is periodic with fundamental period $N=200$.

ii) $x(n) = \cos 3\pi n$

→ Comparing with $\cos(3\pi n) = \cos(\omega n)$

where,

$$\omega = 3\pi$$

$$2\pi f = 3\pi$$

$$f = \frac{3}{2} = \frac{k}{N}$$

→ Here, f is expressed in ratio of two integers with $k=3$ and $N=2$.

→ Hence, the signal is periodic with fundamental period $N=2$.

iii) $x(n) = \sin 3n$

→ Comparing with $\sin(\omega n) = \sin 3n$

where,

$$\omega = 3$$

$$2\pi f = 3$$

$$f = \frac{3}{2\pi} = \frac{3}{2 \times 3.14}$$

where,

$$k = 3$$

$$N = 2\pi$$

→ Hence, the signal ~~periodic~~ is non-periodic bcz ratio of $\frac{k}{N}$ is not integer.

iv) $x(n) = \cos\frac{2\pi n}{5} + \cos\frac{2\pi n}{7}$

→ Comparing the eqn with $\cos(\omega_1 n) + \cos(\omega_2 n)$

$$\omega_1 = 2\pi/5 \qquad \omega_2 = \frac{2\pi}{7}$$

$$2\pi f_1 = \frac{2\pi}{5} \qquad 2\pi f_2 = \frac{2\pi}{7}$$

$$f_1 = \frac{2\cancel{\pi}\,1}{\cancel{2\pi}\,5} \qquad f_2 = \frac{\cancel{2\pi}\,1}{\cancel{2\pi}\,7}$$

$$f_1 = \frac{k_1}{N_1} = \frac{1}{5} \qquad f_2 = \frac{k_2}{N_2} = \frac{1}{7}$$

→ Hence, it is the ratio of two integers the signal is periodic.

→ The fundamental period is the L.C.M of N_1 and N_2

L.C.M = 5 * 7 = 35 is the fundamental period

(v) $x_n = \cos\left(\frac{n}{8}\right) \cos\left(\frac{n\pi}{8}\right)$

→ Soln:

Comparing the eqn with $\cos(\omega_1 n) * \cos(\omega_2 n)$

$\omega_1 = \frac{1}{8}$ $\omega_2 = \frac{\pi}{8}$

$2\pi f_1 = \frac{1}{8}$ $2\pi f_2 = \frac{\pi}{8}$

$f_1 = \frac{1}{8 \times 2\pi}$ periodic $f_2 = \frac{1}{16}$

non-periodic $f_1 = \frac{1}{16\pi}$

→ Hence, periodic * non-periodic = non-periodic.

vi) $x(n) = \sin(\pi + 0.2n)$

Comparing with $\sin(\omega n + \theta)$

$\theta = \pi$ (phase shift)

$\omega = 0.2$

$2\pi f = 0.2$

$f = \frac{0.2}{2\pi}$

$f = \frac{1}{10\pi}$ is not ratio of two integer Hence, the signal is non-periodic.

vii) $x(n) = e^{(j\pi/4)n}$.

Comparing with $e^{(j\pi/4)n} = e^{(j\omega)n}$

$\pi/4 = \omega$,

$\omega = \frac{\pi}{4}$

$2\pi f = \frac{\pi}{4}$

$f = \frac{1}{8}$

Note: If $x(n)$ then discrete value.
$x(t)$ then continuous

Qn: $x(t) = \cos t + \sin \sqrt{2}\, t$

→ Comparing with

$x(t) = \cos \omega_1 t + \sin \omega_2 t$

$\omega_1 = 1$ $\qquad$ $\omega_2 = \sqrt{2}$

$2\pi f_1 = 1$ $\qquad$ $2\pi f_2 = \sqrt{2}$

$f_1 = \frac{1}{2\pi}$ $\qquad$ $f_2 = \frac{\sqrt{2}}{2\pi}$

$f_2 = \frac{1}{\sqrt{2}\pi}$

Now,

$T_1 = \frac{1}{f_1} = 2\pi$

$T_2 = \frac{1}{f_2} = \sqrt{2}\pi$

Since, $\frac{T_1}{T_2} = \frac{2\pi}{\sqrt{2}\pi} = \sqrt{2}$ is not the ratio of two integer so the signal is non-periodic.

Q: $x(t) = 2\cos 100\pi t + 5 \sin 5t$

comparring with

$x(t) = A\cos \omega_1 t + A \sin \omega_2 t$

$\omega_1 = 100\pi$ $\qquad$ $\omega_2 = 50$

$2\pi f_1 = 100\pi$ $\qquad$ $2\pi f_2 = 50$

$f_1 = 50$ $\qquad$ $f_2 = \frac{25}{\pi}$

$T_1 = \frac{1}{f_1} = \frac{1}{50}$

$$T_2 = \frac{1}{f_2} = \frac{\pi}{25}$$

Hence;

$$\frac{T_1}{T_2} = \frac{1/50}{\pi/25} = \frac{1}{50} \times \frac{25}{\pi} = \frac{1}{2\pi}$$

it is Non-periodic.

Q. $x(t) = \cos 100\pi t + \sin 50\pi t$

→

$\omega_1 = 100\pi$ $\omega_2 = 50\pi$

$2\pi f_1 = 100\pi$ $2\pi f_2 = 50\pi$

$f_1 = 50$ $f_2 = 25$

$T_1 = 1/f_1$ $T_2 = 1/f_2$

$= 1/50$ $T_2 = 1/25$

Hence,

$$\frac{T_1}{T_2} = \frac{1/50}{1/25} = \frac{1}{2}$$

Hence, it is periodic. and for the period, take the L.C.M of T_1 and T_2. ~~will be~~ $\frac{1}{2F}$

Then, we get.

$$L.C.M = \frac{1}{25}$$

Formula:

$\cos 3x = 4\cos^3 x - 3\cos x$

Q. $x(t) = \cos^3 t$

Now,

$$\cos^3 x = \frac{\cos 3x + 3\cos x}{4}$$

$$\cos^3 x = \frac{1}{4}\cos 3x + \frac{3}{4}\cos x$$

$\omega_1 = 3$ $\qquad$ $\omega_2 = 1$

$2\pi f_1 = \frac{3}{2\pi}$ $\qquad$ $f_2 = \frac{1}{2\pi}$

$T_1 = \frac{2\pi}{3}$ $\qquad$ $T_2 = 2\pi$

$\frac{T_1}{T_2} = \frac{2\pi}{3} \times \frac{1}{2\pi} = \frac{1}{3}$ is

Hence, it is periodic.

Now,

fundamental period

e) Even and odd signal:

→ A signal $x(t)$ is said to be symmetrical or even if it satisfies the following conditions.

- Condition for even signal: $x(t) = x(-t)$

$x(n) = x(-n)$

example of even signal is cosine wave

i.e. $\cos\theta = \cos(-\theta)$

→ A signal $x(t)$ is said to be anti-symmetrical or odd if it satisfies the following conditions.

Condition for anti-symmetry:-

$x(t) = -x(t)$

$x(n) = -x(-n)$

example of odd signal is sine wave i.e.

$\sin\theta = -\sin(-\theta)$.

Decomposition of signal into odd and even components.

→ Let the signal is represented into its odd and even parts.

$$x(t) = x_e(t) + x_o(t) \quad \text{---(i)}$$

where,

$x_e(t)$ = even components of signal.

$x_o(t)$ = odd components of signal.

Substituting $t = -t$ in eq^n (i)

$$x(-t) = x_e(-t) + x_o(-t) \quad \text{---} \quad \text{(ii)}$$

by defination;

$$x_e(-t) = x_e(t)$$

$$x_o(-t) = -x_o(t)$$

Now,

eq^n (ii) becomes.

$$x(-t) = x_e(t) + \{-x_o(t)\} \quad \text{---} \quad \text{(iii)}$$

even — On adding eq^n (i) & (iii)

$$x(t) + x(-t) = x_e(t) + x_o(t) + x_e(t) - x_o(t)$$

or, $$\boxed{x_e(t) = \frac{1}{2}\{x(t) + x(-t)\}} \quad (*)$$

odd. Similarly,

odd. On subtracting eq^n (i) and (iii)

$$x(t) - x(-t) = x_e(t) + x_o(t) - x_e(t) + x_o(t)$$

or, $$\boxed{x_o(t) = \frac{1}{2}\{x(t) - x(-t)\}} \quad (*)(*)$$

1Q. Find the even and odd components of the following signal.

→

$x(t) = 1 + t + 3t^2 + 5t^3 + 9t^4$.

We know that,

$x_e(t) = \frac{1}{2}\{x(t) + x(-t)\}$ (formula).

$x(-t) = 1 + (-t) + 3(-t)^2 + 5(-t)^3 + 9(-t)^4$.

$= 1 - t + 3t^2 - 5t^3 + 9t^4$

Now,

i) $x_e(t) = \frac{1}{2}\{(1 + t + 3t^2 + 5t^3 + 9t^4) + (1 - t + 3t^2 - 5t^3 + 9t^4)\}$

$= 1 + 3t^2 + 9t^4$.

ii) $x_o(t) = \frac{1}{2}\{x(t) - x(-t)\}$

$= \frac{1}{2}\{(1 + t + 3t^2 + 5t^3 + 9t^4) - (1 - t + 3t^2 - 5t^3 + 9t^4)$

$= t + 5t^3$

Q. $x(t) = (1 + t^3)\cos(10t)$

Soln:

$x(t) = (1 + t^3)\cos(10t)$

$x(-t) = (1 + (-t)^3)\cos\{10(-t)\}$ $\quad \because \cos(-\theta) = \cos\theta$

$\therefore x(-t) = (1 - t^3)\cos(10t)$

i) $x_e(t) = \frac{1}{2}\{x(t) + x(-t)\}$

$= \cos(10t)$

ii) $x_o(t) = \frac{1}{2}\{x(t) - x(-t)\}$

$= t^3 \cos(10t)$

Q. $x(t) = e^{jt}$

→

$x(t) = e^{jt}$

$x(-t) = e^{j(-t)} = e^{-jt}$

i) $x_e(t) = \frac{1}{2}\{x(t) + x(-t)\}$

$= \frac{1}{2}\{e^{jt} + e^{-jt}\}$ $\quad \therefore \frac{1}{2}\{e^{jt} + e^{-jt}\} = \cos t$ formula.

$= \cos t$

ii) $x_o(t) = \frac{1}{2}\{x(t) - x(-t)\}$

$= \frac{1}{2j}\{e^{jt} - e^{-jt}\} * j$

$\Rightarrow \therefore \frac{1}{2j}\{e^{jt} - e^{-jt}\} = \sin t$ formula

$= j \sin t$

f) Energy and power signal

→ Energy signal is one which have finite energy and zero average power.

Hence $x(t)$ is an energy signal if

~~$0 < E < \infty$ and $P = 0$~~

$0 < E < \infty$ aand $P = 0$

where,

E = Energy

P = Power of signal $x(t)$

→ The power signal is one which has finite average power and infinite energy.

Hence,

$x(t)$ is a power signal if

$0 < p < \infty$ and $E = \infty$

where;

E = Energy

P = Power of signal $x(t)$.

→ If the signal does not satisfy any of the above conditions then it is called as neither energy nor power signal.

✱ Energy of CT and DT signal.

→

$$\text{Energy } (E) = \int_{-\infty}^{\infty} |x(t)|^2 \, dt \quad \text{[for CT signal.]}$$

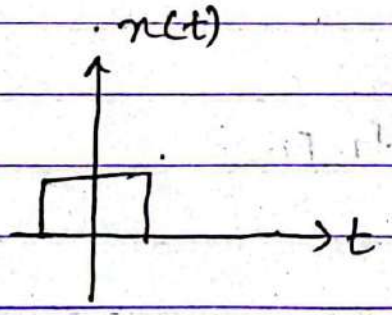
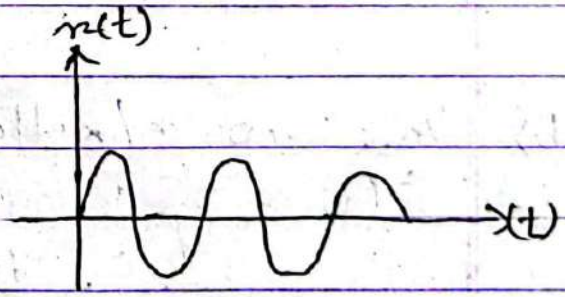
$$E = \sum_{n=-\infty}^{\infty} |x(n)|^2 \quad \text{[for DT signal.]}$$

✱ Power of CT and DT signal

→

$$\text{Power, } (P) = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 dt \text{ for CT signal}$$

$$P = \lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2 \text{ for DT signal.}$$

Energy Signal	Power Signal
1) $0 < E < \infty$ $E = \int_{-\infty}^{\infty} \lvert x(t) \rvert^2 dt$	1) $0 < P < \infty$ $P = \lim_{T \to \infty} \int_{-T/2}^{T/2} \lvert x(t) \rvert^2 dt$
2) Non-periodic signals are energy signal.	2) Practical periodic signals are power signal.
3) Power of the signal is zero.	3) Energy of the power signal is infinite.
4) 	4) 

Elementary Signals :

→ They are the basic, fundamental waveform used in signal processing and system analysis.

→ They serve as building blocks to represent more complex signals.

→ The some, common elementary signals are!

a) Unit Step signal

b) Unit Impulse / Delta / Direc. Delta Function

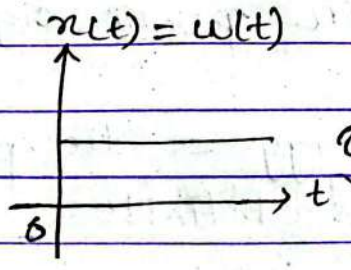
c) Signum function.

d) Unit Ramp function.

a) Unit step signal

→ $u(t) = 1$ for $t \geq 0$

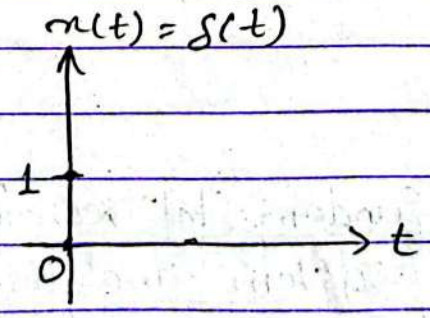
0 for $t < 0$



Continuous signal

b) Unit Impulse / Delta / Direc - Delta Fn.

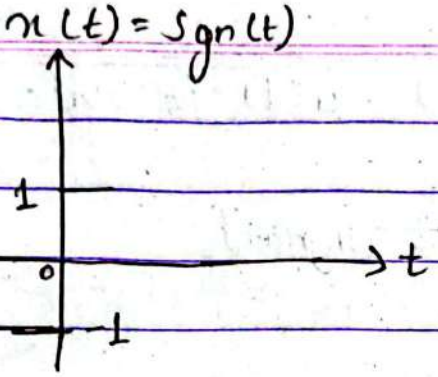
→ $\delta(t) = \begin{cases} 1 & \text{for } t = 0 \\ 0 & \text{for } t \neq 0 \end{cases}$



for continuous

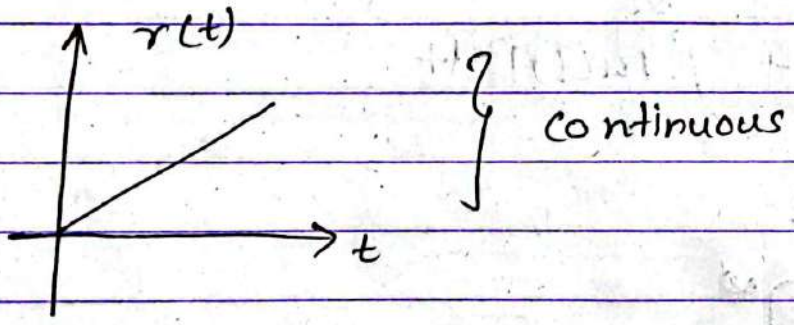
c) Signum function:

→ $\text{Sgn}(t) = \begin{cases} 1 & \text{for } t > 0 \\ -1 & \text{for } t < 0 \end{cases}$



d) Unit Ramp function :-

$$r(t) = \begin{cases} t & \text{for } t > 0 \\ 0 & \text{for } t < 0 \end{cases}$$



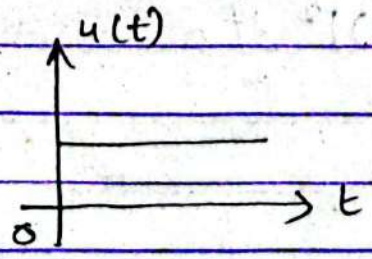
Imp

Q. Check wheather the signal x(t) is energy or power signal.

$x(t) = u(t)$

→ Hence, it is a unit step signal. and is defined by

$$u(t) = \begin{cases} 1 & \text{for } t \geq 0 \\ 0 & \text{for } t < 0 \end{cases}$$



i) Energy of signal $x(t) = u(t)$ is calcalated as:

$$E = \int_{-\infty}^{\infty} |x(t)|^2 \, dt \quad \text{[for signal]}$$

$$= \int_{-\infty}^{\infty} |u(t)|^2 \, dt$$

$$= \int_{-\infty}^{0} |u(t)|^2 \, dt + \int_{0}^{\infty} |u(t)|^2 \, dt$$

$$= 0 + \int_{0}^{\infty} |u(t)|^2 \, dt$$

$$= \int_{0}^{\infty} 1 \cdot dt$$

$$= [t]_{0}^{\infty}$$

$$= (\infty - 0)$$

$$= \infty$$

Hence energy $= \infty$

ii) Power of signal $x(t) = u(t)$

$$P = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 \, dt$$

$$P = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{0} |x(t)|^2 dt + \int_{0}^{T/2} |x(t)|^2 dt$$

$$= \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{0} |A(t)|^2 dt + \int_{0}^{T/2} |A(t)|^2 dt$$

$$= \lim_{T\to\infty} \frac{1}{T} \left[0 + \int_{0}^{T/2} 1\, dt \right]$$

$$= \lim_{T\to\infty} \frac{1}{T} [t]_0^{T/2}$$

$$= \lim_{T\to\infty} \frac{1}{T} \times \frac{T}{2}$$

$$= \frac{1}{2}$$

Hence, the power of the signal is finite and energy is infinite, so, the given signal is power signal.

Q. Compute the energy and power signal of the signal $x(t) = A\sin t$ for $-\infty < t < \infty$

Soln:

$\Rightarrow$

Formula: $\sin^2\theta = \frac{1-\cos 2\theta}{2}$

i) Energy of the signal $x(t) = A\sin(t)$

Soln:

$$E = \int_{-\infty}^{\infty} |x(t)|^2 \, dt$$

$$= \int_{-\infty}^{\infty} |A \sin t|^2 \, dt$$

$$= \int_{-\infty}^{\infty} A^2 \sin^2 t \, dt$$

$$= A^2 \int_{-\infty}^{\infty} \sin^2 t \, dt$$

$$= A^2 \int_{-\infty}^{\infty} \frac{1-\cos 2t}{2} \, dt.$$

$$= \frac{A^2}{2} \int_{-\infty}^{\infty} 1-\cos 2t \, dt.$$

$$= \frac{A^2}{2}\left[\int_{-\infty}^{\infty} 1 \, dt. - \int_{-\infty}^{\infty} \cos 2t \, dt.\right]$$

$$= \frac{A^2}{2}\left\{\left[t\right]_{-\infty}^{\infty} - \left[\frac{\sin 2t}{2}\right]_{-\infty}^{\infty}\right\}$$

$$= \frac{A^2}{2}(\infty - \infty)$$

$$= \frac{A^2}{2} \times \infty \qquad = \infty$$

i) Power signal

Soln:

$$P = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 dt.$$

$$= \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} |A\sin t|^2 dt.$$

$$= \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} A^2 \sin^2 t \, dt$$

$$= \lim_{T\to\infty} \frac{A^2}{T} \int_{-T/2}^{T/2} \sin^2 t \, dt$$

$$= \lim_{T\to\infty} \frac{A^2}{T} \int_{-T/2}^{T/2} \frac{1-\cos 2t}{2} dt.$$

$$= \lim_{T\to\infty} \frac{A^2}{2T} \int_{-T/2}^{T/2} 1-\cos 2t \, dt$$

$$= \lim_{T\to\infty} \frac{A^2}{2T} \left[\int_{-T/2}^{0} 1\,dt - \int_{0}^{T/2} \cos 2t \, dt \right]$$

$$= \lim_{T\to\infty} \frac{A^2}{2T} \left[[t]_{-T/2}^{0} - \left[\frac{\sin 2t}{2}\right]_{0}^{T/2} \right]$$

$$= \lim_{T\to\infty} \frac{A^2}{2T} \left[\frac{T}{2} - \left\{ \frac{\sin 2(T/2)}{2} - \frac{\sin 2\times 0}{2} \right\} \right]$$

$$P = \lim_{T\to\infty} \frac{A^2}{2T}\left[\frac{T}{2} - \frac{\sin T}{2}\right]$$

$$= \lim_{T\to\infty} \frac{A^2}{2T}\left[\frac{T}{2} - \frac{\sin T}{2}\right]$$

$$P = \lim_{T\to\infty} \frac{A^2}{2T} \times \frac{T}{2} - \lim_{T\to\infty} \frac{A^2}{2T} \times \frac{\sin T}{2}$$

$$= \frac{A^2}{4} - 0$$

$$P = \frac{A^2}{4}$$

Since power is finite and energy is infinite it is called as power signal.

Q^n. Check wheather the signal is energy or power signal.

$x(n) = u(n)$

Soln:

$u(n) = 1$ for $n \geq 0$

0 for $n < 0$

i) For energy signal.

$$E = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$E = \sum_{n=-\infty}^{0} |x(n)|^2 + \sum_{n=0}^{\infty} |x(n)|^2$$

$$E = \sum_{n=-\infty}^{0} |\alpha(n)|^2 + \sum_{n=0}^{\infty} |\beta(n)|^2$$

$$= 0 + \sum_{n=0}^{\infty} 1$$

$$= \frac{1}{1-r}$$

$$= \frac{1}{1-1}$$

$$= \infty$$

$\because S_\infty = \frac{a}{1-r}$

a = first term

r = common ratio

i.e. $r = \frac{2^{nd}\ term}{1^{st}\ term}$

ii) Power,

$$P = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |u(n)|^2$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=0}^{N} 1$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \times (N+1)$$

~~direct add~~

$\Rightarrow \sum_{n=-N}^{0} u(n) + \sum_{n=0}^{N} u(n)$

$\Rightarrow 0 + \sum_{n=0}^{N} u(n)$

$n = 1$ to $N = N$

$n = 0$ to $N = N+1$

$$P = \lim_{N\to\infty} \frac{N+1}{2N+1}$$

If it gives indeterminate form i.e $\left(\frac{\infty}{\infty}, \infty-\infty, \frac{0}{0}\right)$ then compute अंश को derivative और हर को derivative तब जाए

$$P = \frac{1}{2}$$

Hence it is power signal.

Q. $x(n) = \left(\frac{1}{3}\right)^n u(n)$.

→ Solution:

Given,

$x(n) = \left(\frac{1}{3}\right)^n u(n)$

$u(n) = 1$ for $n \geq 0$
$\Rightarrow 0$ for < 0.

i) For energy signal.

$$E = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$= \sum_{n=0}^{\infty} \left(\frac{1}{9}\right)^n$$

$$= \left(\frac{1}{9}\right)^0 + \left(\frac{1}{9}\right) + \left(\frac{1}{9}\right)^2 + \cdots$$

$S_\infty = \frac{a}{1-r}$

$a = 1$

$r = \frac{1/9}{1} = 1/9$

$$= \frac{1}{1-1/9} \Rightarrow \frac{9}{8} \quad \therefore E = 9/8$$

ii) →

⇒

=

=

=

ii) For power signal

$$\rightarrow \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2$$

$$\Rightarrow \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} \left[\left(\frac{1}{3}\right)^n u(n)\right]^2$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=0}^{N} \left(\frac{1}{9}\right)^n$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \left(\frac{1}{9}\right)^0 + \left(\frac{1}{9}\right)^1 + \left(\frac{1}{9}\right)^2 + \cdots \left(\frac{1}{9}\right)^N$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \left[\frac{1\left(1-\frac{1}{9}\right)^{N+1}}{1-\frac{1}{9}}\right]$$

$\Rightarrow \frac{1}{2\times\infty+1}$ * finite value

$= 0$

Energy Signal.

$\therefore$ $S_n = \frac{a(1-r^n)}{1-r}$

$n = N+1$

$a = 1$ 1st term

$r = \frac{2^{nd}\text{ term}}{1^{st}\text{ term}}$

$r = \frac{1/9}{1}$

$= 1/9$

* $x(t) = e^{-4t} u(t)$

Soln:

i) for energy signal:

$$\Rightarrow E = \int_{-\infty}^{\infty} |x(t)|^2 dt.$$

$$\Rightarrow \int_{0}^{\infty} |e^{-4t} u(t)|^2 dt$$

$$\Rightarrow \int_{0}^{\infty} e^{-8t} |u(t)|^2 dt$$

$$\Rightarrow \int_{0}^{\infty} e^{-8t} * 1 \, dt.$$

$$\Rightarrow \left[\frac{e^{-8t}}{-8}\right]_0^{\infty}$$

$$\Rightarrow \frac{1}{-8} [e^{-\infty} - e^{0}]$$

$$\Rightarrow -1/8 [0 - 1]$$

$$\Rightarrow 1/8$$

ii) for power.

$$\rightarrow \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 dt$$

$$P \Rightarrow \lim_{T\to\infty} \frac{1}{T} \int_0^{T/2} e^{-8t}\, dt$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{-8T} \left[e^{-8\times T/2} - e^{0} \right]$$

$$\Rightarrow \frac{1}{\infty} \left[e^{-\infty} - 1 \right]$$

$$\Rightarrow 0 * [0 - 1]$$

$$\Rightarrow 0$$

Hence,

energy = finite

power = 0

So, energy signal.

Q. Find energy and power of the signal $x(t) = e^{-a|t|}$ for $a>0$ and stata wheather it is energy signal, power signal or neither.

Soln:

$x(t) = e^{-a|t|}$

$|x| = -x$ for $x<0$

x for $x>0$

$$x(t) = \begin{cases} e^{at} & \text{for } t<0 \\ e^{-at} & \text{for } t>0 \end{cases}$$

(1) Energy signal:-

$$E = \int_{-\infty}^{\infty} |x(t)|^2 \, dt$$

$$= \int_{-\infty}^{\infty} e^{-a|t|} \, dt$$

$$= \int_{-\infty}^{0} |e^{at}|^2 \, dt + \int_{0}^{\infty} |e^{-at}|^2 \, dt$$

$$\Rightarrow \int_{-\infty}^{0} e^{2at} \, dt + \int_{0}^{\infty} e^{-2at} \, dt$$

$$= \left[\frac{e^{2at}}{2a} \right]_{-\infty}^{0} + \left[\frac{e^{-2at}}{-2a} \right]_{0}^{\infty}$$

$$\Rightarrow \frac{1}{a}$$

Similarly for power signal.

$$P = \lim_{T \to 0} \int_{-T/2}^{T/2} |x(t)|^2 \, dt$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} \left| e^{-a|t|} \right|^2 dt$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} e^{-2a|t|}\, dt$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \left[\int_{-T/2}^{0} e^{2at}\, dt + \int_{0}^{T/2} e^{-2at}\, dt \right]$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \left[\left(\frac{e^{2at}}{2a} \right)_{-T/2}^{0} + \left[\frac{e^{-2at}}{-2a} \right]_{0}^{T/2} \right]$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \left[\frac{1}{2a} \left(e^{0} - e^{2a(-T/2)} \right) + \frac{1}{2a} \left(e^{-2a \times T/2} - e^{0} \right) \right]$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \left(\frac{1 - e^{-aT}}{2a} - \frac{e^{-aT} - 1}{2a} \right)$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \left(\frac{1 - e^{-aT} - e^{-aT} + 1}{2a} \right)$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \left(\frac{2 - 2e^{-aT}}{2a} \right)$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{aT} \left(1 - e^{-aT} \right)$$

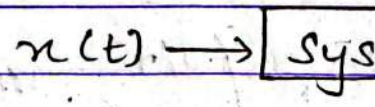
$$\lim_{T\to\infty} \frac{1 - e^{\infty}}{a \times \infty}$$

$$= 0 \quad \text{Ans}$$

System:

→ A system is a set of elements that are connected together and produce output in the response to input signal.

→ The response or output of the system depends upon transfer function of the system.



$$y(t) = F[x(t)]$$

Types of ~~Signals~~ System:

→ Like signals system are of two types:-

1) Continuous time system
2) Discrete time system

1) Continuous time system

- Linear time system (LT system) handle continuous time signal.
- For example ~~ad~~ audio and video amplifier, analog filter etc.

2) Discrete time System

→ It handels the discrete time signal.

- For example computer, up, shift registers, etc.

* On the basis of system properties:

Continuous and discrete time ~~signal~~ systems are further classified as:

a) Time invariant and variant system.
b) Casual and non-casual system.
c) Stable and un-stable system.
d) Linear and non-linear system.
e) Static and dynamic system.

a) Time invariant and variant System:

- A system is time invariant if the input and output does not vary with time.
- For time invariant system, the time shift in the input signal results in corresponding time shift in output.

Q. Check whether the following systems are time invariant or variant.

a) $y(t) = t\,x(t) + 3$

Soln:

i) Delaying the input by t_1

$y(t-t_1) = t\,x(t-t_1) + 3 \quad \text{---} \quad eq^n(i)$

ii) Delaying the output by t_1

$y(t-t_1) = (t-t_1)\,x(t-t_1) + 3 \quad \text{---} \quad (ii)$

Hence $y(t, t_1) \neq y(t - t_1)$

So, it is time variant.

Q: $y(t) = x(t) \cos 200\pi t$

Soln:

i) Delaying on input side by t_1

$y(t, t_1) = x(t - t_1) \cos 200\pi t \quad ---(i)$

ii) Delaying on output side by t_1

$y(t - t_1) = x(t - t_1) \cos 200\pi (t - t_1) \quad ---(ii)$

Hence it is time variant.

Q. $y(n) = x(n) - x(n-1)$

Delaying on input side by k samples

$y(n, k) = x(n-k) - x(n-k-1) \quad ---(i)$

Delaying output side by k

$y(n-k) = x(n-k) - x(n-k-1) \quad ---(ii)$

Time - invariant.

Q $y(n) = x(2n)$

Soln:

i) Delaying on input side by k

$$y(n,k) = x[2(n-k)] \quad \text{---(i)}$$

Delaying on output side by k.

$$y(n-k) = x[2(n-k)]$$

Hence the system is time variant.

Q. $y(n) = x(-n)$

Soln:

Delaying on input by k

$$y(n,k) = x(-n-k) \quad \text{---(i)}$$

Delaying on output by k

$$y(n-k) = x[(-n-k)] \quad \text{---(ii)}$$

Hence, it is time invariant.

Qn. $y(n) = \sum_{k=n_0}^{n} x(k)$.

Soln:

→ $y(n) = f[x(n)]$

$y(n) = x(n_0) + x(n_1) + x(n_2) + \cdots x(n)$

Delaying input by k samples.

$y(n,k) = x(n_0-k) + x(n_1-k) + x(n_2-k) + \cdots x(n-k)$ ... eq1

Delaying output by k samples.

$y(n-k) = x(n_0-k) + x(n_1-k) + (n_2-k) + \cdots x(n-k)$

Hence, it is time-invariant.

b) Casual and non-casual System:

- A system is said to be casual if its o/p at any time depends upon present and past input only. Hence the o/p is the function of $x(n)$, $x(n-1)$, $x(n-2)$, $x(n-3)$. ...etc for the casual system.

→ The system in non-casual if its output depends upon future value of input.

i.e. $x(n+1)$, $x(n+2)$ + ...

Note: Casual = present & past only.
Non-casual = Future.

Q. check wheather the system is casual or non-casual.

(i) $y(n) = x(n) + x^2(n-1)$

soln:

for $n = -1$, $y(-1) = x(-1) + x^2(-1-1)$

for $n = 0$, $y(0) = x(0) + x^2(-1)$

for $n = 1$, $y(1) = x(1) + x^2(0)$

Hence the above system is casual system.
In all the above cases the o/p devends upon present and past input only.

(ii) $y(n) = x(n+1) + 3x(n) + 5x(n-1)$

soln:

for $n = -1$, $y(-1) = x(0) + 3x(-1) + 5x(-2)$

for $n = 0$, $y(0) = x(1) + 3x(1) + 5x(-1)$

for $n = 1$, $y(1) = x(2) + 3x(2) + 5x(0)$

Hence the above system is Non-casual.

(iii) $y(n) = x(2n)$

soln:

for $n = -1$, $y(-1) = x(2(-1)) = x(-2)$

for $n = 0$, $y(0) = x(0)$

for $n = 1$, $y(1) = x(2)$

non-casual.

Q. $y(n) = \frac{1}{2}\left[x(n-1) + \frac{x(n)}{x(n-1)}\right]$

Soln:

$n=-1,\ y(-1) = \frac{1}{2}\left[x(-2) + \frac{x(-1)}{x(-1-1)}\right]$

$n=0,\ y(0) = \frac{1}{2}\left[x(-1) + \frac{x(0)}{x(-1)}\right]$

$n=1,\ y(1) = \frac{1}{2}\left[x(0) + \frac{x(1)}{x(0)}\right]$

Hence the above eqn. is casual.

Q. $y(n) = \sum_{k=-\infty}^{n+1} x(k)$

Soln:

$y(n) = x(n+1) + x(n) + x(n-1) + x(n-2) \cdots + x(-\infty)$

a) for $n=-1$

$y(-1) = x(0) + x(-1) + x(-2) + x(-3) + \cdots x(-\infty)$

b) for $n=0$;

$y(0) = x(1) + x(0) + x(-1) + x(-2) + \cdots + x(-\infty)$

c) for $n=1$.

→ $y(1) = x(2) + x(1) + x(0) + x(-1) \cdots + x(-\infty)$

∴ non-casual.

vi) $y(n) = x(n^2)$

→ Soln:

for $n = -1$, $y(-1) = x(1)$

for $n = 0$, $y(0) = x(0)$

for $n = 1$, $y(1) = x(1)$

∴ non-casual.

Stable and Unstable system:

→ When every bounded input produces bounded output then the system is called bounded input bounded output (BIBO) stable.

→ An LTI (Linear Time Invariant) is BIBO stable if and only if its impulse response is absolutely summable.

$$S = \sum_{n=-\infty}^{\infty} |h(n)| < \infty$$

where;

$h(n)$ = impulse response.

Q. Determine wheather the following system are stable or unstable:

ii) $y(t) = t\,x(t)$

Let $x(t)$ be bounded.

As $t \to \infty$, $y(t) \to \infty$, since $x(t)$ is multiplied by t.

Hence, o/p is unbounded and the system is unstable.

iii) $y(t) = x(t) \sin 100\pi t$

→ Let $x(t)$ be bounded.

Here $x(t)$ is multiplied by $\sin 100\pi t$.

We know that the value of sine function lies between -1 and 1.

Hence o/p $y(t)$ is bounded as long as $x(t)$ is bounded and the system is stable.

iii) $y(n) = x(n)\,u(n)$

→ Let $x(n)$ is bounded

This means $u(n)$ is bounded sequence. Hence as long as $x(n)$ is bounded, $y(n)$ is also bounded, $y(n)$ is also bounded and hence the system is stable.

$\because u(n) = 1$ for $n \geq 0$

0 for $n < 0$

iv) $y(n) = x(n) + nx(n+1)$

→ As $n \to \infty$, $y(n) \to \infty$, the given system is unbounded.

Q. Consider the system with impulse response $h(n) = 3^{-n} u(n)$. Determine wheather the system is stable or unstable.

→ soln:

$$S = \sum_{n=-\infty}^{\infty} |h(n)|$$

$$S = \sum_{n=-\infty}^{\infty} |3^{-n} u(n)|$$

$$S = \sum_{n=0}^{\infty} 3^{-n}$$

$$S = 3^{-0} + 3^{-1} + 3^{-2} + 3^{-3} + \cdots$$

$$= 1 + \frac{1}{3} + \frac{1}{9} + \frac{1}{27} + \cdots$$

$$= \frac{1}{1 - 1/3} \qquad \because S_\infty = \frac{a}{1-r}$$

$$= 3/2 \quad \alpha < \infty$$

Since $S < \infty$, the system is stable.

d) Linear and non-linear system:

A system is said to be linear if it satisfies the superposition principle.

→ Let $x_1(t)$ is the input and $y_1(t)$ is the o/p i.e.

$$y_1(t) = F[x_1(t)].$$

$x_2(t)$ is i/p and $y_2(t)$ is o/p

i.e. $y_2(t) = f[x_2(t)]$

Thus for a linear system,

$$F[a_1 x_1(t) + a_2 x_2(t)] = a_1 y_1(t) + a_2 y_2(t)$$

where a_1 and a_2 are orbitary constant.

Then for discrete time system,

$$F[a_1 x_1(n) + a_2 x_2(n)] = a_1 y_1(n) + a_2 y_2(n)$$

Q^n Check whether the following systems are linear or non-linear.

$y(t) = t\,x(t)$

→

i) $y_1(t) = t\,x_1(t)$

ii) $y_2(t) = t\,x_2(t)$

The linear combination of two o/p will be

$$y_3(t) = a_1 y_1(t) + a_2 y_2(t) \quad \text{---} \quad (*)$$

$$y_3(t) = a_1 t\,x_1(t) + a_2 t\,x_2(t) \quad \text{---} \quad (i)$$

Response to linear combination of I/p becomes.

$$y_3'(t) = F\left[a_1 x_1(t) + a_2 x_2(t)\right] \quad \text{---} \quad (*)$$

$$= t\left[a_1 x_1(t) + a_2 x_2(t)\right]$$

$$= t\,a_1 x_1(t) + t\,a_2 x_2(t) \quad \text{---} \quad (ii)$$

Comparing eq^n (i) and (ii) we get,

$y_3(t) = y_3'(t)$, the given system is linear.

Q. $y(t) = x^2(t)$

→

i) $y_1(t) = F[x_1(t)] = x_1^2(t)$

ii) $y_2(t) = x_2^2(t)$

The linear combination of two I/p is

$$y_3(t) = a_1 y_1(t) + a_2 y_2(t)$$
$$= a_1 x_1^2(t) + a_2 x_2^2(t) \quad \text{--- (i)}$$

Response the linear combination of i/p becomes

$$y_3'(t) = F[a_1 x_1(t) + a_2 x_2(t)]$$
$$= [a_1 x_1(t) + a_2 x_2(t)]^2$$

$$= a_1^2 x_1^2(t) + a_2^2 x_2^2(t) + 2a_1 a_2 x_1(t) x_2(t) \quad \text{--- (ii)}$$

Comparing (i) and (ii).

$y_3'(t) \neq y_3(t)$ so non-linear.

Q. $y(t) = 10x(t) + 5$

→

$y_1(t) = 10x_1(t) + 5$

$y_2(t) = 10x_2(t) + 5$

The linear combition of two I/p is

$$y_3(t) = a_1 y_1(t) + a_2 y_2(t)$$
$$= a_1 [10 x_1(t) + 5] + a_2 [10 x_2(t) + 5]$$
$$= 10 a_1 x_1(t) + 5 a_1 + 10 a_2 x_2(t) + 5 a_2$$

$$y_3'(t) = F[a_1 x_1(t) + a_2 x_2(t)]$$

$$= 10 [a_1 x_1(t) + a_2 x_2(t)] + 5$$
$$= 10 a_1 x_1(t) + 10 a_2 x_2(t) + 5$$

$\therefore$ It is non linear.

Q. $y(t) = x(t) + \cos(100\pi t)$

→ Soln:

$y_1(t) = x_1(t) + \cos(100\pi t)$

$y_2(t) = x_2(t) + \cos(100\pi t)$

The linear combition of two i/p is

$$y_3(t) = a_1 y_1(t) + a_2 y_2(t)$$
$$= a_1 [x_1(t) + \cos(100\pi t)] + a_2 [a x_2(t) + \cos(100\pi t)]$$

$$= a_1 x_1(t) + a_1 \cos(100\pi t) + a_2 x_2(t) + a_2 \cos(100\pi t)$$

Now,

$y_3'(t) = F[a_1 x_1(t) + a_2 x_2(t)]$

$= a_1 x_1(t) + a_2 x_2(t) + \cos(100\pi t)$

Hence, the system is non-linear.

Qn: $y(t) = e^{x(t)}$

soln:

$y_1(t) = e^{x_1(t)}$

$y_2(t) = e^{x_2(t)}$

The linear combination of two i/p is

$y_3(t) = a_1 y_1(t) + a_2 y_2(t)$

$= a_1 e^{x_1(t)} + a_2 e^{x_2(t)}$ -- (i)

$y_3'(t) = F[a_1 y_1(t) + a_2 y_2(t)]$

$= e^{[a_1 y_1(t) + a_2 y_2(t)]}$ -- (ii)

Non linear

Presnt aaya → static else dynamic

e) Static and Dynamic :

→ Static or memoryless system whose value depends only upon the present value of the i/p signal. Otherwise the system is solid to be dynamic or with memory.

Q^n $y(t) = x(t^2)$

⇒

i) for $n = -1$

$y(-1) = x(1)$

ii) for $n = 0$

→ $y(0) = x(0)$

iii) for $n = 1$

→ $y(1) = x(1)$

So dynamic.

Q^r $y(t) = x(t) \cos 100\pi t$

soln:

for $n = -1$, $y(-1) = x(-1) \cos(-100\pi)$

for $n = 0$, $y(0) = x(0) \cos(0)$

for $n = 1$, $y(1) = x(1) \cos(100\pi)$

so it is static

DC

Chapter-4

Overview of Data Communication Networking and Protocols

→ Data communication refers to the transmission of data between two or more computer.

→ Computer network is a system which allows communication among the computer connected in the network.

→ The best example of the Computer Networ is Internet.

Types of Computer Network:

There are three types of Computer Network:

i) Local area Network (LAN)
ii) Metropolitian Area Network (MAN)
iii) Wide Area Network (WAN)

i) LAN:

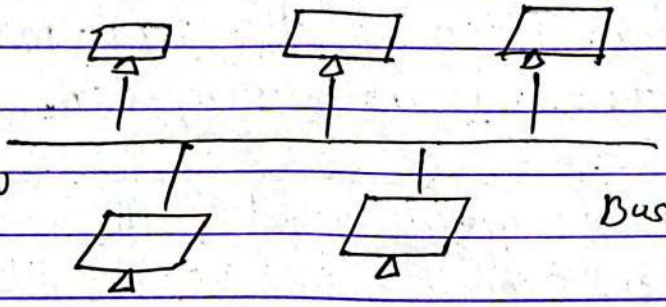
→ It is the group of computers connected in small area such as room, building, school, hospital.

→ LAN due to small size data is transfer at faster rate upto 100 Mbps.

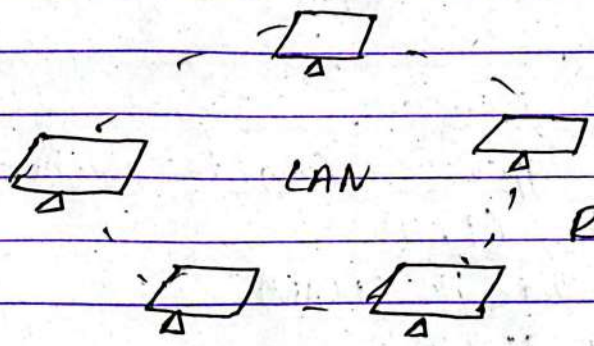
→ It can be done using twisted pair or coaxial cable.

→ It can go upto 1km radius.

→ It is useful network for sharing resource like files, games, etc.



Bus topology



Ring topology

(iii)

→

(ii) Metropolitian Area Network (MAN):

→ The combination of LAN in large geographical area is called as metropolitian Area Network. →

→

→ It can extend upto 50 km of range.

→ High speed cable like optics fibre is used. →

→ It is used in communication between banks in a city, colleges with in a city etc.

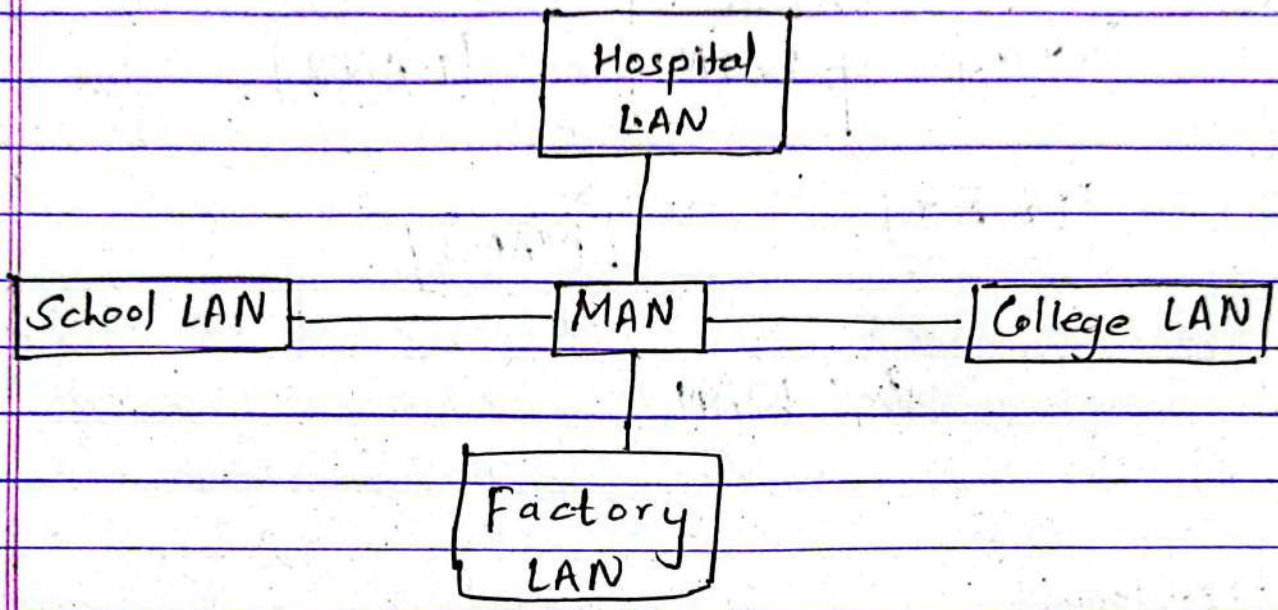


fig: MAN

iii) Wide Area Network (WAN):-

→ It is a Network used for long distance transmission. i.e. Over country, continent or even whole world.

→ It is larger than LAN and MAN.

→ It uses telephone lines, optic cable, Radio waves, satellite links,

→ Example: Internet connection.

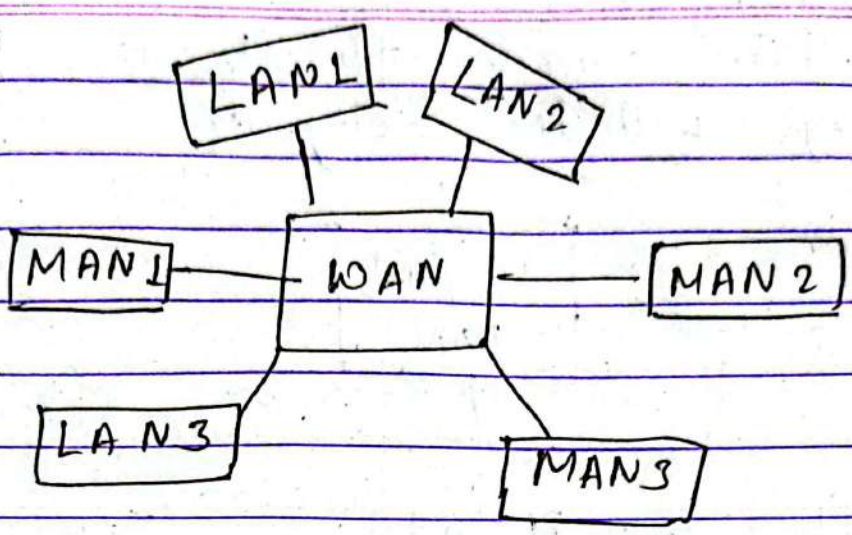
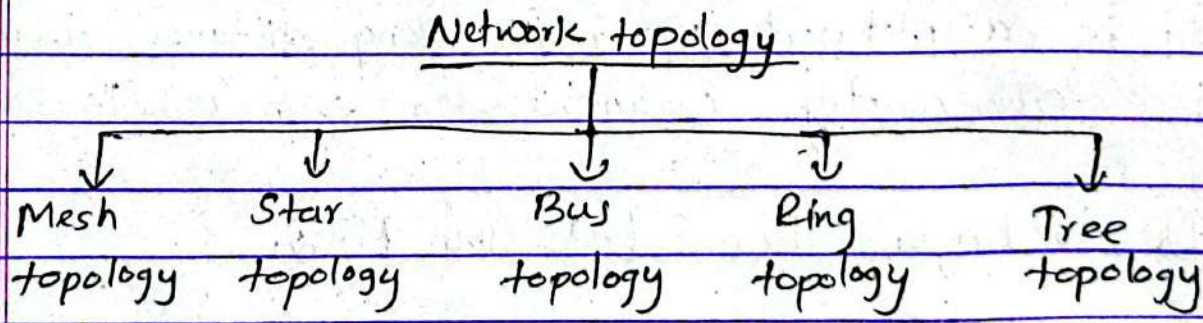


fig: WAN

Topology:

→ It is the geometrical representation of the relationship of all the links connecting the divice or nodes. is called as topology.



A) Mesh Topology:

→ In mesh topology every device has point-to-point link to every other devices as shown in fig. below:

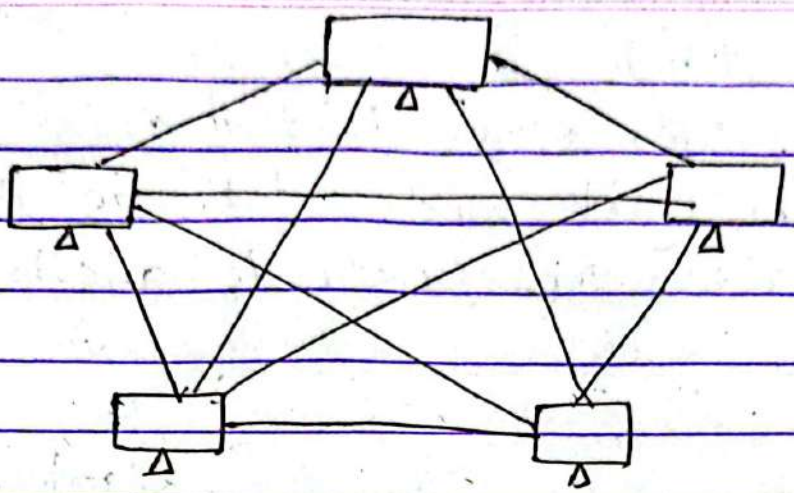


fig: Mesh topology

→ No. of channel = $\frac{n(n-1)}{2}$

Advantages of Mesh topology.

1. If one link fails it does not effed the entire system.
2. Fault identification and isolation becomes easy.

Disadvantages

1. Difficult installation.
2. Network require huge amount of cables, so it is expensive.

B) Star Topology:

→ All the devices are connected to the central controller called Hub.

→ It has dedicated point to point connection between

devices and Hub.

→ If one device wants to send data to another device First it sends data to the controller which then sends data to another connected device.

Advantages	Disadvantages
i) Less Expensive	i) Single point error or failure goes down the whole network dead.
ii) Easy Installation	ii) No. of devices are limited
iii) Easy to find error or fault in the network.	

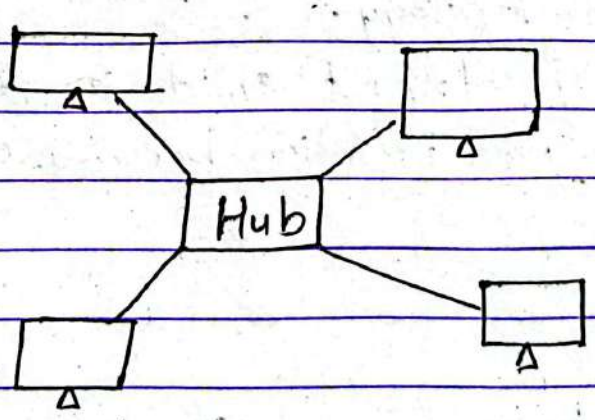


fig: Star topology

c) Bus Topology:

→ In bus topology all the device are connected to the single cable called as bus.

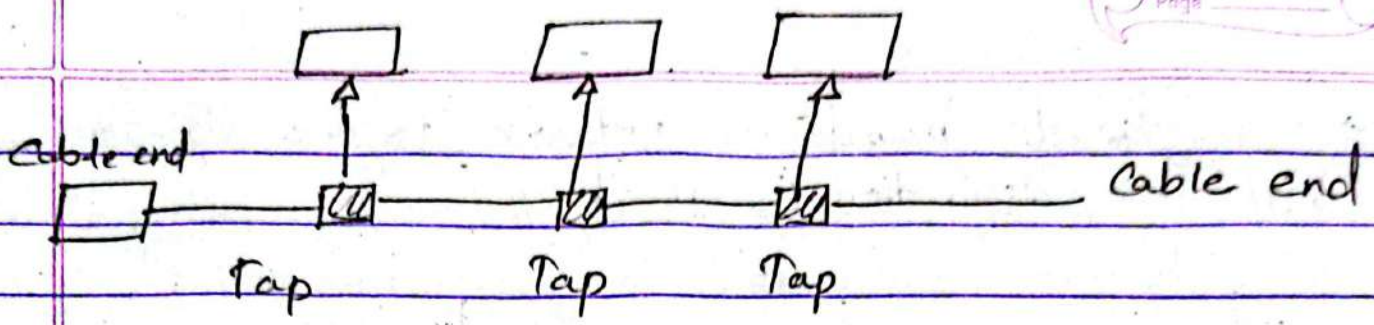


fig: Bus Topology

→ The devices are connected with the help of Tap.
→ The tap is the connector that links the devices to the bus..

Advantages	Disadvantages
i) Easy installation.	i) A fault in cable stops all transmission.
ii) It requires less cable compared to Mesh and star topology.	ii) There is limit in cable, cable length, no. of tap.
iii) It is less expensive.	

2) Ring Topology:
→ In ring topology each device is connected to next device forming a ring as shown in figure below.

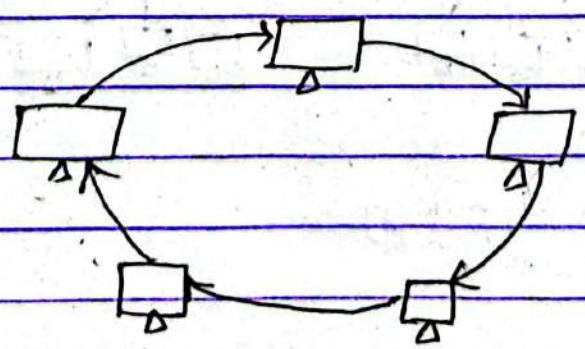


fig: ring topology

→ Data travels around the network in one direction till the destination is reached.

Advantages	Disadvantages
i) Easy installation.	i) A fault in ring stops all the transmission.
ii) Fault installation is simplified.	ii) It has limitation on the cable length, no. of nodes that can be connected.

E) Tree topology:

→ It is modified version of star topology.

→ In this topology, nodes are linked to a central hub that controls ~~to~~ the traffic ~~to~~ the network.

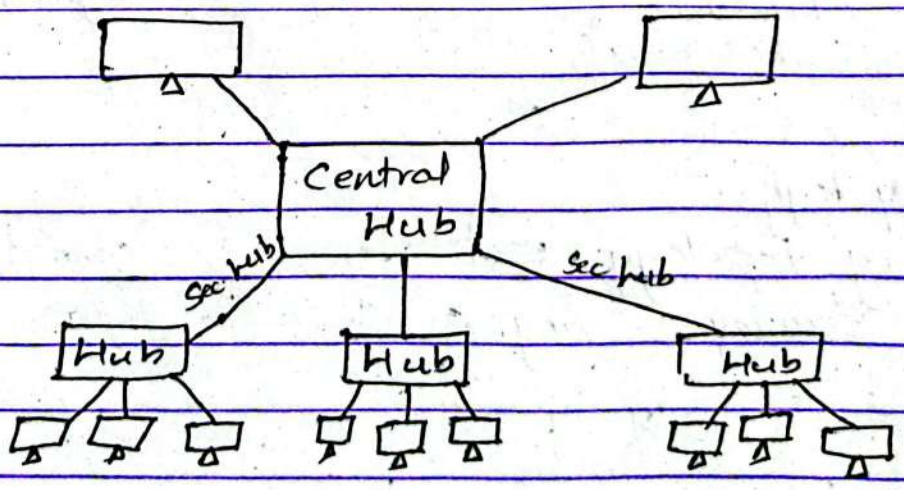


fig: Tree topology.

Advantages	Disadvantages
i) It allows more device is to connected	i) If the central hub fails the system breaks down.
ii) It reduces network structure.	ii) Cable is cost is more.

OSI Model (Open System Interconnection):

→ An ISO (International Standard Organization) that cover all aspects of network communication is open system interconnection (OSI Model).

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

please do not touch Shirijan pet Alligator.

1) Physical layer:

→ Physical layer deals with the physical connection of device with transmission and reception of signal.

→ It converts the digital data into electrical signal.

→ Examples: Hubs, Multiplexure, Repeater, etc.

2) Data link layer:

→ Synchronous and error control for the information which is to be transmitted over physical link is carried out.

→ It enables the error detection and add bits which is to be transmitted.

→ These error detection bits are used by the data link layer to detect and correct the error.

3) Network layer:

→ It routes the signal through various channel to the destination.

→ It divides msg into packets and assemble packets into msg.

→ Hence, it acts as network controller for routing data.

4) Transport Layer:

→ It is responsible for source to destination delivery of entire msg.

→ This layer ensures that packets are deliver error free, in sequence and without dublication.

5) Session Layer:

→ It established synchronization between communication system.

6) Presentation Layer:

→ This layer is concern with syntax and semantics. of the information exchange between the two systems.

→ Example:
One system is using ASCII code and another system is using gray code. Under such conditions the presentation layer provides translation from ASCII to gray code and vice-versa.

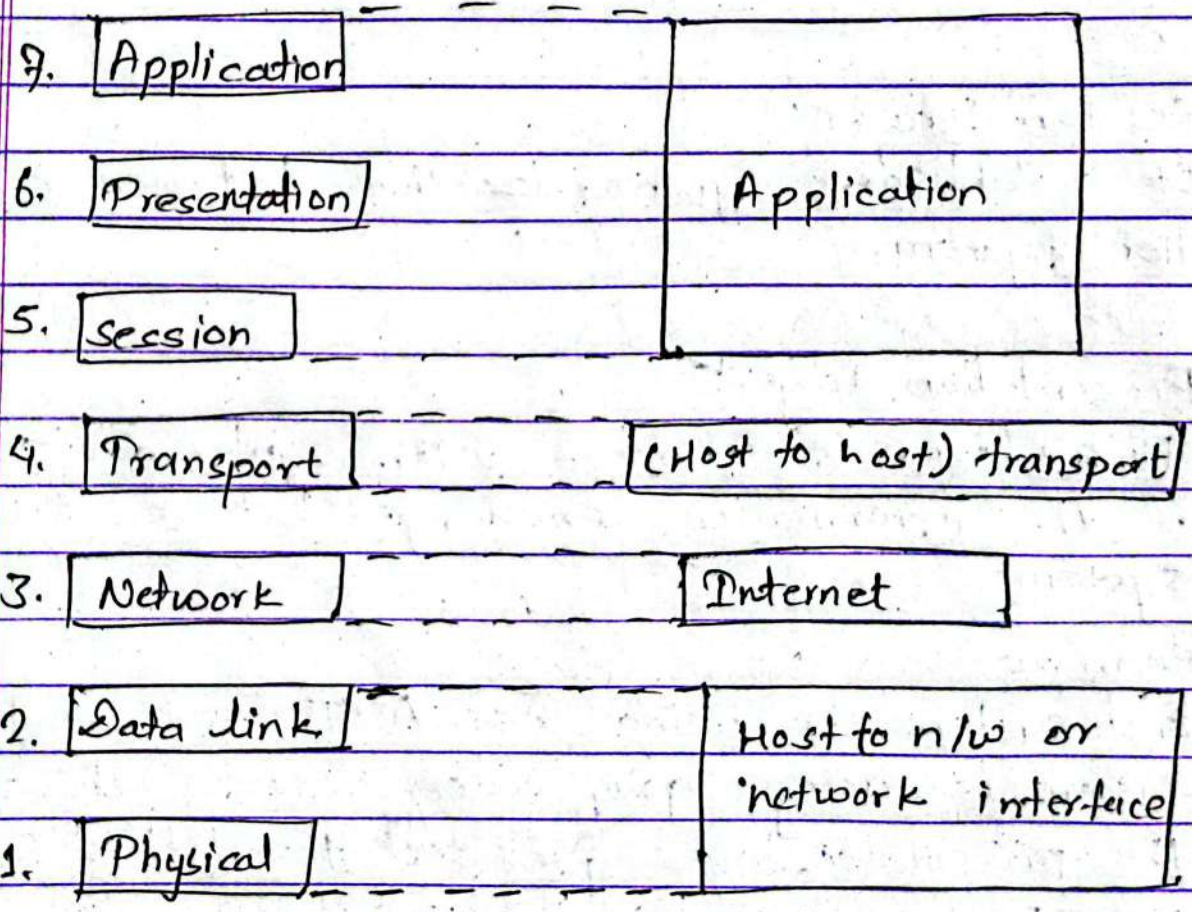
7) Application Layer:

→ It is the top most layer of the OSI model.

→ It provides services that directly supports user application such as data base access, email, etc.

TCP/IP (Transmission Control Protocol / Internet Protocol).

→ IT is most widely used protocol for interconnecting computers and also it is the protocal of internet.



1. Network Interface layer: (Physical + Data link)

→ Physical र Data link layer मा जे लेखेको छ त्यही लेख्ने OSI Model को।

2. Internet layer

→ OSI को Network मा जे छ त्यही।

3. Transport layer

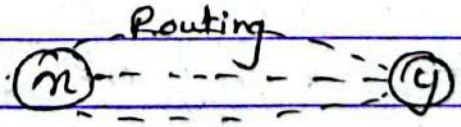
→ Same as OSI (transport layer)

4. Application

→ Application, + Presentation + session OSI layer को।

Routing:

→ Routing is the process of selecting the path in a network along which to send the network traffic.

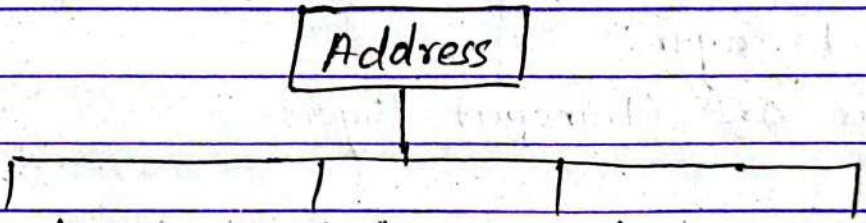


→ Routing is performed for many kind of network including telephone network (circuit switching), electronic data network such as internet.

→ Routing algorithm are used to find the best route to send the data from sender to the reciver.

→ For example: Shortest path algorithm (Dijkstra's algorithm).

Different types of Address used in TCP/IP Model.



1) Physical address (MAC address)

→ It is the address of a node defined by LAN or WAN.

→ The size and format of these address vary depending on the network.

→ Example:

Most local area network uses 6-byte (6x8) = 48 bit physical address written as:

07:01:02:01:2C:4B

2) Logical address:

→ Logical address is also called IP address.

→ The logical address in the internet is currently a 32-bit address that can define host connected to the internet.

→ Example: Ip address :- 192. 168. 1.1

(3) Port address:

→ In the TCP/Ip architecture, the label assigned to a process is called port address.

→ These port number allow different application on the same computer to share network resource simultaneously.

→ Example: A port address is a 16-bit address.

(4) Specific address:

→ Some application have user friendly address that are designed for that specific application.

→ Example of Specific address are the email address (xyz@gmail.com).

✱ IEEE Standard

→ The institution of electrical and electronics engineer (IEEE) has developed the layered architecture and other standards of LAN.

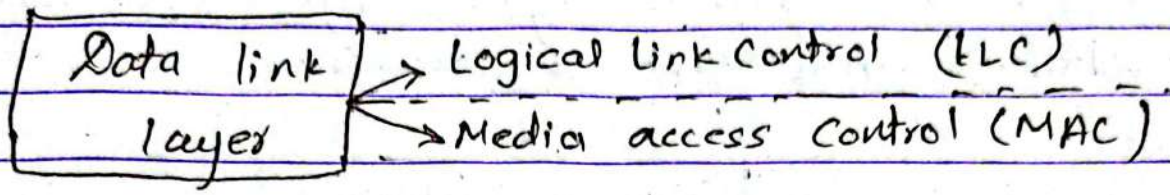
→ The IEE 802 standard are as follows :-

802.1 → High level Interface
802.2 → Logical link control (LLC)
802.3 → Carrier sense Multiple access / Collision detection (CSMA/CD)
802.4 → Token bus.
802.5 → Token ring
802.6 → Metropolitan area network
802.7 → Broad based LAN.
802.8 → Fiber optic LAN
802.9 → Integrated data and voice network
802.10 → Security
802.11 → wireless n/w

✱ LLC/MAC

→ The IEE has sub-divided the data link layer into two sub-layer;

(i) Logical link control (LLC)
(ii) Media access control (MAC)

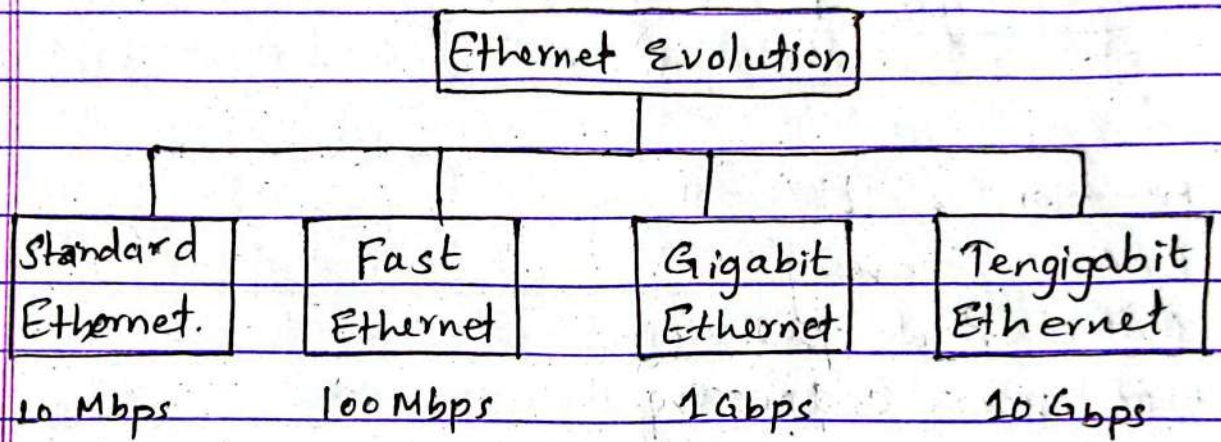


* Function of LLC
→ Error recovery
→ Control flow operation
→ Has user addressing

* Functions of MAC:
→ Detection of error.
→ It perfom the control of access to media.
→ It performs unique addressing directly connected to LAN.

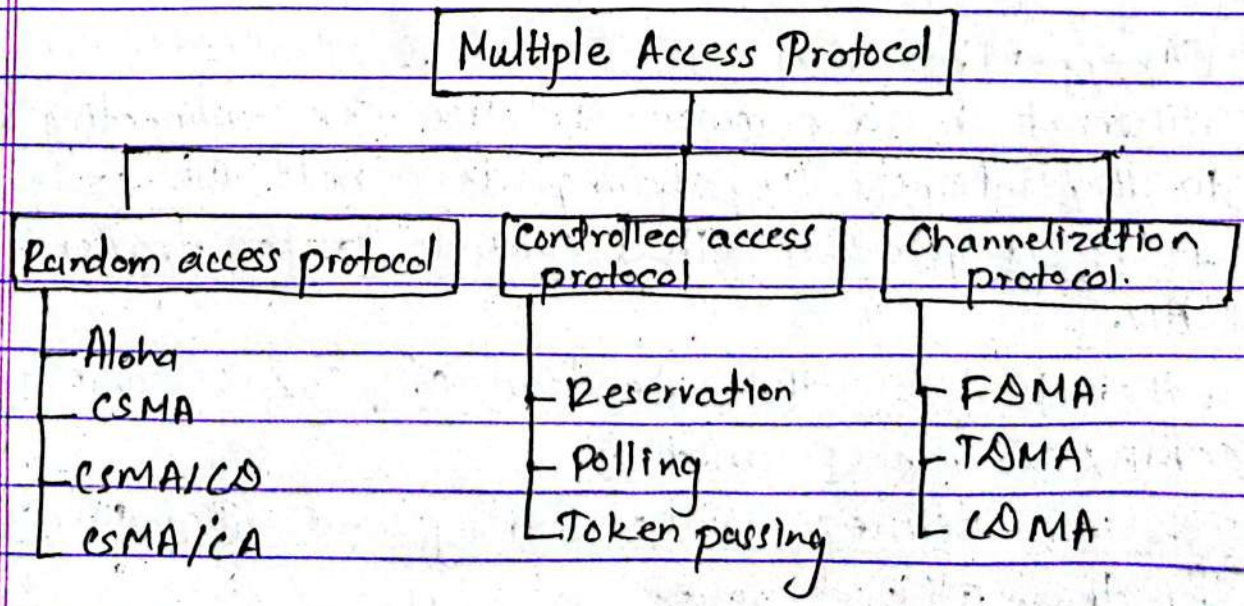
⁂ Ethernet :
→ Ethernet is a common solution for connecting computer to the internet for sharing data bet^n the computer.
→ It is a protocal that controls data transmitted over LAN.
→ Ethernet has the standard of 802.3 and uses CSMA/CD access method.
→ Ethernet defines no. of wiring and signalling standard for the physical layer.

→ Ethernet has gone through 4th generation of evolution during last few decades.



※ Multiple access protocol.

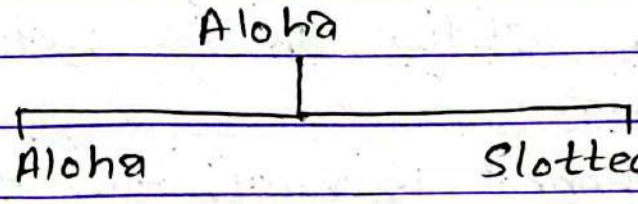
→ When no. of users use a common link of communication system, multiple access protocol is used in order to co-ordinate the access to the communication link.



* Aloha :

→ It is the multiple access protocol for transmitting of data with the shared network channel.

→ It operates on MAC sub-layer of OSI Model.



a) Pure Aloha: (18.4% (η) efficiency)

→ In pure aloha, the time of transmission is continuous

→ When a station has available frame it sends the frame

→ If there is collision, and frame is destroyed and sender waits for random amount of time before re-transmitting it.

b) Slotted Aloha (38.8% η)

→ Slotted Aloha reduces the no. of collision and doubles the capacity of pure Aloha.

→ The shared channel is divided into no. of discrete time interval called slot.

→ However, there can be still collision if more than one station tries to transmit at the beginning of the same time slot.

※ CSMA-CD (Carrier Sense Multiple Access / Collision Detection)

→ It is used for ethernet wired network.

→ In CSMA/CD, when a station has data to send, it first listen to determine wheather any other station on the network is occupying the medium.

→ If the channel is busy, the station will wait until it becomes idle before transmitting data

→ Since it is possible for the 2 station to listen at the same time, it is also possible that 2- station could transmit the data at the same time.

→ When this occur a collision takes place and jamming signal is sent throughout the network.

→ The station will then wait for a random period of time, before re-transmitting their respective frame.

→ Hence CSMA/CD deals with the transmission after collision has occured.

CSMA/CA (Carrier Sense Multiple Access/ Collision Avoidence).

→ CSMA/CA is used for wireless 802.11.

→ 802.11 wireless station are not cable of transmitting and receiving at the same time, so they are not capable of detecting a collision during their transmission.

→ It attemps to avoid collision by waiting for the wireless medium to be clear for the amount of time it takes for a packet to propagate through the medium.

→ When 802.11 device intends to transmit the msg, it will first sense wheather another station is already transmitting.

→ If no other transmission are sensed, the 802.11 device will send RTs packets to the destination station.

→ If the other station sense the medium is clear, CTs signal (Clear to send) is replied by the destination station.

→ If the transmitting station doesn't receive CTs packet in reply, it begins the RTs procedure again.

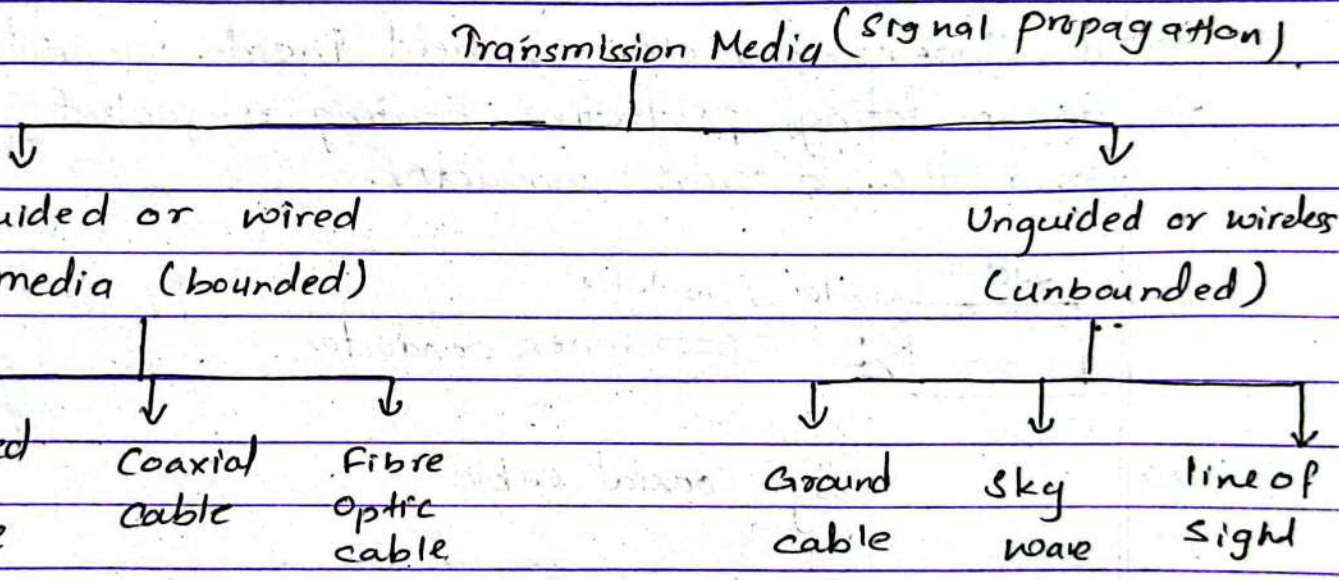
→ Hence it acts to prevent collision before they happen.

DC

Chapter-5

Transmission Media

* Transmission Media:
→ Transmission media is the physical path between transmitter and receiver.
→ Signal travel from transmiter to reciver through a path called as medium.



Guided media

** (1) Twisted pair cable:
→ It is the oldest and least expensive most commonly use medium.
→ It has pair of insulated wire to reduce intereference

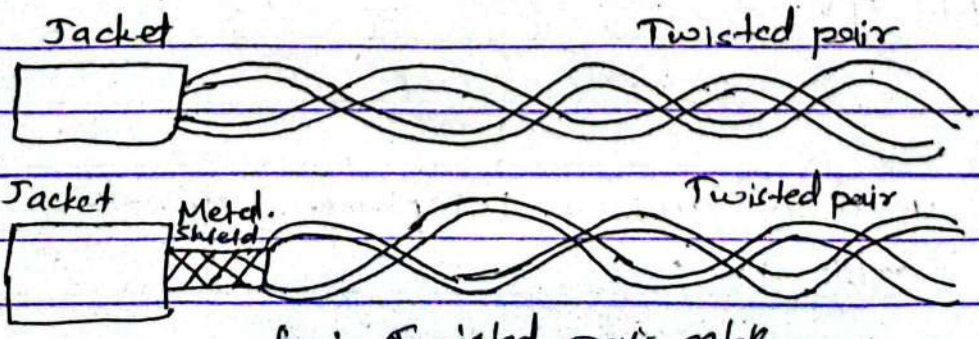


fig: Twisted pair cable

* Application of Twisted pair cable
→ It is used in telephone line to carry voice and data.
→ It is used in local Area Network (LAN).

② Coaxial Cable:
→ It consists of two conductors.
→ The inner conductor is held inside an insulator.
→ An insulating protective coating a jacket cover the outside conductor.

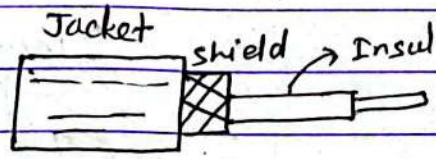


fig: Coaxial Cable

→ The coaxial cable have the data rate up 100 Mbps.
→ It needs repeater and amplifier ~~very~~ in every few km.
→ The noise immunity of coaxial cable is good.
→ Typical impedence of coaxial cable is 75 Ω for cable TV.

* Applications
→ It is used in analog telephone network.
→ Use in cable TV

→ Used in Ethernet.

(3) Fibre Optic Cable:

→ Optical fibre consists of thin glass fibre that can carry information and frequency in the speed of light.

→ The typical optical fibre consists of strand of glass called core.

→ Around the core there is a ~~constric~~ concentric layer of glass called ~~clad~~ cladding.

→ The coating cladding consists of plastic called jacket.

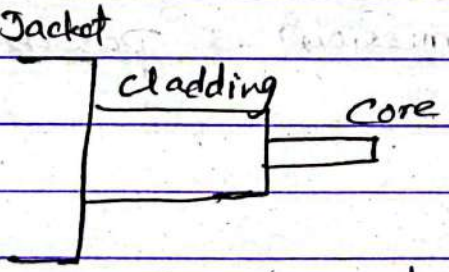


fig: Optical Fibre

→ It has extremly high bandwidth i.e. capable of 2 ~~Gp~~ Gbps.

→ It has very high noise immunity, resistance to electromagnetic interference.

→ It needs repeater at the 10 or 100 km apart.

* Applications:
→ It is used in long distance communication.
→ It is used in hospital.
→ It is use in millitary applications.

☆ Unguided media
→ Unguided media are the ways of transmitting data without using any cable.
→ This type of transmission is called wireless transmission.
→ Here, the transmission and reception are achived by the means of antenna.
→ Wireless propagation (transmission) is possible in following ways.

① Ground wave Propagation:
→ In this propagation, radio wave travels through the lowest portion of the atmosphere
→ It takes below the frequency of ~~capil~~ 2 MHz.
→ This low freq^n signal radiate in all direction from the transmitting antenna and follow the curvature of the earth.
→ Eg: AM radio

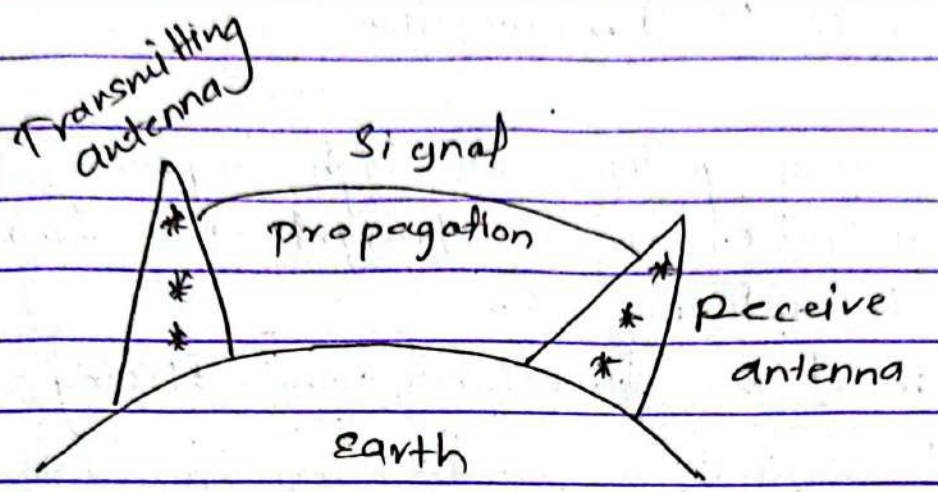


fig:- Ground wave propagation (below 2MHz).

② Sky wave propagation:

→ In this propagation, radio waves radiate into the ionosphere and gets reflected to the earth.

→ It takes place for freqⁿ between 2 to 30 MHz.

→ This types of transmission allow communication at greater distance.

→ Example: International broadcast such as BBC and Voice of America.

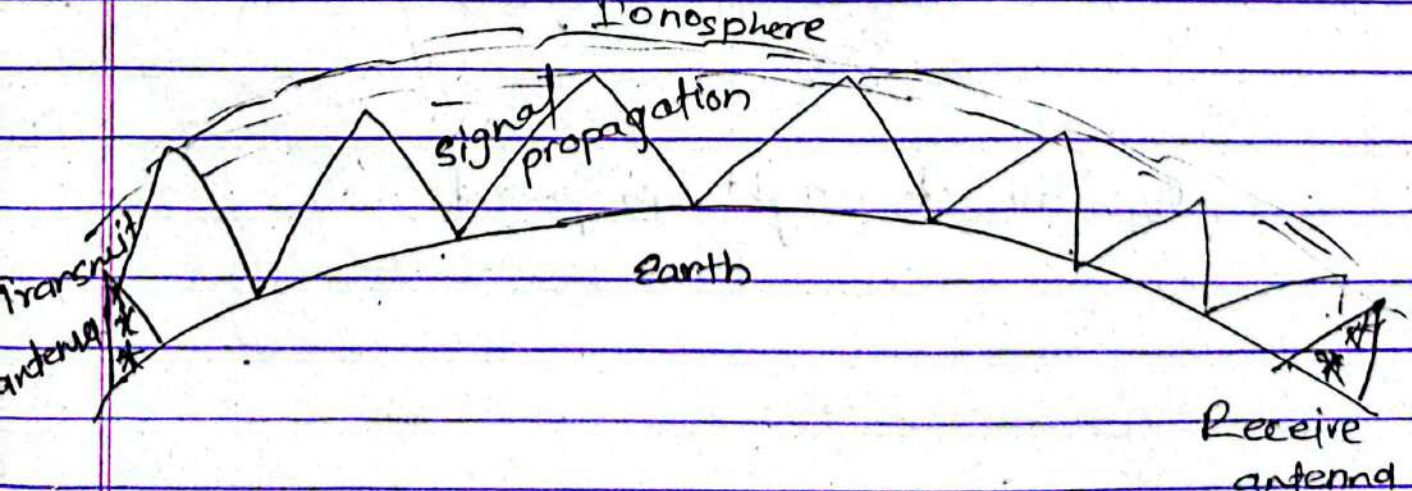


fig: Sky wave propagation (2 to 30 MHz)

(3) Line of sight (LOS) propagation:-

→ In this propagation, very high frequency signal are transmitted in a straight line from antenna to antenna.

→ Antenna must be directional and facing each other.

→ LOS propagation takes place for frequency about 30MHz.

→ Distance of signal propagation is limited due to the curvature of the earth.

→ The maximum range of propagation is limited to line of sight (LOC) i.e. receiving antenna ~~to the~~ can see the transmitting antenna.

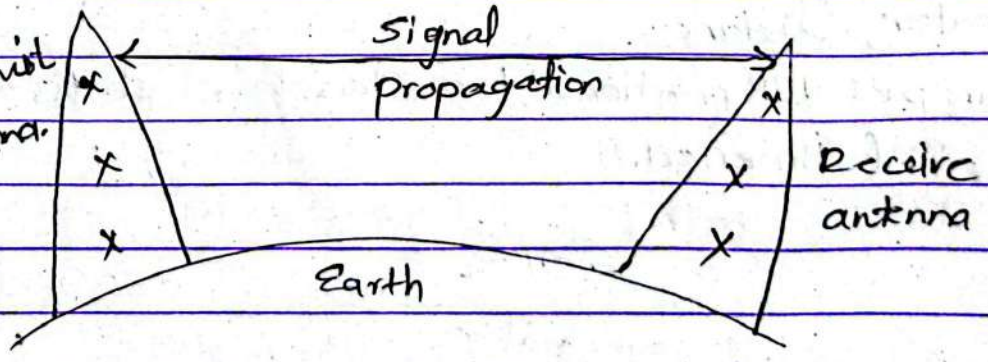


fig: Line of - sight propagation.

Some of the unguided transmission are :

1) Terrestial Microwave

→ It operates at high frequency of (3-10) GHz.
→ It is typically used, coaxial cable is not practical.
→ It uses parabolic disc shaped antenna of 3m diameter which transmit, receive electromagnetic mares.
→ It travels in straight line (LOS) propagation.

* Disadvantages

→ It is diffracted around the solid objects.
→ It is refracted by atmosphere thus, causing beam to be projected away from the receiver.

* Applications :

→ Voice and television transmission.

2) Satellite microwave :

→ Satellite are transponder that are set in a geo-stationary orbit directly over the equator.
→ A transponder is a unit that receive one frequency and re-transmit to another.
→ The geo-stationary orbit is 36,000 km from earth surface.
→ Source transmit signal to the satellite. which amplify or repeats and re-transmits to destination.

→ Optimum transmission is 1 to 10 GHz range in the bandwidth of 100 MHz.

→ If the satellite communication is beth to ground station i.e. one transmiter and another receiver, it is called as point to point satellite communication.

→ If one earth station transmits and multiple ground station receives the signal then it is called as multipoint or broad cast configuration.

* Application:

→ Long distance telephones

→ TV distribution

→ Global Positioning System (GPS)

3) VSAT (Very Small Aperature Terminal):

→ VSAT system provide the facility of division of total capacity of single satellite to multiple private users.

→ Thus, it commonly connects a central location with many remote areas.

→ VSAT is a low cost alternative in which a numbers of low cost suscriber station are equipped with the low cost VSAT antenna.

→ It is used for business data application requiring high data rates for short periods of time.

4) Cellular Telephony:

→ Cellular radio is a technique to increase the capacity for mobile, radio, telephone service.

→ The essence of cellular network is the use of multiple low power transmitter in the order of 100 watt or less.

→ The range of such transmitter is small and hence, area can be divided into cells & each one served by its own antenna.

→ Each cell is allocated band of frequency and is served by base station consisting of transmitter, receiver and control unit.

→ Adjacent cells are assigned different frequency to avoid cross-talk or interference.

→ Thus, the main advantage of using cellular telephony for mobile communication is frequency re-use.

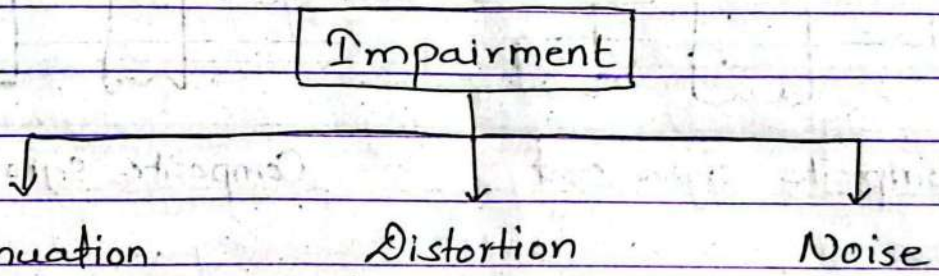
Chapter-6

Impairments, Error handling and Compression Technique:

Transmission Impairment (Weak):

→ The transmission media are not perfect.

→ The ~~inf~~ inperfection (fault) cause impairement (weak) in the signal sent through the medium. This means ⇒ that the signal at the beginning and end of the medium are not same.

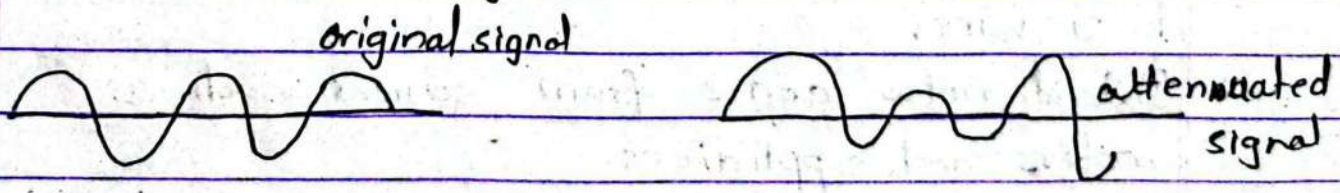


1) Attenuation:

→ Attenuation is the loss of signal energy due to the resistance of the medium.

→ Attenuation is caused by signal absorption, connector loss and coupling loss.

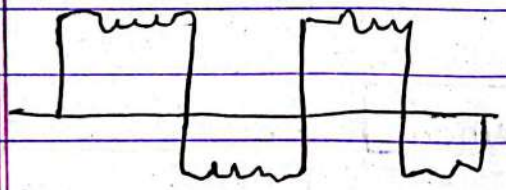
→ Example: Copper cabling has much greater attenuation than fibre cabling.



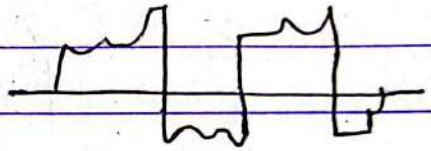
2) Distortion:

→ Distortion is the alternation of signal due to the different propagation speed of each of the frequency that make up a signal.

→ Distortion occurs in composite signal made of different frequency.



Composite signal sent



Composite signal received.

3) Noise:

→ Noise is the un-wanted form of signal.

→ Noise is the external energy that corrupts a signal.

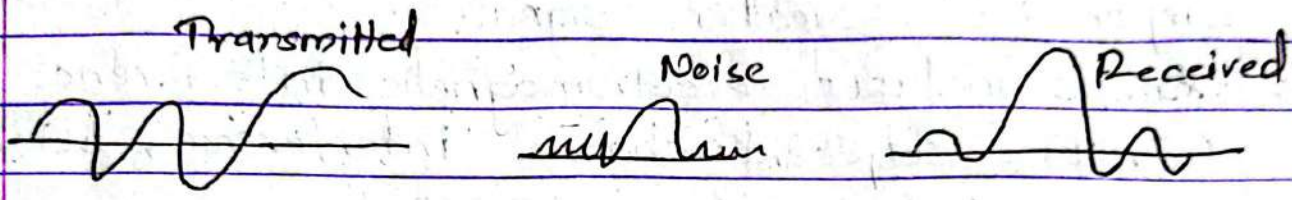
→ There are several types of noise they are Thermal noise, induced noise and impulse noise.

→ Thermal noise is the random motion of electron in a wire.

→ Induced noise come from sources such as motors and appliances.

→ Impulse noise is a spike that comes from power lines lightening.

→ The better signal to noise ratio of an electrical transmission system, the greater is the efficiency of the system.



⇒ Some of the others impairments are cross-talk and interference.

* Cross-talk:

→ It is an unwanted coupling between signal path.

→ It can occur by electrical coupling between near by twisted pair lines carrying multiple signal.

→ Thus, cross talk is the effect of one wire on the another.

→ One wire acts as sending antenna and other acts as receving antenna.

→ For example:

Another conversations is sometimes heard using telephone lines.

* Interference:

→ It is the type of signal impairment in which one signal interfere the frequency component of another signal.

→ Example includes electromagnetic interference (EMI), adjecent channel interference, inter signal interference.

Q1 A signal travels through a transmission medium and its power is reduce to one half. Find the attenuation (loss of power) ?

Soln:

→ Attenuation (loss of power) is given by;

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

where, P_1 = input signal = P_1

P_2 = Output signal = $1/2\ P_1$

$$= 10 \log_{10} \frac{1/2\ P_1}{P_1}$$

$$= 10 \log_{10} \frac{1}{2}$$

$$= -3.01 \text{ dB}.$$

$\therefore$ Attenuation (A) $= -3.01$ dB

Q) If a signal at the beginning of a cable with -0.3dB per km has a power of 2mW, what is the power of signal at 5km.

Soln:

The loss of cable in dB is $-0.3 \times 5 = -1.5\,dB$

Now,

Attenuation (Loss of power) is given by;

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

or, $-1.5\,dB = 10 \log_{10} \frac{P_2}{2}$

or, $\frac{-1.5}{10} = \log_{10} \frac{P_2}{2}$

or, $-0.15 = \log_{10} \frac{P_2}{2}$

or, $10^{-0.15} = \frac{P_2}{2}$

$\therefore P_2 = 1.41\,mW.$

Q. The power of signal is 10mW and the power of Noise is 1μW. Now what are the values of SNR dB, and SNR.

Soln:

Power of signal (S) = $10\,mW = 10 \times 10^{-3}\,W.$

Noise of the signal (N) = $1\,\mu W = 10 \times 10^{-6}\,W.$

Now,

$$SNR = \frac{\text{Signal (S)}}{\text{Noise (N)}}$$

$$= \frac{10 \times 10^{-3}\ W}{10 \times 10^{-6}\ W}$$

$$SNR = 10^4$$

Then,

$$SNR_{dB} = 10 \log_{10}\left(\frac{S}{N}\right)$$

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

$$SNR_{dB} = 40\ dB$$

Error and it's types:

→ During transmission the signal gets contaminated due to the addition of noise.

→ i.e. 0 may changed to 1 and vise-versa.

→ This error can become a serious issue in the accuracy of digital system. So, it is necessary to detect and correct the error.

→ Depending upon the no. of bits in error, error can be classified into two types:-

1) Single bit error
2) Burst error

1) Singale Signal bit error:

→ The term single bit error means that only one bit of a given data unit is changed from 1 to 0 or 0 to 1.

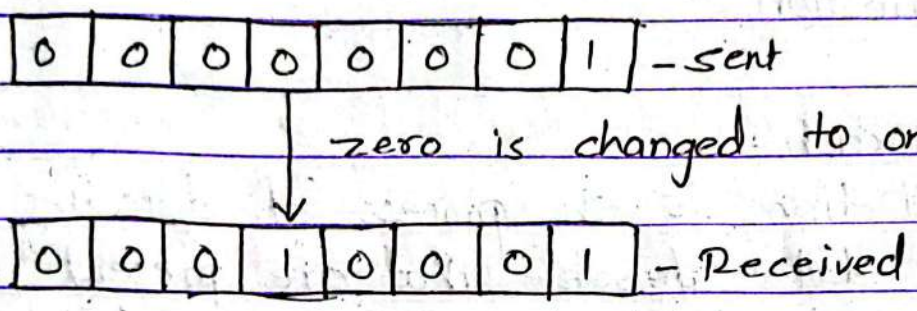


fig: Sig. Single bit error.

2) Burst error:

→ The term burst error means two or more bits in the data unit have changed from 0 1 to 0 or vice versa.

→ The burst error does not necessarly mean that the error occured in consecutive bits.

→ The length of the burst is measured from the first corrupted bit to last corrupted bit.

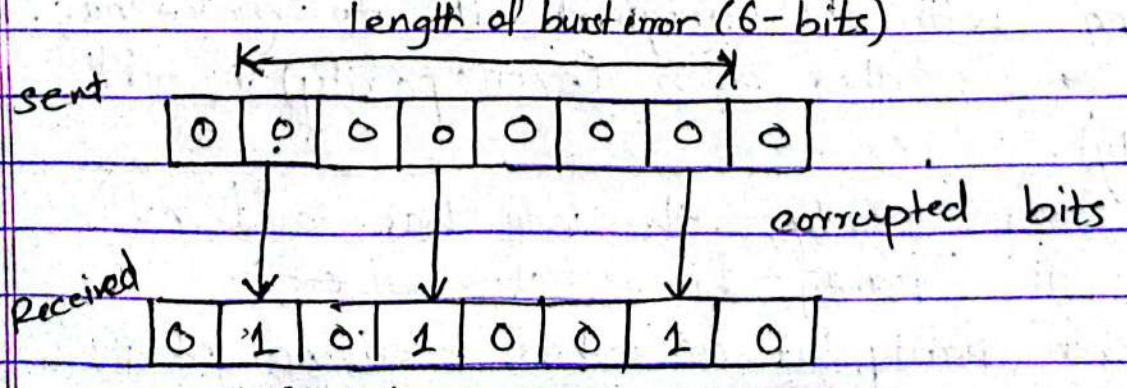


fig: burst error

Date
Page

* Error detection and correction :

→ Error control mechanism may involve two possible ways:-

a) Error detection
b) Error Correction

a) Error detection :

→ Error detection is the process of detecting the error ~~data present~~ that are present in the data transmitted from transmitter to receiver.

→ There are following types of error detection technique. They are :-

i) Parity checking or Vertical redundancy check (VRC)
ii) Longitudinal redundancy check (LRC)
iii) Cyclic redundancy check (CRC)
iv) Checksum.

i) Parity checking or Vertical redundancy check

→ In this method, one extra bit is sent along with the original bits to make no. of one's either even (even parity) or odd (odd parity).

→ In even parity, if the data has odd no. of one's the parity bit is one. ~~else 0~~

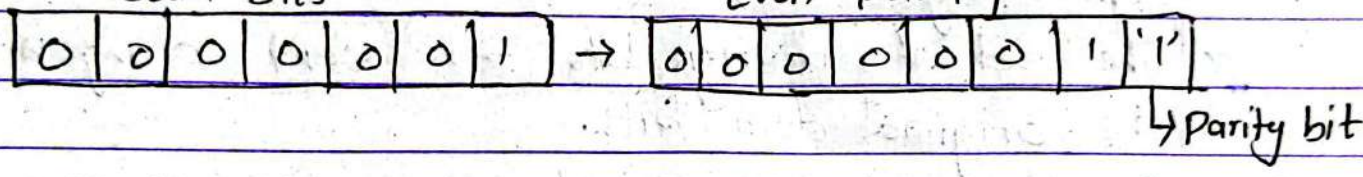
→ In even parity, if data has even. no. of 1's the parity bit is 0.

→ Similarly, in odd parity, if the data has odd no. of ones the parity bit is zero, ~~else 1~~

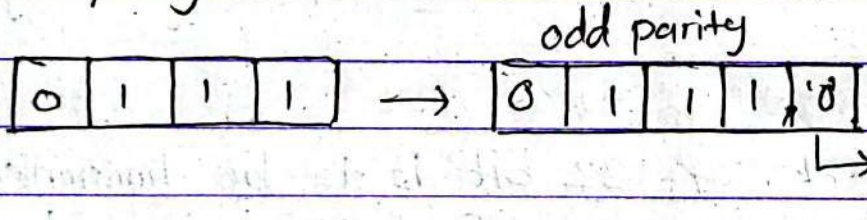
→ In odd parity if the data has even no. of ones the parity bit is one.

→ Examples:

a) even parity



b) Odd parity.



→ If the no. of one's is odd in receiver end ~~and~~ when even parity is used then the data frame is consider to be incorrect. so, it should be corrected.

→ Similarly, for odd parity if the no. of count of one's is even. in receiver end then the data frame is consider to be incrorrect. So, it should be corrected.

→ This parity method works when there is single bit error.

ii) Longitudinal redundancy check (LRC):-

→ It is also called as 2D parity check.

→ In this method ~~column~~ a block of bit is organized into a table with rows and columns.

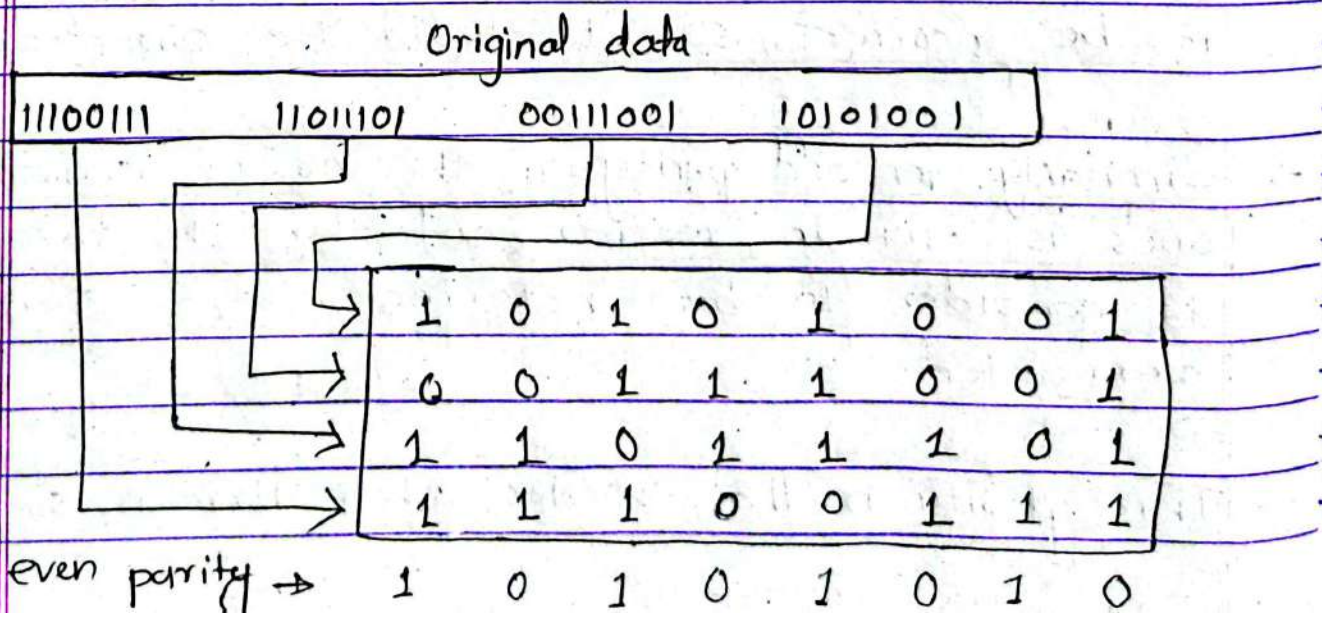
→ The parity bit is calculated for each column seperately.

→ The set of parity bits are sent along with the original data bits.

→ At the receiving ends these are compared with parity bits calculated on the receiving data.

→ Example!

If a block of 32 bit is to be transmitted, it is divided into matrices of 4 rows and 8 columns as shown in fig below:



→ This method can easily detected burst error and single bit error.

⇒

iii) Cyclic Redundancy Check (CRC) :-

→ It is based on binary division.

→ At the sender side, the data unit to be transmitted is divided by pre-determined divisor in order to obtain ~~remind~~ remainder.

→ The divisor is generated by using polynomial.

→ The CRC has one bit less than divisor.

⇒ At the destination, the incoming data (data + CRC) is divided by pre-determined divisor.

→ If the reminder after the division is '0' then there is no error. and accepted else rejected.

Example: (No error in transmission).

Q. Data word to be sent → 100100

Generator polynomial → x^3+x^2+1

→ Soln:

Given polynomial → $x^3 + x^2 + 1$

$1.x^3 + 1.x^2 + 0.x^1 + 1.x^0$

↓ ↓ ↓ ↓

key (k) = 1 1 0 1

The binary data is first augmented by adding (k-1) zeros in the end of the data.

∴ k = 4 bit

k-1 = 3

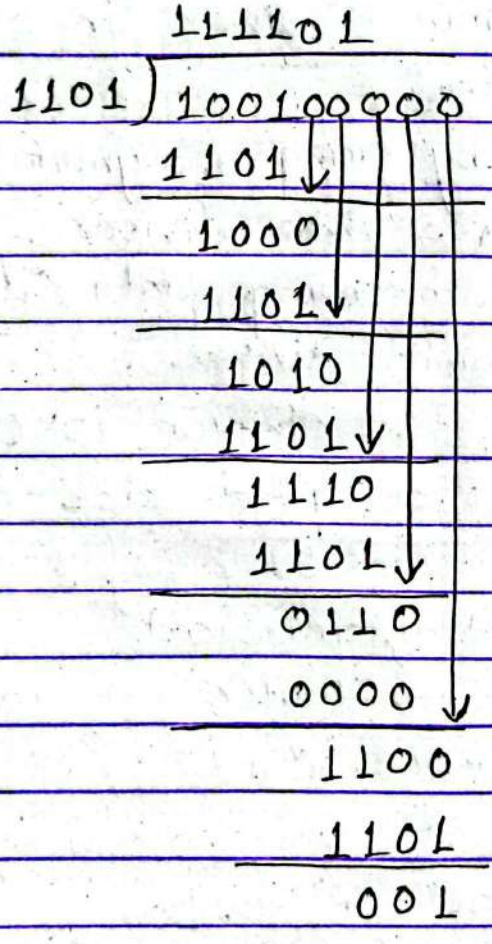
$\therefore k = 4$ bit

$k - 1 = 3$

Now,

$100100 + 000 = 100100000$

a) At sender side



→ CRC (Reminder)

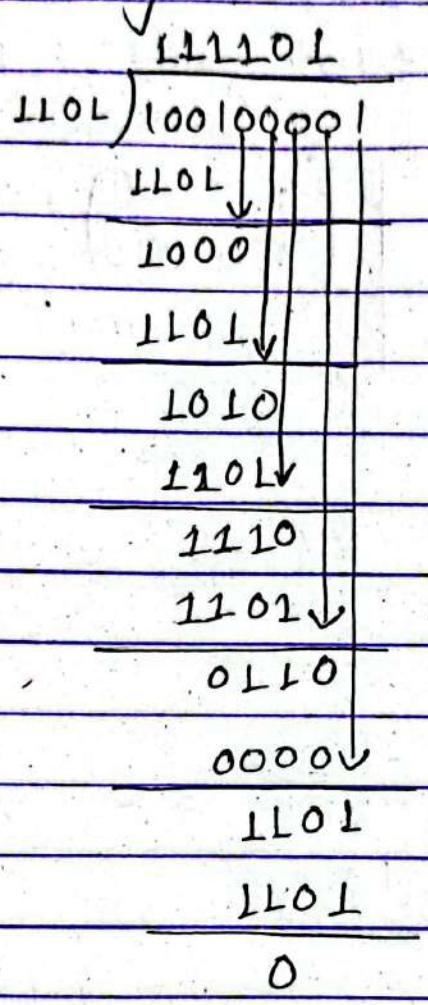
→ Hence the encoaded data to be sent is

~~CRC +~~ (Data + CRC)

i.e. (100100 + 001)

= 100100001

b) At receiving side:



Part-2

Let suppose the sender as usual and the data received at the receiver side is 100000001

Key (k) = 1101

1 0 0 (1) 0 0 0 0 1
1 0 0 (0) 0 0 0 0 1
error

```
        1 1 1 0 1 0
    ---------------
1101 ) 1 0 0 0 0 0 0 0 1
       1 1 0 1
       -------
         1 0 1 0
         1 1 0 1
         -------
           1 1 1 0
           1 1 0 1
           -------
             0 1 1 0
             0 0 0 0
             -------
               1 1 0 0
               1 1 0 1
               -------
                 0 0 1 1
                 0 0 0 0
                 -------
                   0 1 1
```

→ Hence, Since the remainder is not 0 at the receiving end there is error in the received data.

→ It indicates that an error has been occured during data transmission from sender to the

receiver.

Q.? Data word = 1001

polynomial generator = $x^3 + 1$

show that there is error free transmission at the receiver.

Soln:

Given polynomial generator $= 1.x^3 + 0.x^2 + 0.x^1 + 1.x^0$

$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$

$1 \quad 0 \quad 0 \quad 1$

Hence the value of key (k) is 1001.

Now,

Lets add (k-1) zero's to the data word

Then data word become = 1001 + 000

= 1001000

a) At sender side:

```
      1000
   ------------
1001)1001000
     1001
     ----
     0000
     0000
     ----
      0000
      0000
      ----
       0000
       0000
       ----
        000   → CRC
```

Hence the encoded data to be sent;

(Data + CRC)

⇒ 1001 + 000

⇒ 1001000

b) At receiver side

```
      1000
    ------
1001 | 1001000
     - 1001
     ------
       0000
       0000
       ------
        0000
        0000
        ------
         0000
         0000
         ------
          000
```

→ Proved

Hence, it is error free.

iv) Checksum:

→ In checksum error detection, the data is divided into the k-segment each 'n' bit.

→ In the sender side the segments are added using the 1's complement.

→ The sum is complemented to get checksum.

→ The data along with the checksum is transmitted to the receiver.

→ At the receiver side, all receive segments are added using 1's complement to get the sum.

→ The sum is then complemented if the result is 0, the received data is accepted else discarded.

→ Example:

Consider the data unit to be transmitted is

10011001 11100010 00100100 10000100.

also 8-bit checksum is used.

Please Turn Over ⇒

At sender side

1 → 10011001

2 → 11100010

Carry → [1] 01111011

+1

01111100

3 → 00100100

10100000

4 → 10000100

Carry → [1] 00100100

+1

Sum → 00100101

checksum = 1's complement of sum

= 11011010

At receiver side :

P.T.O ⇒

```
  10011001
  11100010
 [1]01111011
      +1
  01111100
  00100100
  10100000
  10000100
 [1]00100100
      +1
  00100101
```

Sum → 00100101

Now,

By adding checksum and sum

= ~~00~~ 11011010 + 00100101

= 11111111

```
  00100101
  11011010
  11111111
```

On complementing this value we get

= 00000000

Hence there is no error occured in data. So, the data is accepted.

Q. Find the checksum value of ~~1001 0011~~ 1001001110010011 and 1001100001001101 of 16 bit segment.

* At sender

```
  1001001110010011
  1001100001001101
Carry 1 0010101111100000
                    + 1
Sum → 0010101111100001
```

* Checksum = 1's complement of sum
= 1101010000011110

* At receiver side:

```
  1001001110010011
  1001100001001101
Carry → 1 0010101111100000
                    + 1
Sum → 0010101111100001
```

By adding sum and checksum

```
  0010101111100001
  1101010000011110
  1111111111111111
```

It's complement is 0000000000000000.
No error occured.

b) Error Correction:

→ Error detection codes are used to detect and correct the error when data is transmitted from sender to receiver.

→ Error correction can be handel in two ways. They are:

i) Backward Error Correction
ii) Forward Error Correction

i) Backward Error Correction

→ Once the Error is detected, the receiver request the sender to retransmit the data unit.

ii) Forward Error Correction

→ In this case, the receiver use as the error correcting part which automatically corrects the error.

→ For correcting error, one has to know the exect position of the error.

→ Hamming code is the technique used in forward error detection.

Data Compression Technique

→ Data compression deals with the algorithm and technique for compression of data.

→ Data compression becomes essential due to the following reasons.

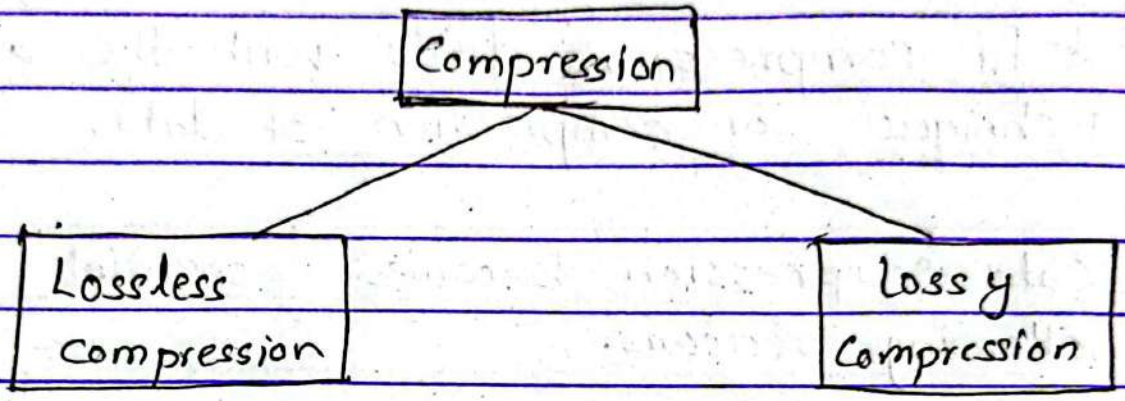
a) Storage :-
The reduction of data reduces the memory requirement. Hence, it helps in storage.

b) Transmission :-
The transmission time of data is directly proportional to the size of the data.

c) Faster Computation :
Reduce data often ~~simplify the~~ Simplifies the algorithm design and facilate faster execution of algorithm.

d) Fo

* Types of Compression:



1) Lossless Compression:

→ Lossless Compression algorithm preserves information and the compression process does not let data loss.

→ Hence ~~these a~~ this algorithm are used in fields where ~~realibil~~ reliablity and preservation of data are arucial (important).

→ However, the compression ratio of this algorithm is small in comparision to lossy compression algorithm.

→ Some of the popular lossless compression algorithm are as follows:-

a) Huffman Coding
b) Run length coding
c) Shanon fano coding
d) Arithmetic coding
e) Dictionary based coding.

→ The example of lossless coding is CT-scan, MRI images.

2) Lossy Compression :
→ It is useful in fields where data loss is accepted.
→ This is non-reversible process and information is lossed.
→ Compression ratio is usually high.
→ Hence, it can save lot of space in storage device.
→ Example of lossy Compression are :-
- JPEG compression (Joint Photography Expert Group).
- MPEG compression (Moving Picture Expert Group).

Chapter-7

Data link Control and Protocol.

Framing:

→ Frames are the units of digital transmission.

→ Framing is the point-to-point connection between two computers or devices consisting of a wire in which data is transmitted.

→ In simple terms, frame is the block of information that is transmitted from sender to the receiver.

→ Framing is an important aspect of data link layer because it allows the transmission of data to be organized and controlled, ensuring that the data is delivered accurately and efficiently.

→ There are two types of framing they are:

1) Fixed-size Framing
2) Variable-size Framing

1) Fixed size Framing:

→ In fixed size framing, each data packet has fixed length.

→ Fixed sized framing helps in easier synchronization between sender and receiver.

→ This means that, regardless of actual data content, each frame occupies the same amount of space.

2) Variable Size Framing:

→ Each data packet has various length.

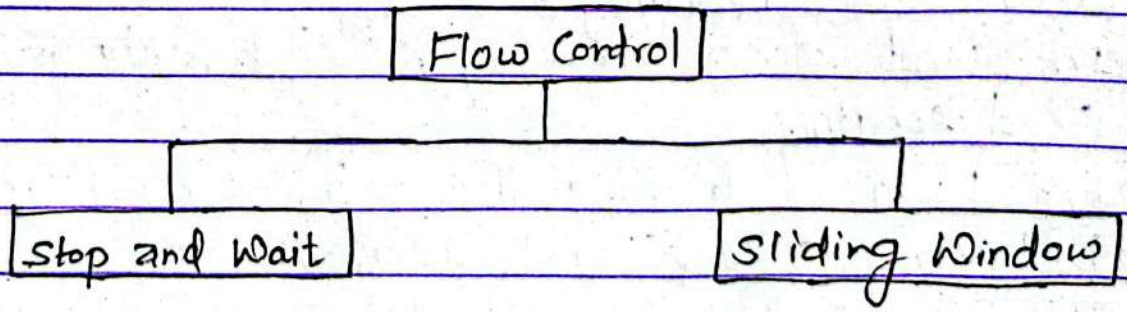
→ Various sized framing helps make difficult synchronization between sender and receiver.

→ ~~That~~ This means that regardless of actual data content, each frame occupies the different amount of space.

Flow Control:

→ Flow Control is the set of procedure that tells the sender how much data it can transmit before it must wait acknowledgement from the receiver.

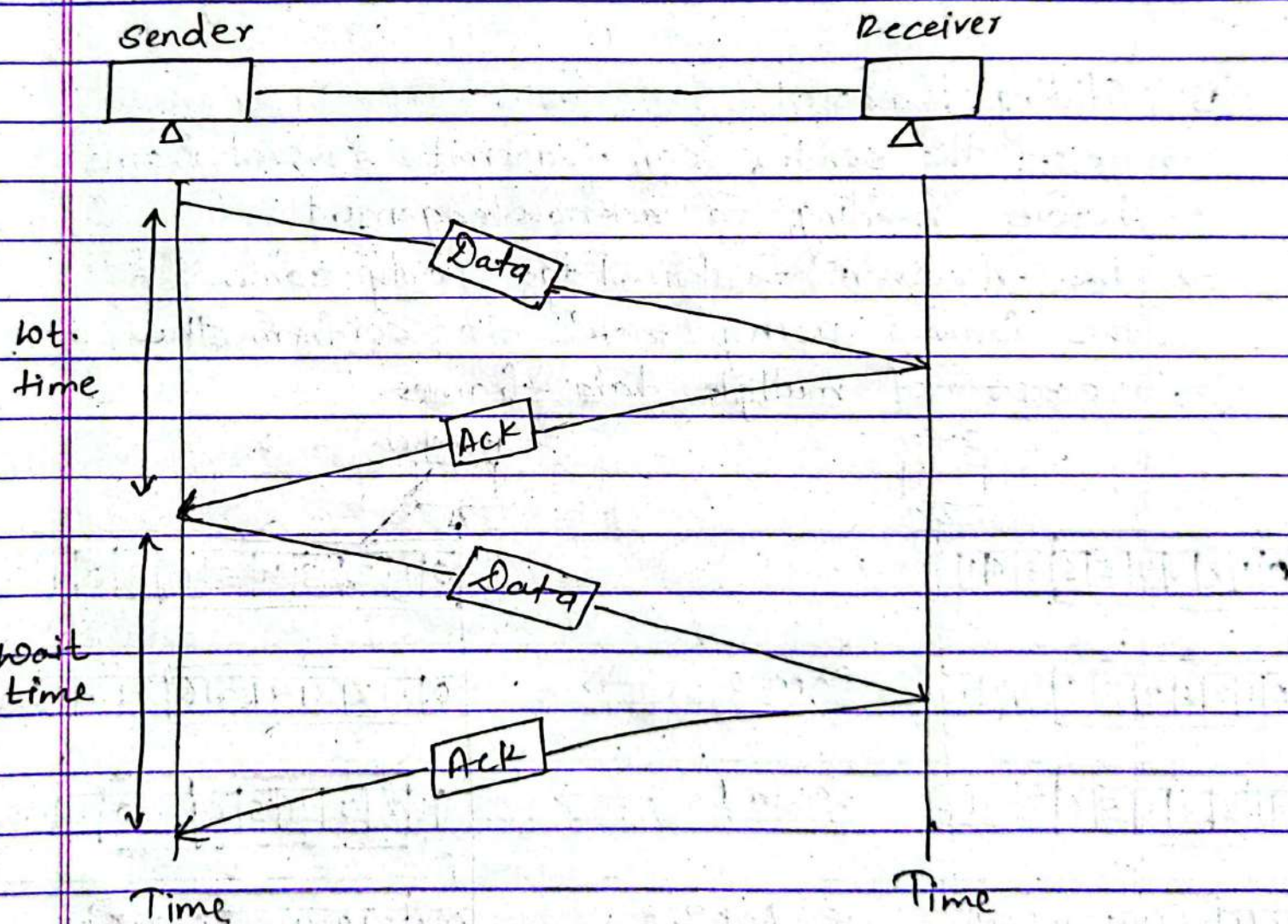
→ Hence, it observes the proper flow of data from sender to receiver.



A) Stop and Wait

→ In this protocol, the sender sends the frame and then waits for an acknowledgement.

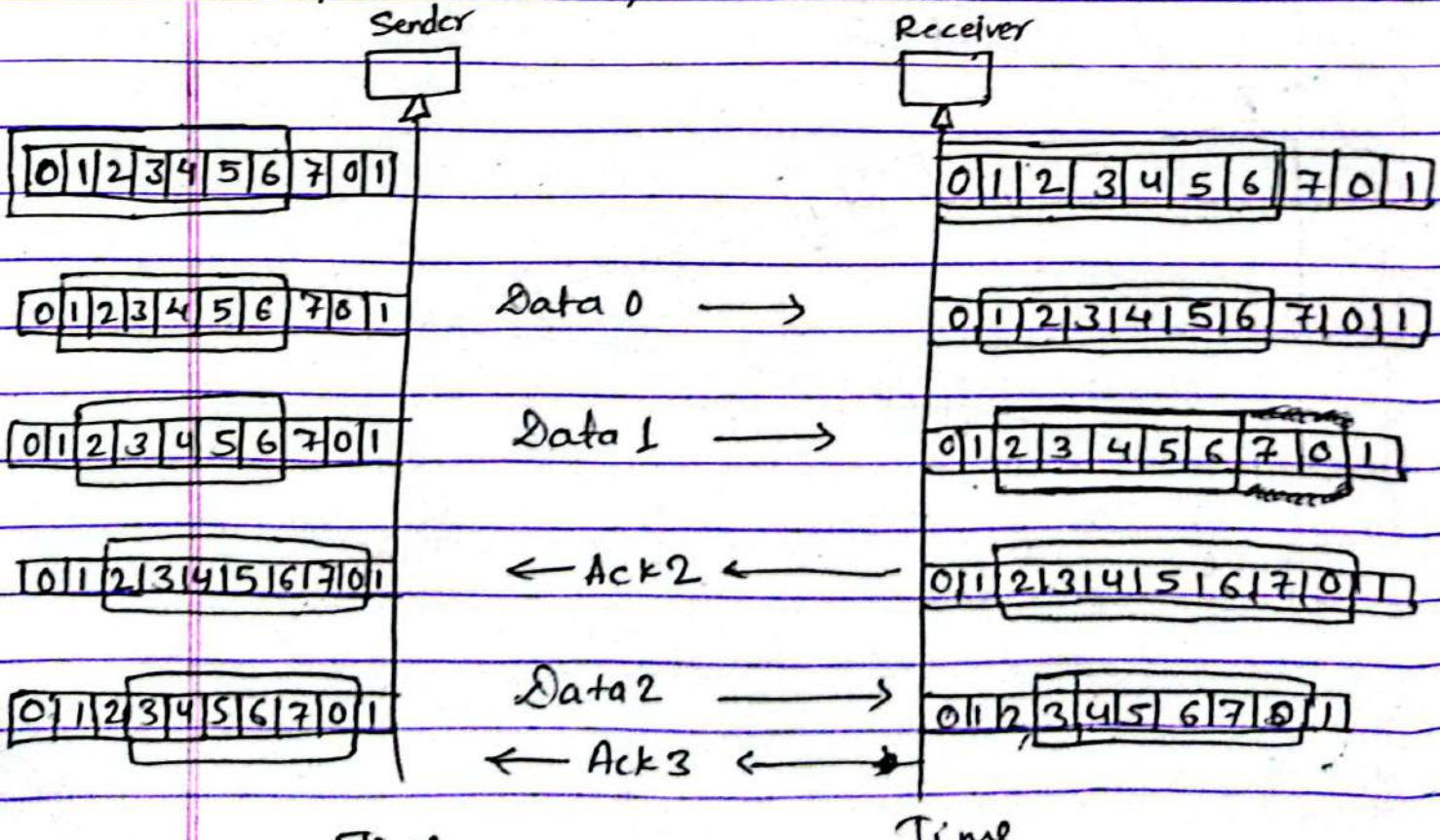
→ The process of sending and waiting repeats until the sender transmits (EOT) end of transmission frame.



* Advantages:
→ Each frame is checked and acknowledged before the next frame is send.
→ This method of transmission is very accurate.

* Disadvantages:
→ It is low efficient due to its waiting time

B) Sliding Window:
→ Here, the sender can transmit several frame before needing a acknowledgement.
→ The receiver acknowledge only some of the frames using ack# to confirm the receipt of multiple data frames.



* Advantages:
→ It performs more efficiently i.e. stop and wait time reduces.
→ Multiple frames can be sent one after another.

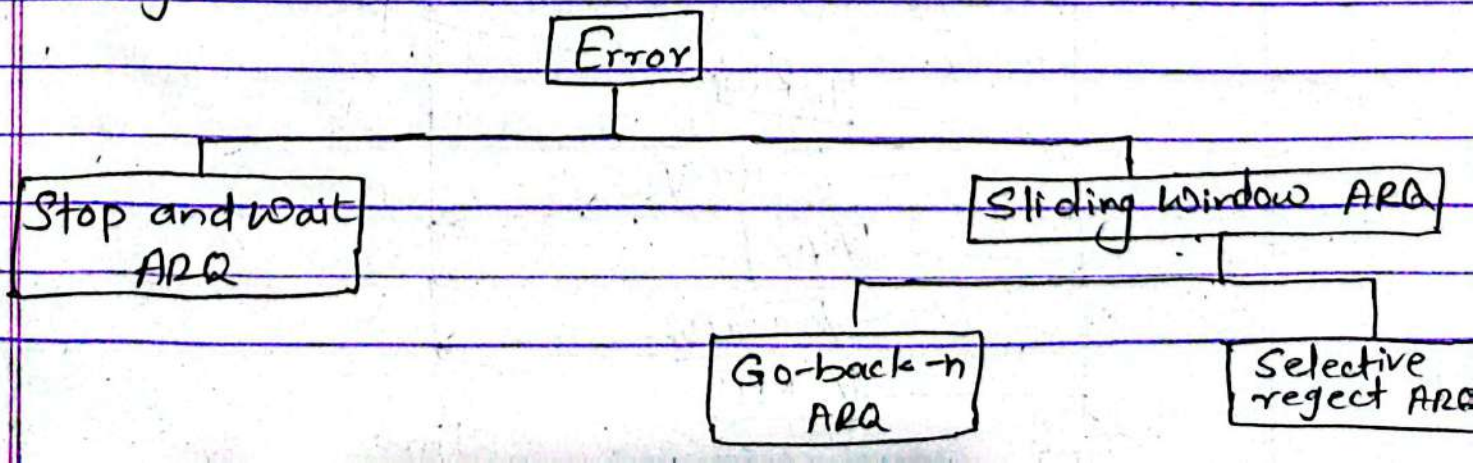
* Disadvantages:
→ Complex due to transfer of multiple frame.

Error Control

→ Error Control in data link layer is based on automatic repeat request (ARQ).
→ In ARQ system of error control, when a error is detected a request is made for retransmission.
→ The retransmission is done in three cases:

1) When the received frame is damage.
2) When the transmitted frame is lost.
3) If the ack from the receiver is lost.

* Categories of Error Control.



A) Stop and Wait ARQ :

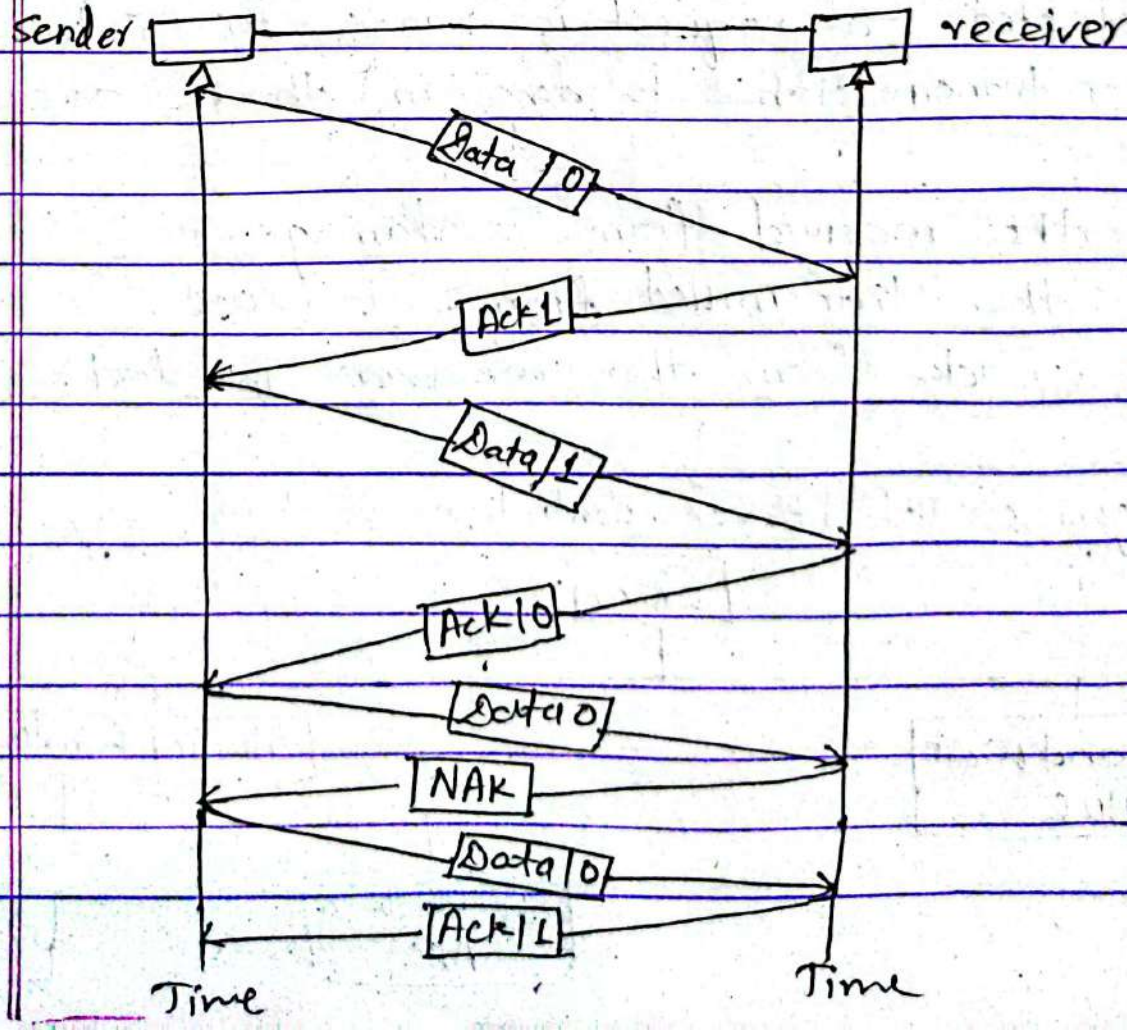
→ In this method, the transmitter transmits the one frame of data and wait for an ack from the receiver.

→ If it receives positive acknowledgement (ack) it transmits the next frame.

→ If it receives the negative acknowledgement (NAK), it retransmit the same frame.

Conditions for stop and Wait ARQ are :

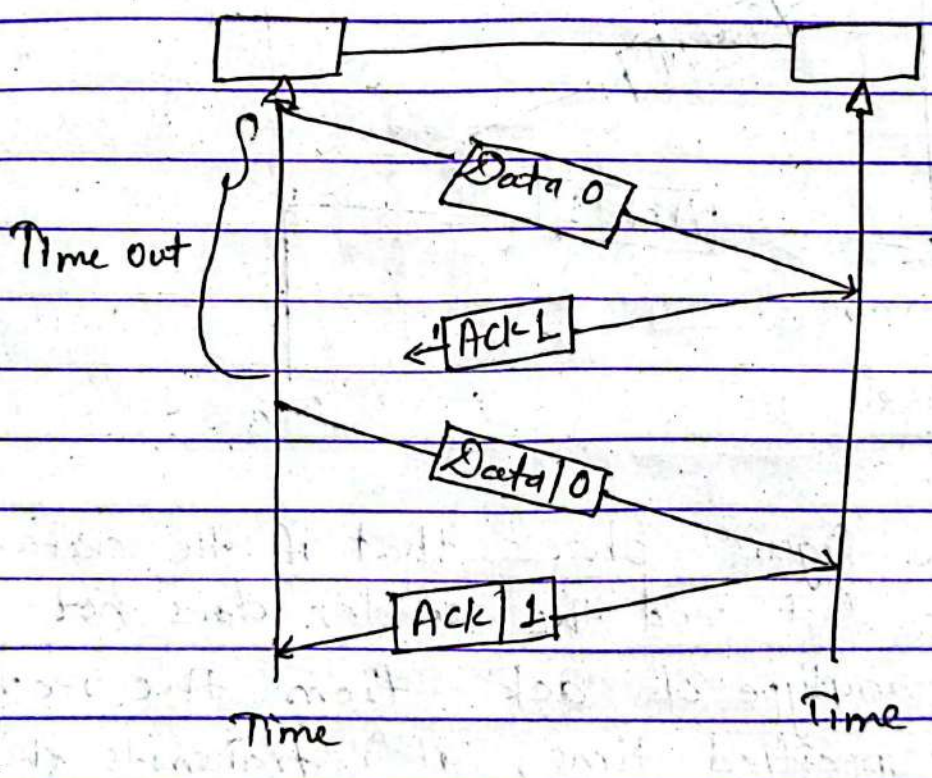
i) stop and wait ARQ when frame is damaged



→ The transmitter transmits the data frame and the receiver returns ack. and this process goes on.

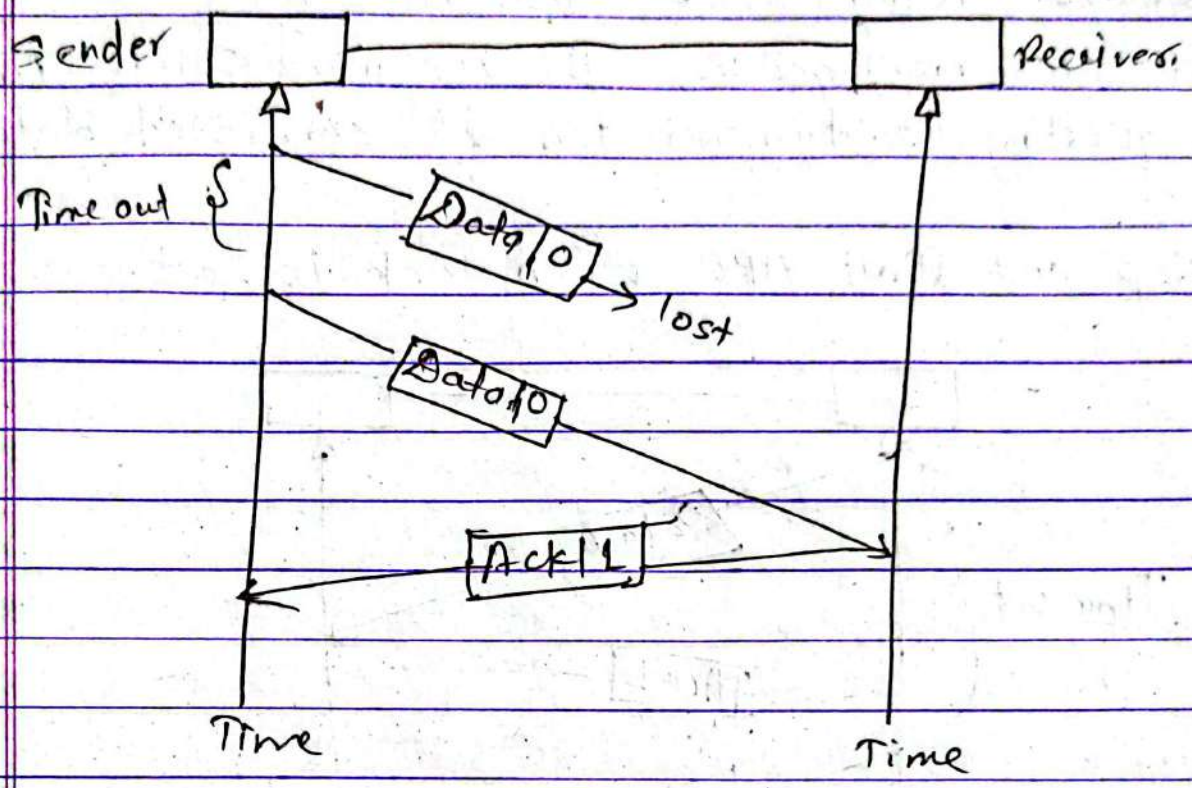
→ If an error occurs, the receiver sends NAK requesting retransmission of corrupted data frame.

ii) Stop and Wait ARQ when ack is lost.



→ The figure above shows that if the ack sent by the receiver is lost, the transmitter (sender) retransmits the same data frame, after the times goes off.

iii) STOP and WAIT ARQ when frame is lost.



→ The above figure shows that if the data frame is lost and the sender does not receive anytype of ack from the receiver in the specified time, it retransmits the same frame again.

* Disadvantage of Stop and Wait ARQ.

→ Stop and wait ARQ protocol becomes inefficient when a propagation delay is much greater than time to transmit a frame.

→ At any moment, only one frame is in transition.

~~Example : I~~

B) Sliding Window ARQ:

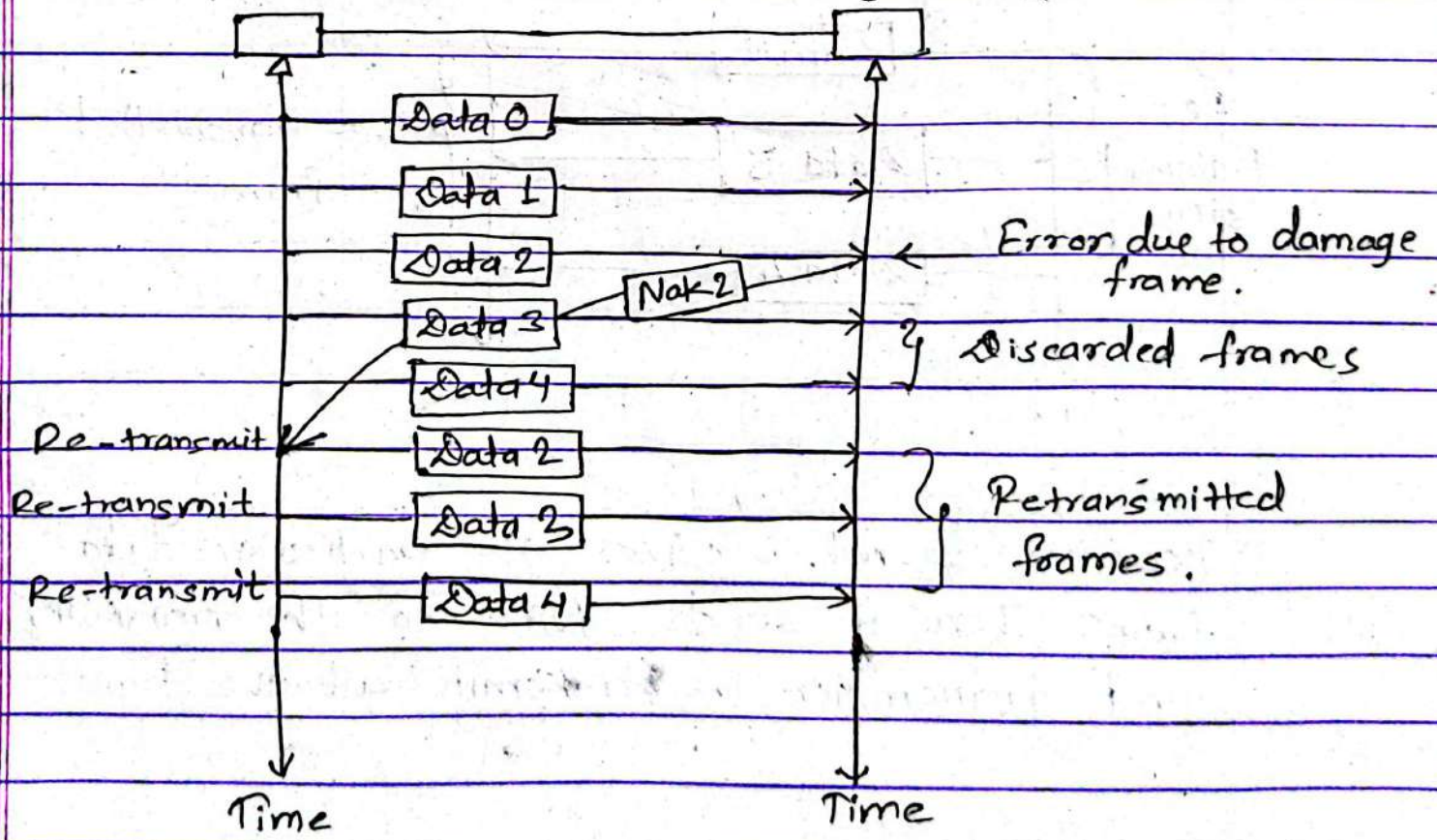
a) ↳ Go-back-n ARQ

b) ↳ Selective reject ARQ

a) ↳ Go-back-n ARQ:

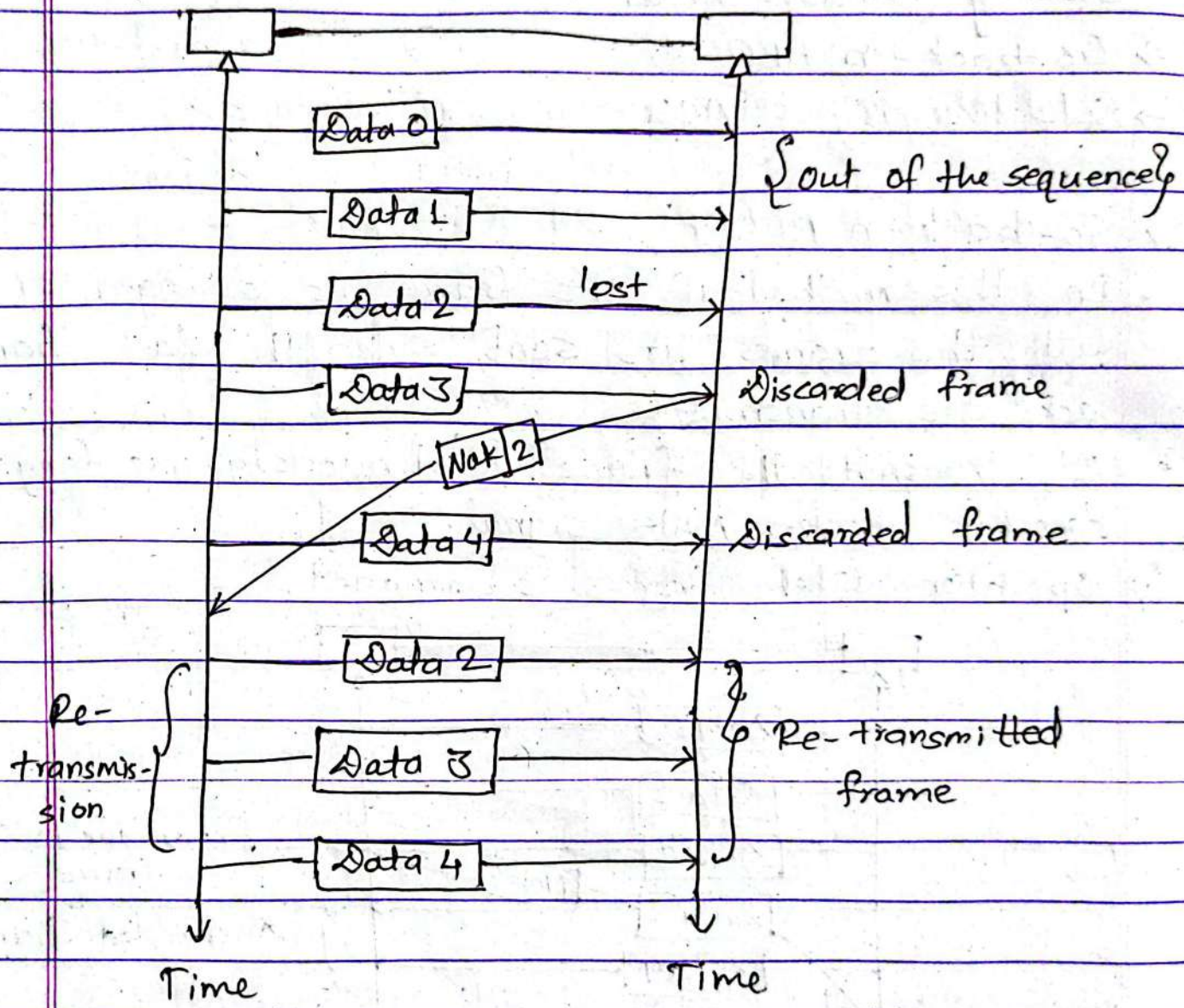
- In this method if one frame is damaged or lost all the frames are sent since the last frame ack are transmitted.
- It transmit the frame continuously as long as it does not receive NAK signal.

i) Operation when frame is damaged.



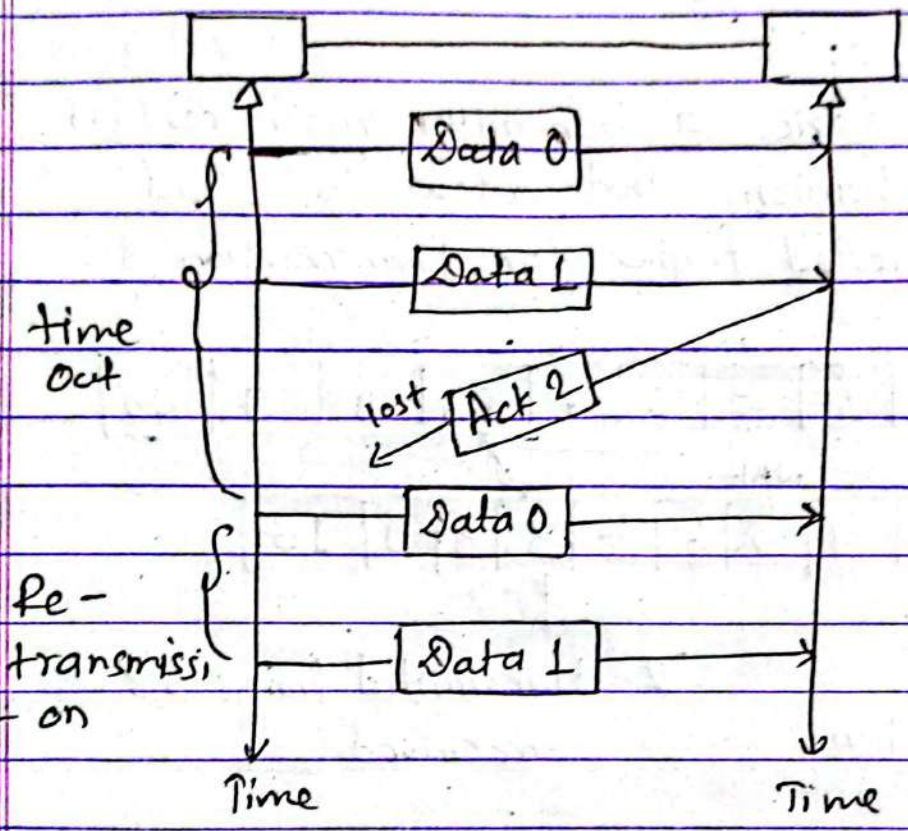
→ If the receiver receives damage data frame than it sends NAK to the transmitter, & transmitter re-transmits all the frame.

ii) Operations when frame is loss



If
-> Receiver does not receives the particular data frame then it sends NAK to the transmitter and transmitter re-transmits all the frame.

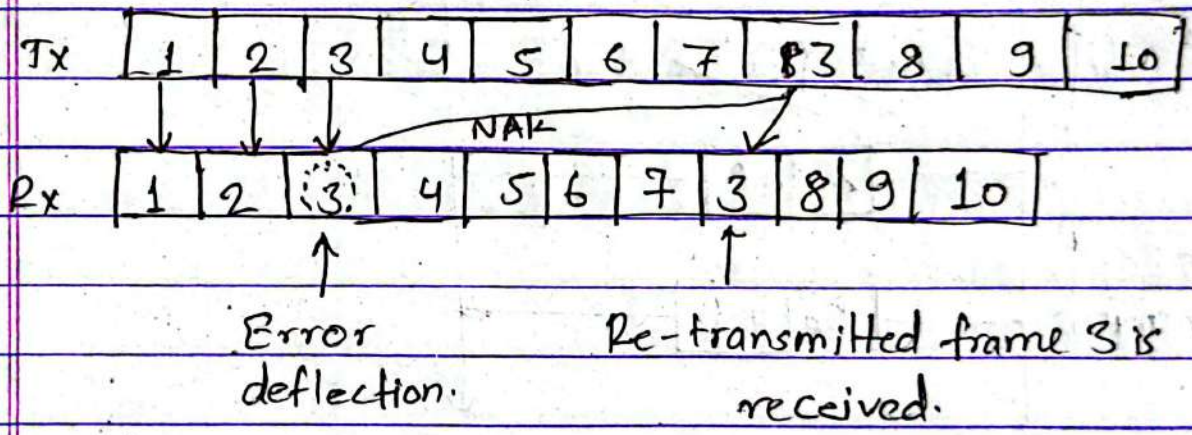
iii) Operation when ack^n is lost.



* Disadvantage of Go-back n ARQ
→ It transmits all the frame if one frame is lost or damage.
→ It transmits frame continuously as long as it does not receives NAk signal.

↳ Selective Window :
• In this method only the specified, damaged or lost frame is retransmitted.

- The receiving device must contain sorting logic to enable it to re-order the frame that is received.
- The sending device a transmitter most contain searching mechanism that allow to find only the requested frame for transmission.



* Advantage:
It has more efficiency

* Disadvantage:
- Requires sorting, storage and extra logic.
- It is more expensive.

Chapter-8

Multiplexing & Switching

* Multiplexing:

→ It is a method by which multiple messages or digital data streams are ~~into one signal~~ combined into one signal over a shared medium.

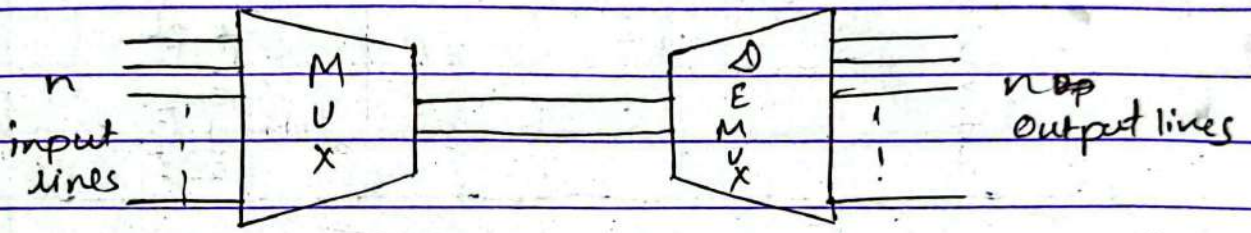


fig: Multiplexing

* Multiplexing Technique:

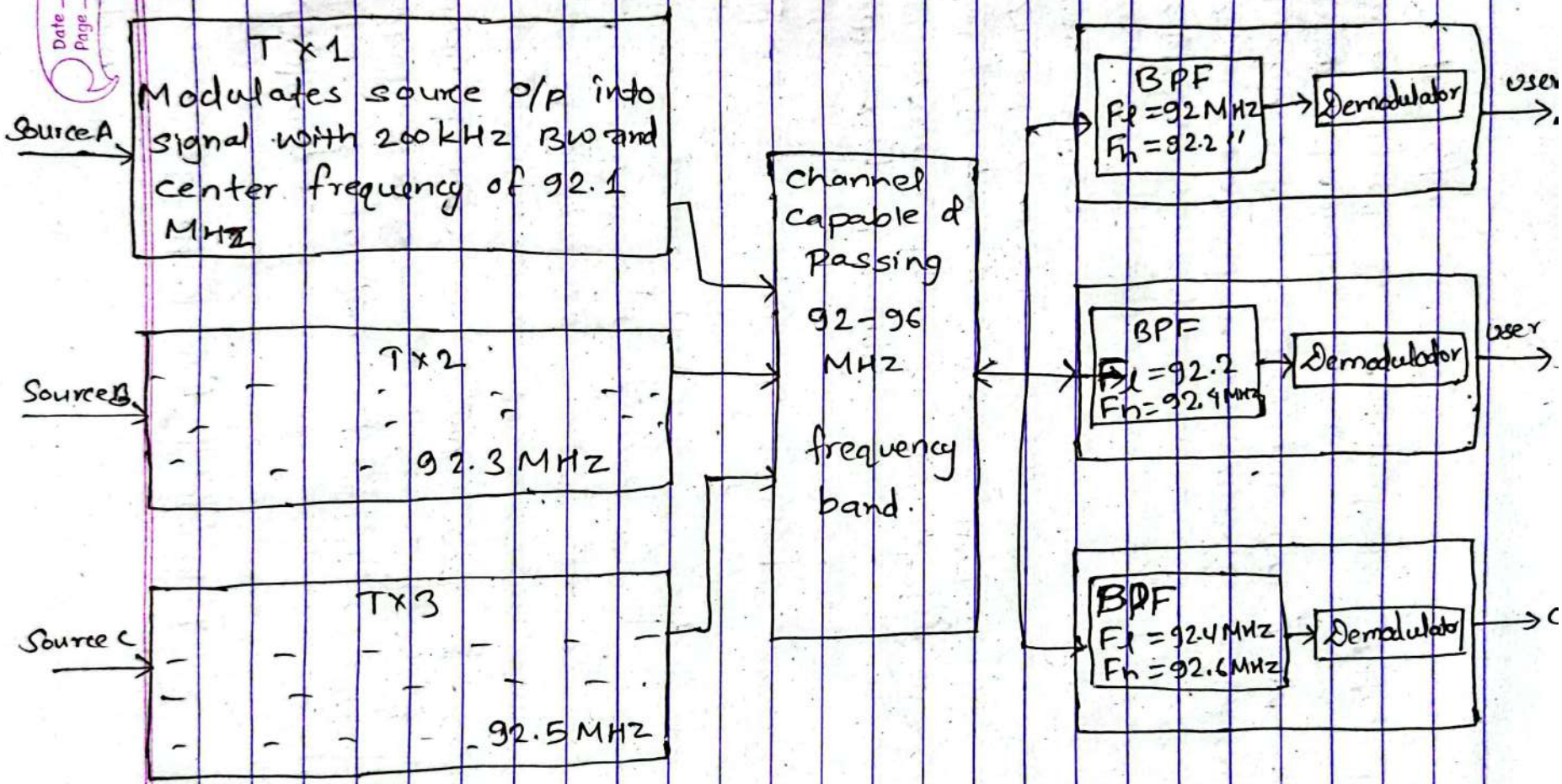
→ The various types of multiplexing techniques are

a) FDM (Frequency Division Multiplixing).
b) WDM (Wavelength " ").
c) TDM (Time " ").

a) FDM:

→ FDM is a scheme or method in which signals are combined for a transmission in a single communication channel.

→ Each signal is assigned to different carrier frequency.



BPF = Band pass filter.
Fl = lower freq^n
Fh = higher "

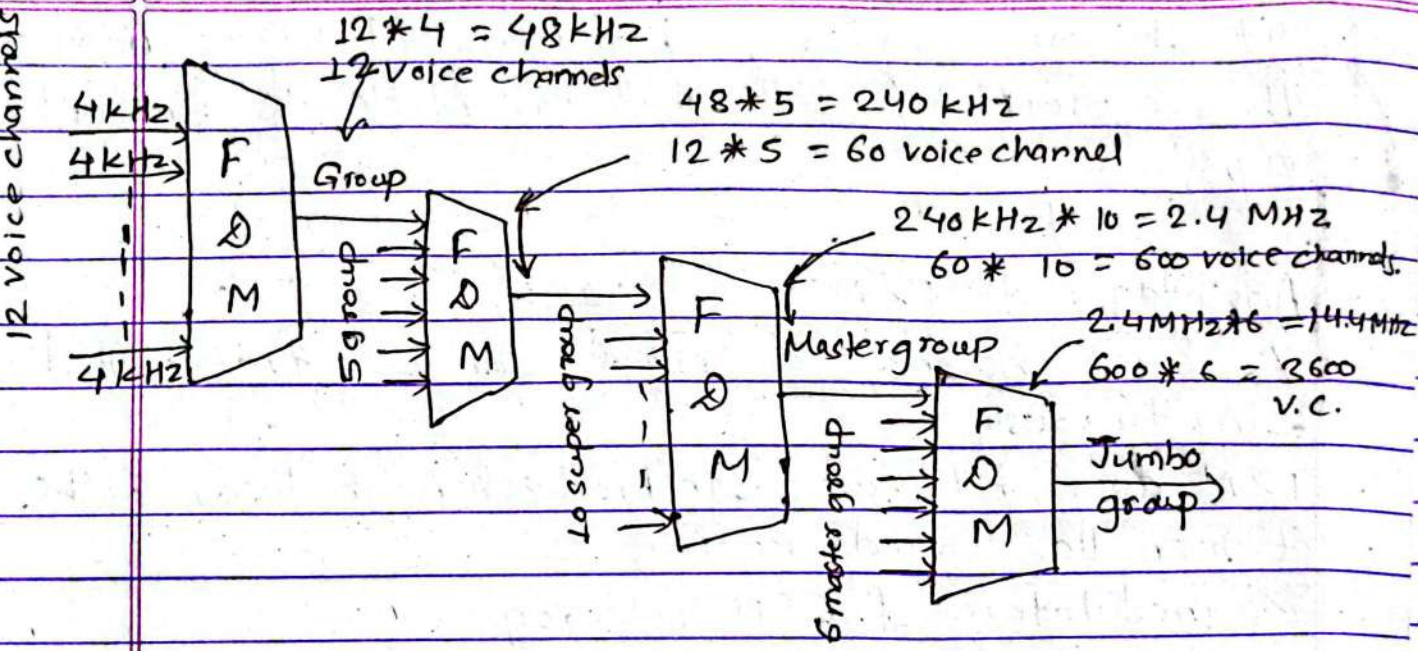
→ At the receiving end, bandpass filter are used to the appropriate users and to block the unwanted signal.

* Advantages of FDM:
→ A large number of signal can be transmitted simultaneously.
→ FDM does not need synchronization between the transmitter and receiver.
→ Demodulation of FDM is easy.

* Drawbacks of FDM.
→ The communication channel must have very large bandwidth.
→ FDM suffer from the problem of crosstalk

* Application of FDM
→ Telephone systems.
→ T.V. broadcasting.

** Telephone System:
→ In 1930's FDM began to be used in the U.S. telephone network.
→ In the U.S AT and T (American Telephone and Telegraphy) company have designed a hierachy of FDM.



Qn.

→ In this analog hierachy, 12 voice channels each having bandwidth of 4 kHz are multiplexed to form a group.

→ A group has 48 kHz of bandwidth and supports 12 voice channels.

→ 5 groups are multiplexed to form a super group.

→ A super group has 240 kHz of bandwidth and supports 60 voke channel

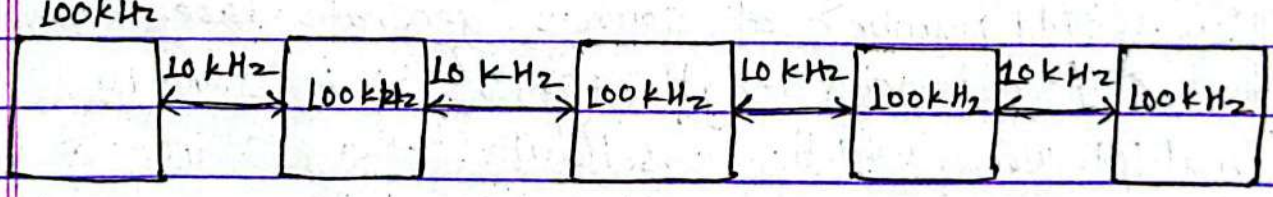
→ 10 super groups are multiplexed to form master groups.

→ Mastergroup has 2.4 MHz of bandwidth and supports 600 voice channels.

→ 6 master group are multiplexed to form a Jumbo group.

Qn. 5 channels each with 100 kHz bandwidth are multiplexed together, what is the minimum bandwidth of the link if there is a guard band of 10 kHz.

→ Soln:



→ This means that for 5 channels we need at least 4 guard band.

→ This means that the required bandwidth = 100×5 + 4×10
= 540 kHz

b) WDM: (Wave length Division Multiplexing):

→ WDM is conceptually same as FDM except that multiplexing and de-multiplexing involve optical signals transmitted through fiber optic channels.

→ In other words WDM refers with the application of FDM in optical fibre.

→ Hence, WDM is designed to use high data rate capability of fiber optic cable.

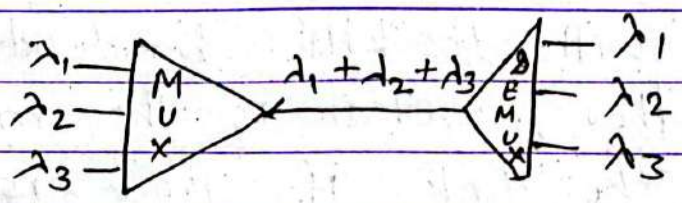


fig: WDM

→ In WDM, number of sources generate laser beam at different wavelength which are sent to multiplexure which consolidate the source of transmission over a single fibre line.

→ Signals are amplified by optical amplifier which are spaced tens of KM apart.

→ Finally they are de-multiplexed and are seperated and sent to a receiver.

c) TDM (Time Division MUX):

→ TDM is a technique used for transmitting several message signal over a single communication channel.

→ Each user is alloted a particular time interval called time slots or slice.

* Types of TDM:-

i) Synchronous TDM.

ii) Asynchronous TDM

i) Synchronous TDM:

→ In Synchronous TDM, all transmitter are assigned with fixed time interval.

→ The device must send data with in the allocated time slot.

→ Even if these do not have a signal to transmit, the time slot of the device without data is empty.

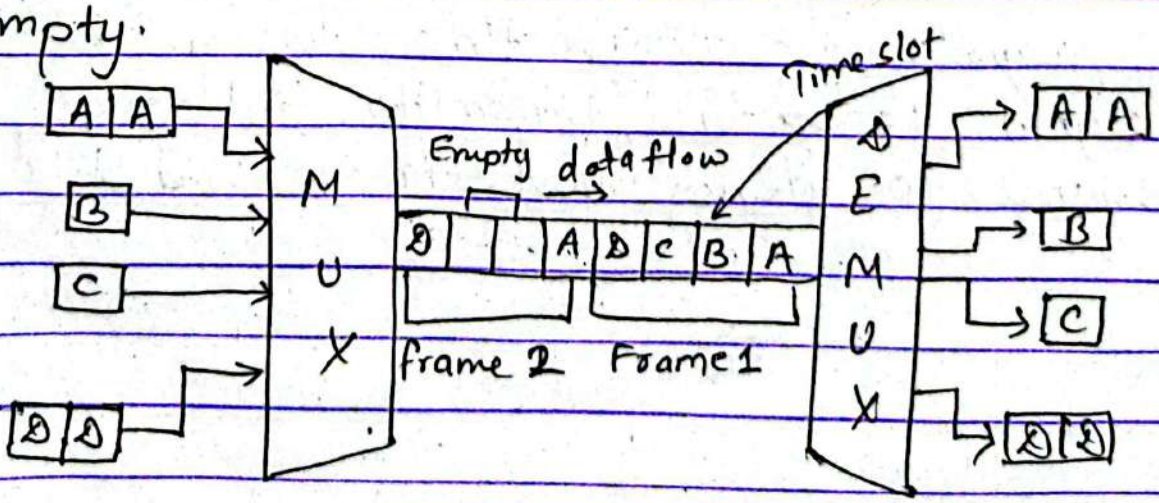


Fig: Synchrorous TDM

→ In the above figure, four transmitter are assigned four time interval per unit frame.

→ In the second frame, the device B and C do not have data to sent, so their space is empty, but the time alloted for them remain in the place.

→ Hence, the disadvantage of this system is that bandwidth is not completely utilized.

(11) Asynchronous ~~Transmission~~ TDM:

→ It is a multiplexing technique in which the time intervals are flexible and not fixed.

→ In asynchronous TDM, the no. of time intervals and no. of transmitter are not equal.

→ In asynchronous TDM, time slots are not assigned to specific transmitter and are assigned to device that one to send data.

⇒

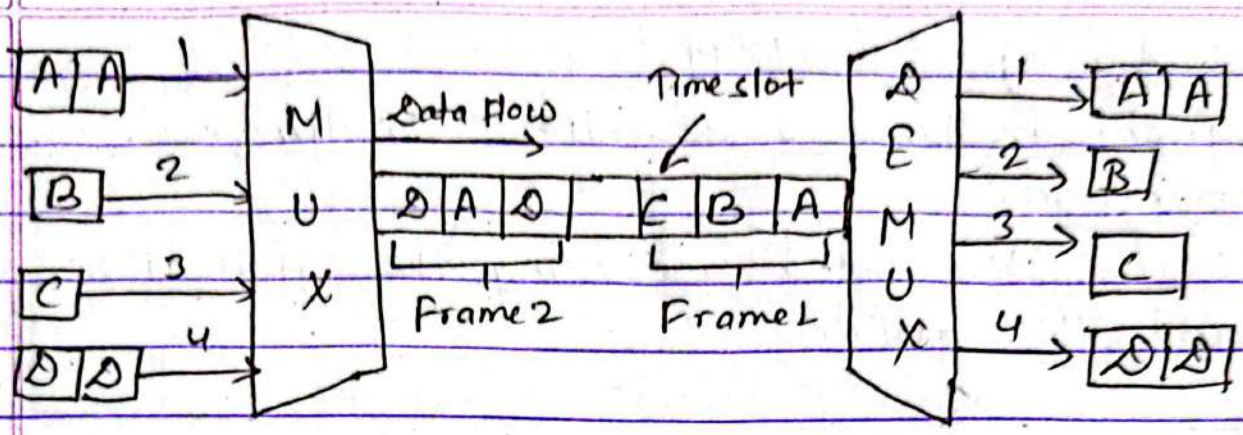


fig: Asynchronous TDM.

→ As shown in fig. the no. of time slot i.e 3 per unit frame is less then the no. of device (four) in the figure.

→ In the first time frame, the slots are occupied and the device that failed to sent data in the 1st time frame i.e. transmitter (D) occupies the second time frame slot.

→ Hence in this system, the multiplexure scans the transmitter and select the ones that have real data to sent.

* Advantages of TDM System:
→ It is more flexible then FDM. method.
→ Intermodulation distortion is absent.
→ TDM circuitary is not very complex.

* Disadvantages of TDM.

→ Synchronization is essential for proper operation.

→ TDM system need addressing the information and the buffer.

* Applications of TDM.

→ It is used in cellular radios.

→ It is used in digital audio mixing system.

→ It is used in SONET (synchronous optical networking).

** Hierarchy of Digital services : (TDM):

→ The telephone company implement TDM to hierarchy of digital signals.

→ Digital services in North America defines for four level transmission hierarchy. T ranges from T_1, T_2, T_3 & T_4.

→ In South America there is 5 level transmission Hence, T ranges from T_1, T_2, T_3, T_4 and T_5

→ The T lines are digital line which are design to transmit digital data (audio or video).

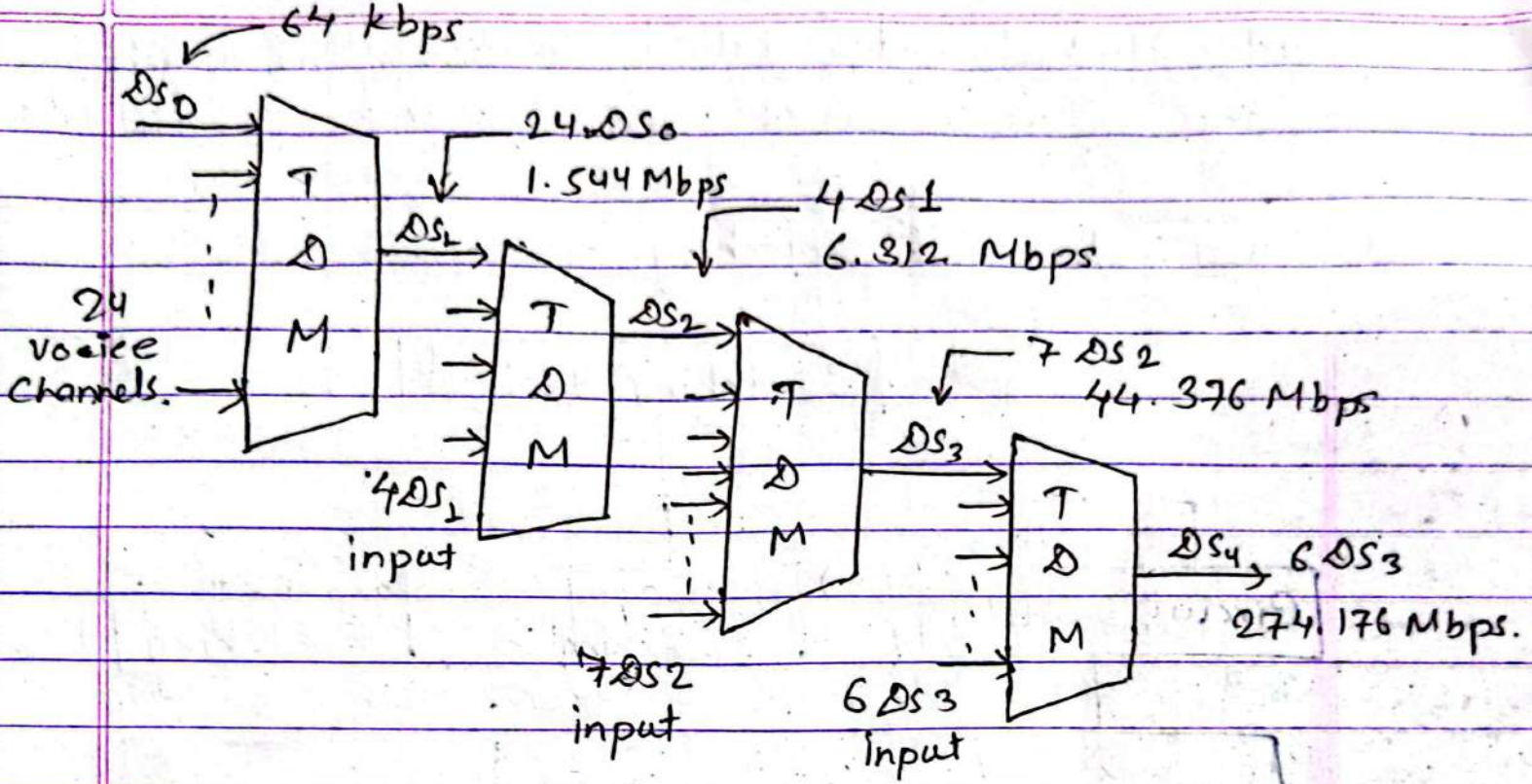


fig: DS hierarchy.

Switching!

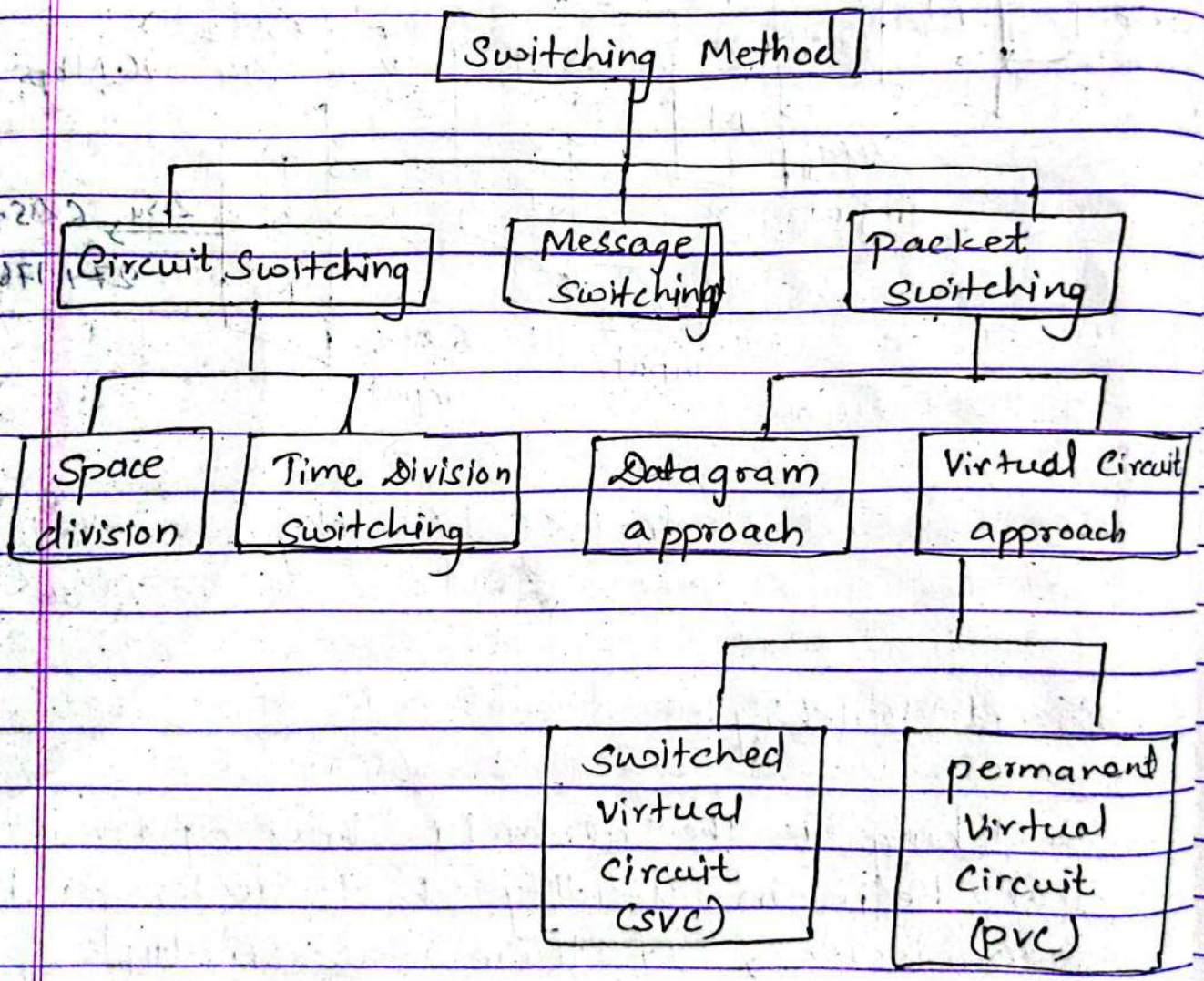
→ Switching is the mechanism in computer network that helps in deciding best routes for data transmission, If there are multiple path in larger network.

→ Switching technique is used to connect the system for making one to one communication.

→ Hence, switched network consists of series of -

inter-linked nodes called switches, in which data is transferred from source to destinatio

Classification of switching.



a) Circuit Switching:

→

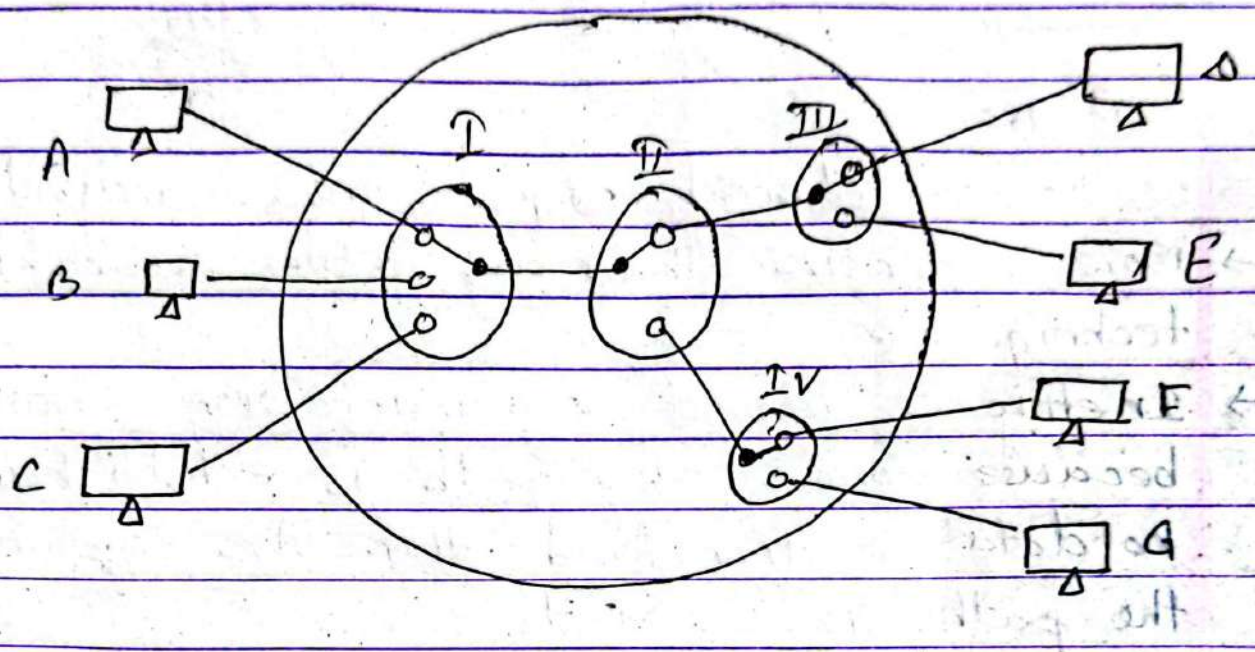


fig: Circuit Switched n/w

→ Nodes I, II, III & IV are connected to the communicating device while III is the routing node

→ Computer A is connected through switches I, II and III to computer D.

→ By moving the level of switches any computer on the left can be connected to any computer on the right.

* Advantages of ckt switching:

→ Dedicated line is established between sender and receiver which provides guranted data transmissio

→ There is no delay in data transmission and hence it is useful in real time data transfer like voice call.

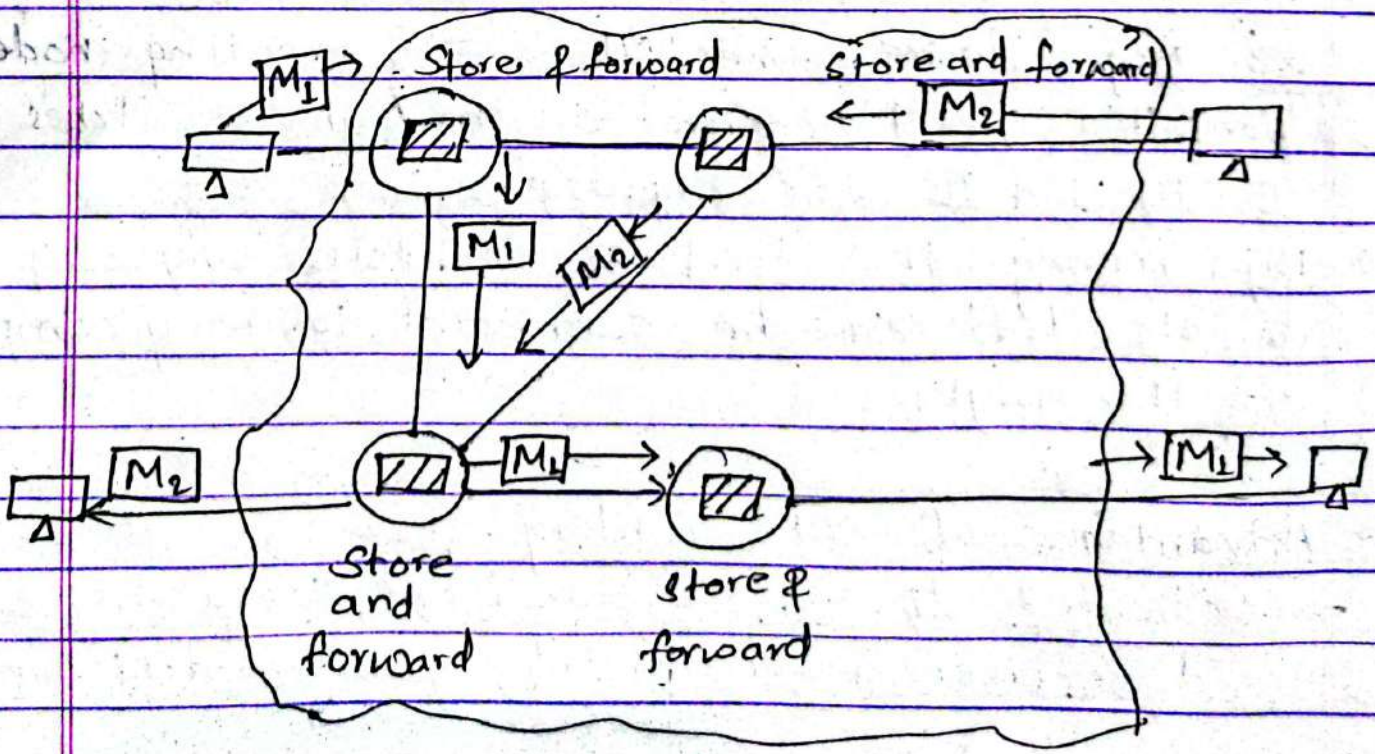
* Disadvantages:

→ Dedicated channel require more bandwidth

→ More expensive than any other switching technique.

→ Inefficient use of communication channel because once the path is established & no data is transferred then the capacity of the path is wasted.

b) Message switching.



→ In this technique there is no dedicated path between sender and receiver.

→ In message switching, each message is treated as independent unit and includes its own source and destination address.

→ Each and every nodes store and forward the entire message to the next node.

→ This type of network is known as store and forward network.

* Advantages: (Pros)
→ Efficiency is improved by sharing a single channel by many message.
→ It supports data of unlimited size.
→ It reduces network traffic.

* Disadvantages: (Cons)
→ As msg length is unlimited, each switching mode should have sufficient storage to buffer msg.
→ It introduce delay so unsuitable for real-time application like voice and video.

c) Packet Switching:

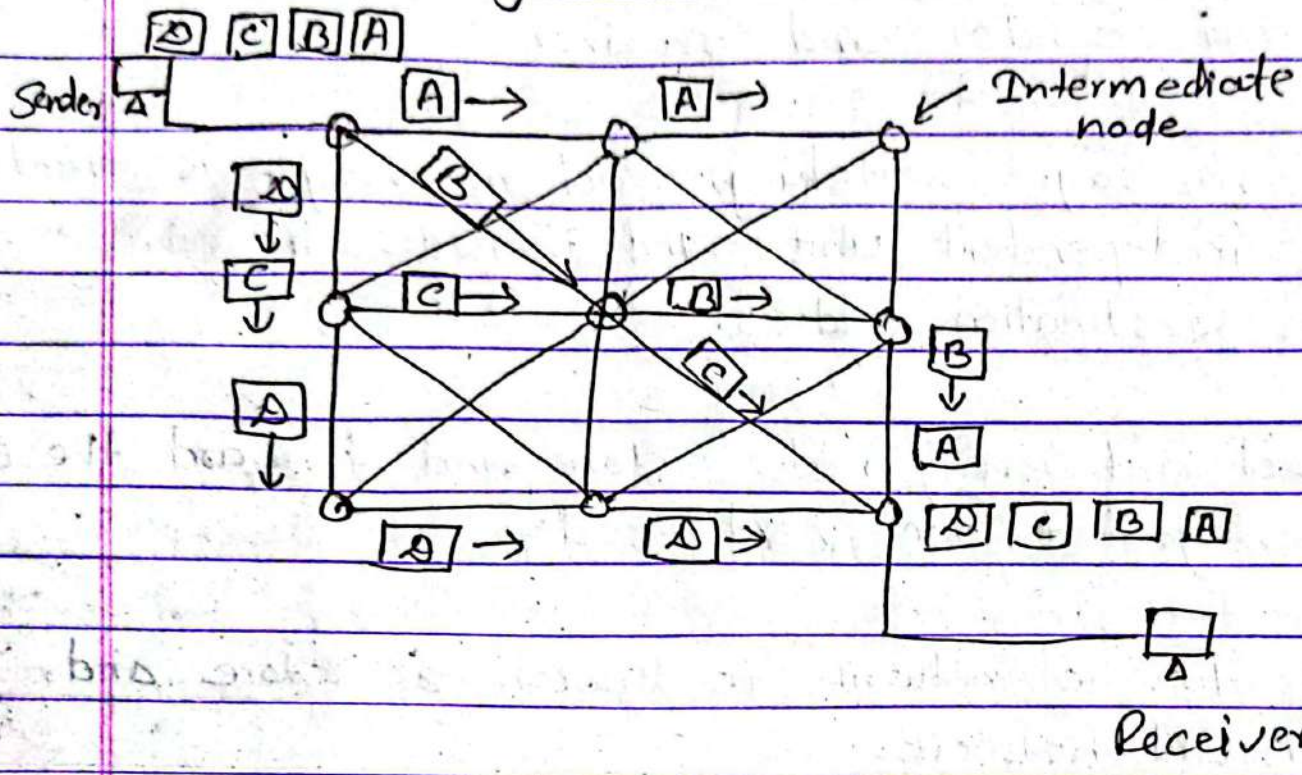


Fig: Packet Switching

→ It is the method for sending the data by dividing the data in packets.

→ Each packet is given a header containing information of the destination.

→ At the destination, the data has to be re-arrange in the form of original message.

→ The biggest packet switch network is the internet.

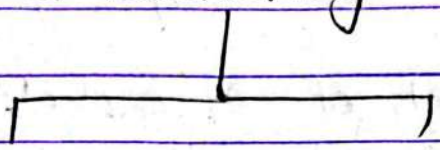
→ The process is diagrammatically represented in fig above.
→ Here, the msg consists of 4 packets A, B, C, D which may follow different route from sender to receiver.

* Advantage:
→ It delivers the data to the destination by finding their own path.
→ It is highly reliable as missing packets are detected by the destination.
→ It uses lesser bandwidth as packets are quickly routed towards the destination.

* Disadvantage:
→ They are unsuitable for application that cannot afford delay in communication like high quality voice call.
→ Protocols used in packet switching are complex.
→ High installation cost is required in packet switching.
→ Since the packets are unordered, it is needed to provide sequence number to each packet.

Packet

Types of Switching:



	Virtual ckt approach	Data gram network
1)	Virtual ckt are network that provide connection oriented ckt at network layer.	1) It is the computer network that provide only a connection less service at n/w layer.
2)	All the packets follows the same path.	2) Every packet is free to choose any path.
3)	Global header is required only for first packet, and other packet doesn't required.	3) The packets must be associated with a header containing source info. about source and upper layer data.
4)	Packets reach in order to destination as they follow the same path.	4) Data packets reach the destination in random order.

5) Vertual circuit are highly reliable.	5) Datagram network are not reliable as virtual circuit.
6) It is costly to implement.	6) It is easy and cost efficient.
7) X.25 is based on virtual packed switching	7) The internet uses datagram packet switching network.

* Private branch exchange (PBX)

→ It is a private telephone network used with in a company or organization.

→ It's main function is to connect the employee internaly.

→ Many PBX uses VOIP (Voice Over Internet Protocol) which provides much flexiblity.

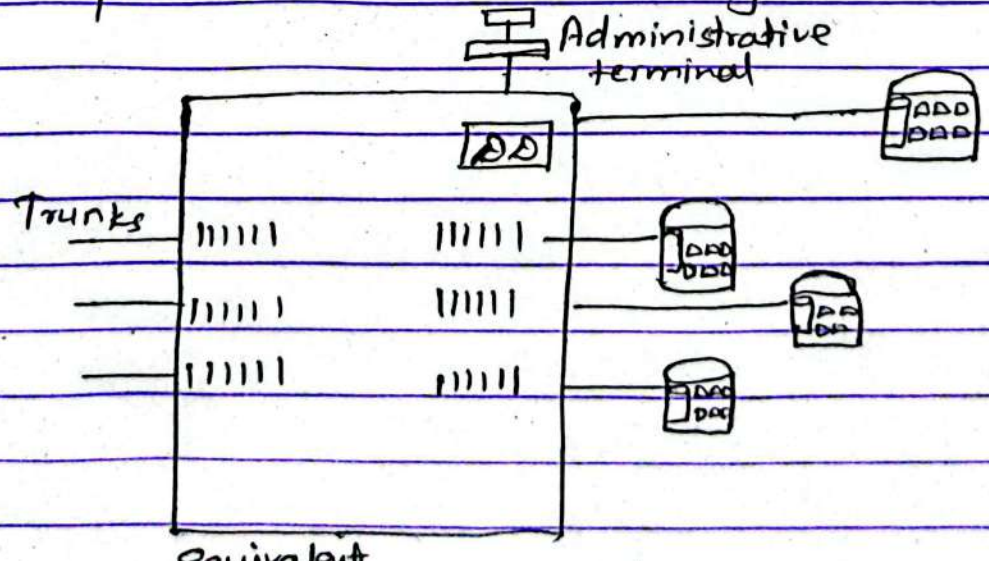


fig: PBX Components

→ It has trunks to connect PBX with PSTN (Public switch telephone network.

→ A cabinate serve as housing for internal path.

→

* Advantages:

→ It is efficient in handling multiple calls.

→ For larger organization it helps in hosting their own phone system.

* Disadvantages:

→ Initial cost is higher due to purchasing hardware and software.

→ It is complicated to design.

DC

Chapter-9

Data Encoding & Modulation

Data Encoding:

→ Data Encoding is the method to convert the data int signal form.

→ In the case of digital data, Encoding is directly run while for another data sampling and quantization are necessary before encoding.

→ Decoding is the reverse process of encoding which is used to extract information from the converted formate.

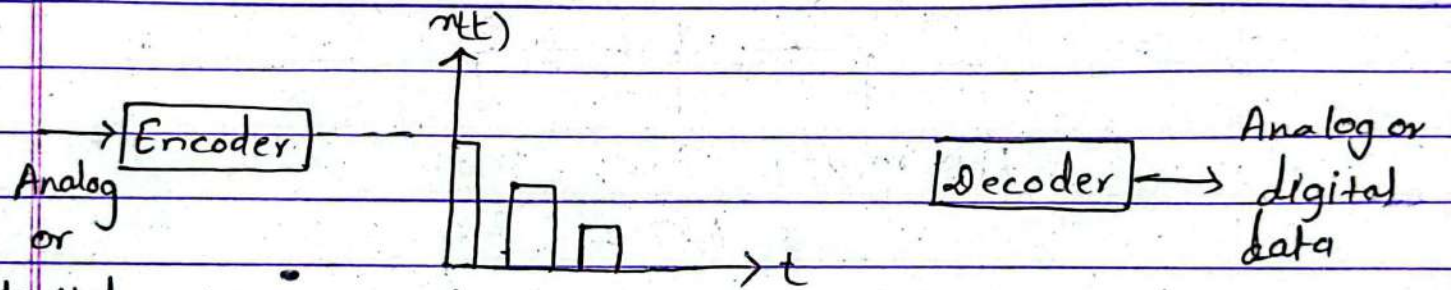
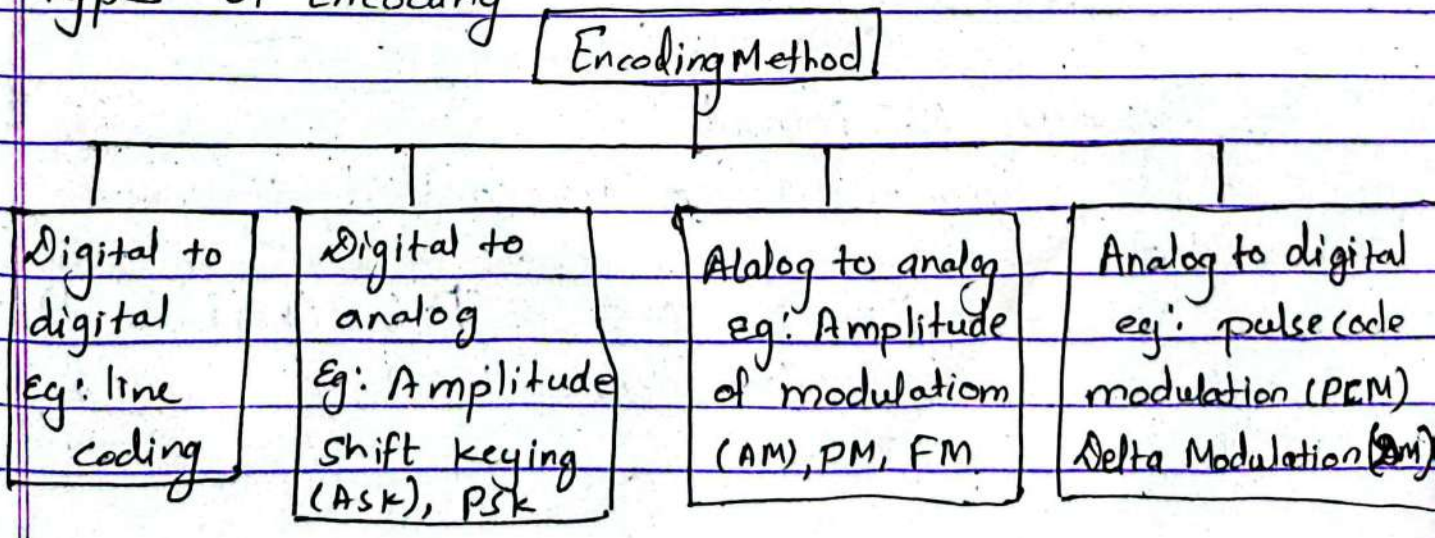
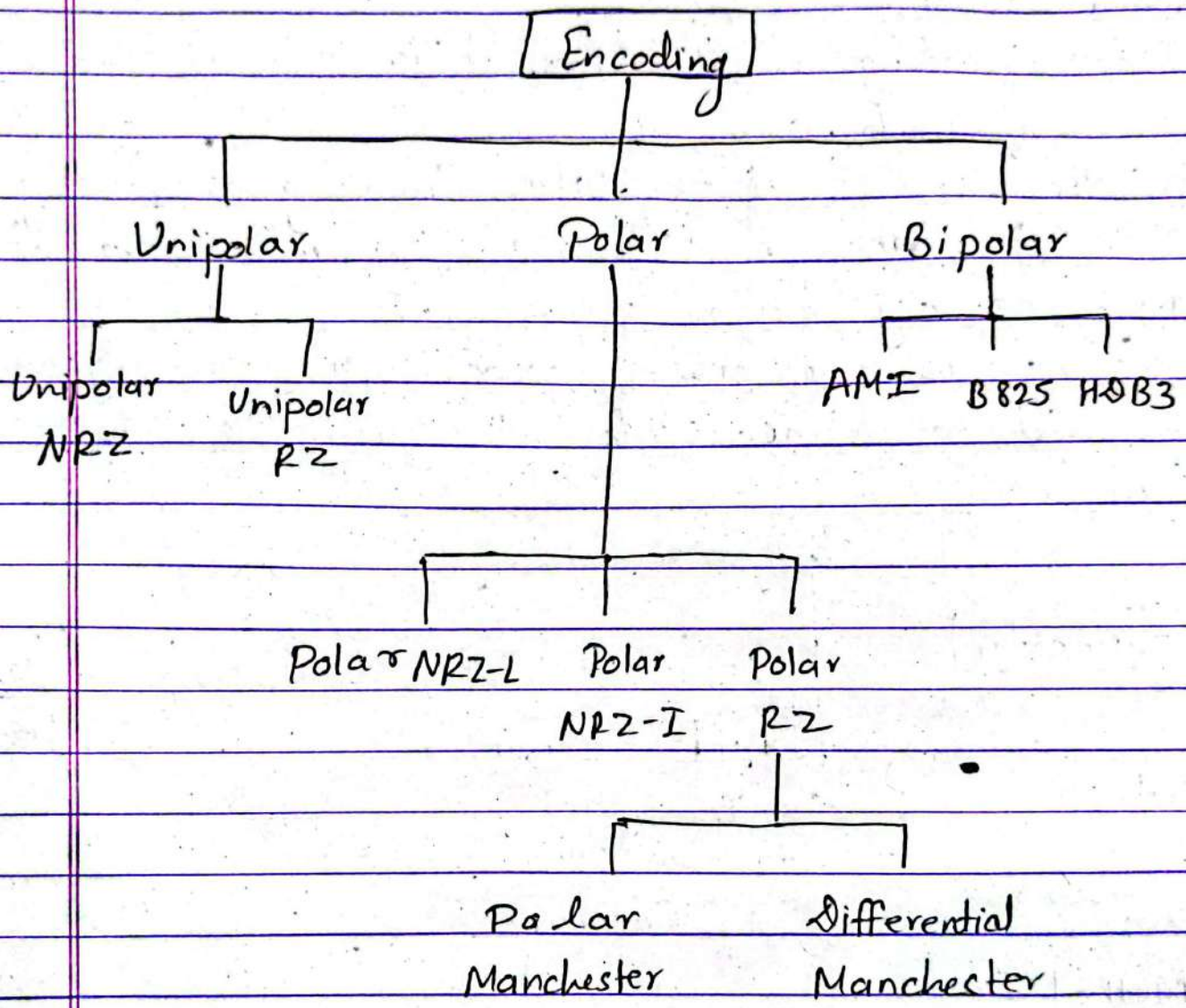


fig: Encoding

* Types of Encoding Method



* Types of encoding :



** Unipolar RZ format

→ If 'symbol 1 is transmitted then, we have,

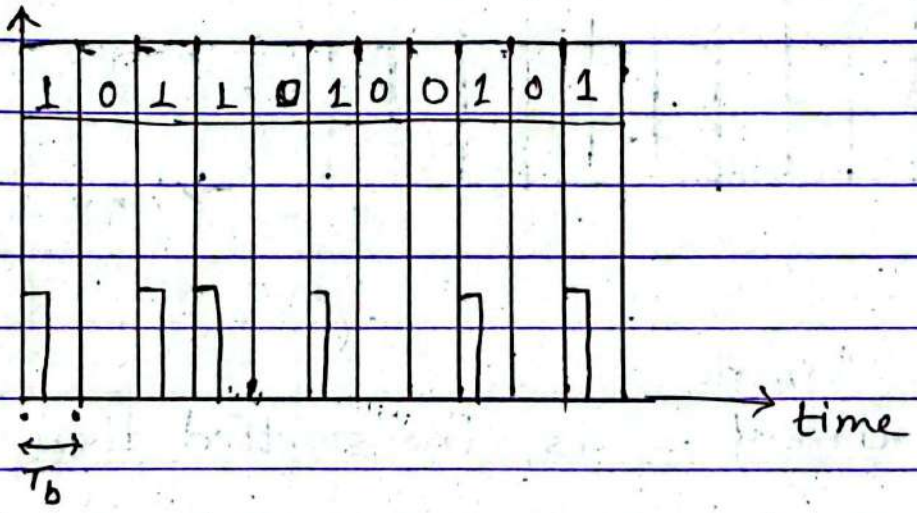
$$x(t) = \begin{cases} A & \text{for } 0 \le t < T_b/2 \quad \text{(half interval)} \\ 0 & \text{for } T_b/2 \le t < T_b \quad (\text{"} \quad \text{"}) \end{cases}$$

RZ → Return to zero

If symbol 0 is transmitted then,

$x(t) = 0$ for $0 \leq t < T_b$ (complete interval)

Eg:
Draw the binary sequence of Unipolar RZ data
1011010010101



A = Amplitude
T_b = Pulse duration

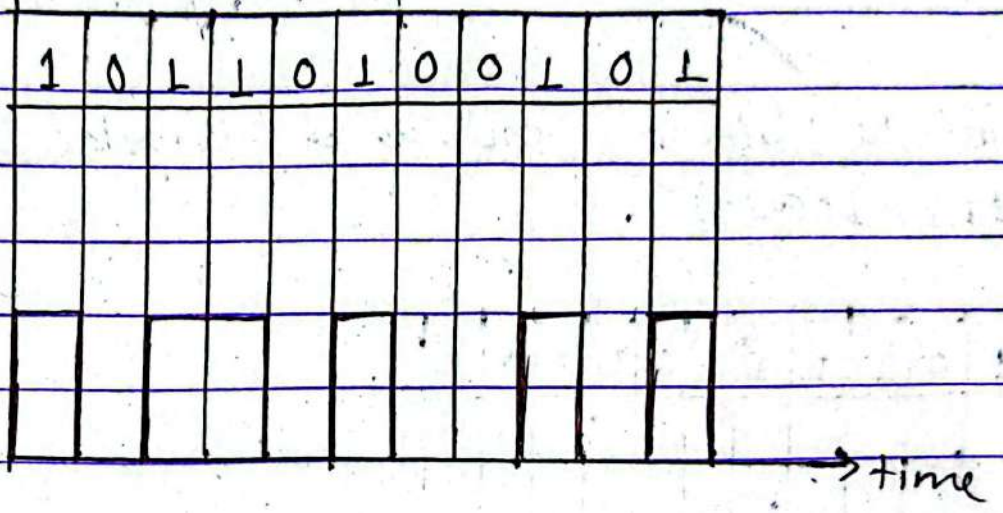
fig: Unipolar format

* Unipolar NRZ formation (non-return to zero).
→ The symbol '1' is transmitted then we have,
$x(t) = A$ for $0 \leq t < T_b$
If symbol 0 is transmitted then,
$x(t) = 0$ for $0 \leq t < T_b$ (Complete interval)

Q. Draw the Unipolar NRZ formate of sequence

1 0 1 1 0 1 0 0 1 0 1

(A) Binary sequence



✱ Polar RZ formate

→ If the symbol '1' is transmitted then, we have,

$x(t) = +A/2$ for $0 \leq t < T_b/2$

0 for $T_b/2 \leq t \leq T_b$

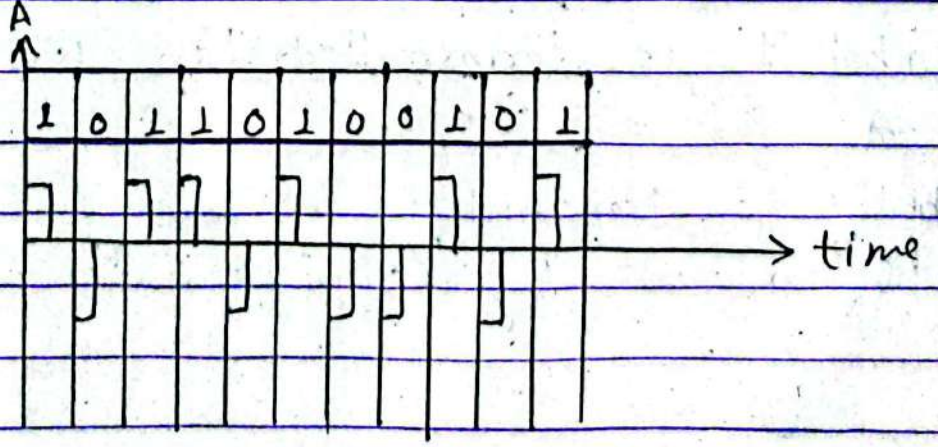
If symbol '0' is transmitted then,

$x(t) = -A/2$ for $0 \leq t < T_b/2$

0 for $T_b/2 \leq t < T_b$

1 आरए Positive A/2

0 आरए Negative A/2



Polar NRZ

→ The two types popular method of polar NRZ transmission are:-

(i) NRZ - L (level)

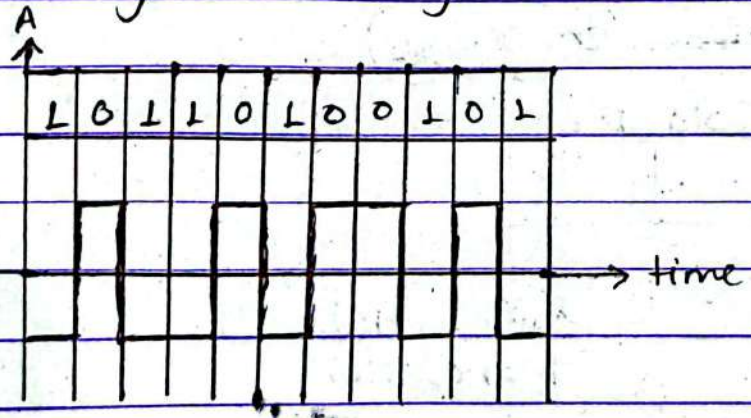
(ii) NRZ - I (Inversion)

(i) NRZ-L (0 में +high voltage and 1 में - Voltage)

→ In NRZ-L encoding the types of signal depends on the type of bit it represent.

→ A pasitive voltage usually means the bit zero,

→ A negative voltage means bit 1 and vice versa.



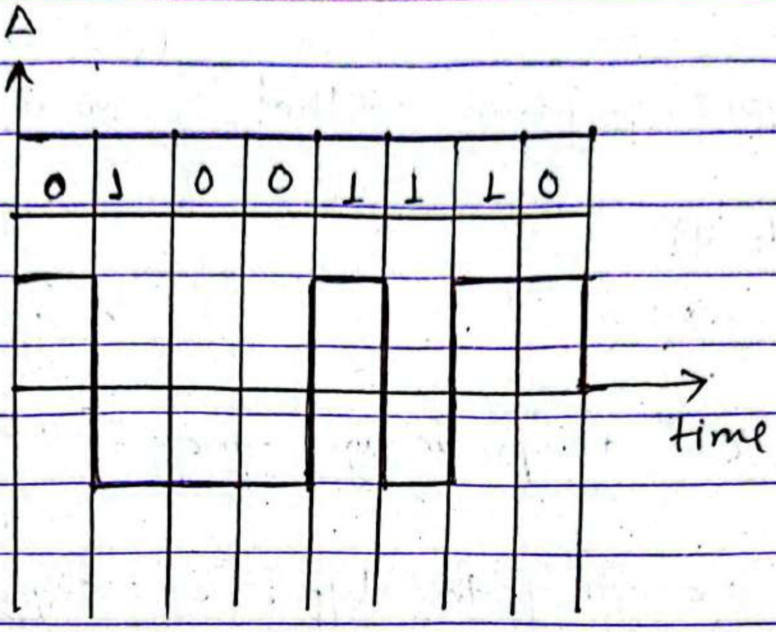
polar NRZ-L

(ii) NRZ - I (सभी पहिली cycle (Pulse duration) either 0 or +1)

→ In this method the inversion of voltage level represents 1 bit.

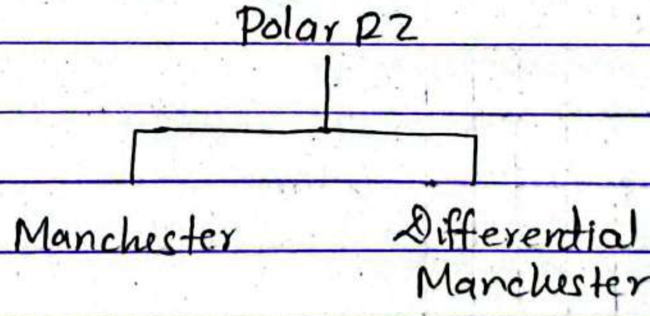
→ It means signal is changed each time 1 bit is encountred.

0 आउटा है उ रहती.
1 आउटा opposite cycle.



NRZ - I

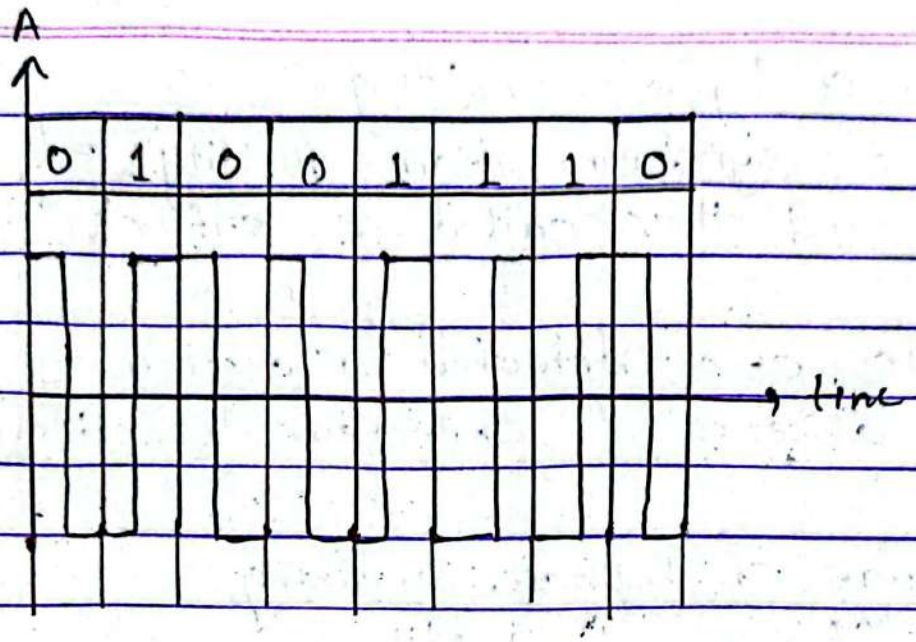
Polar RZ (Biphase encoding)



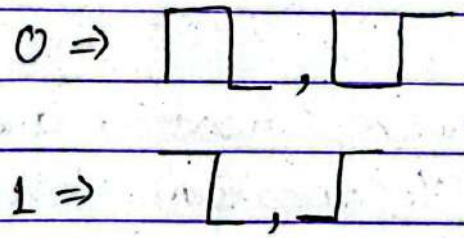
1) Manchester

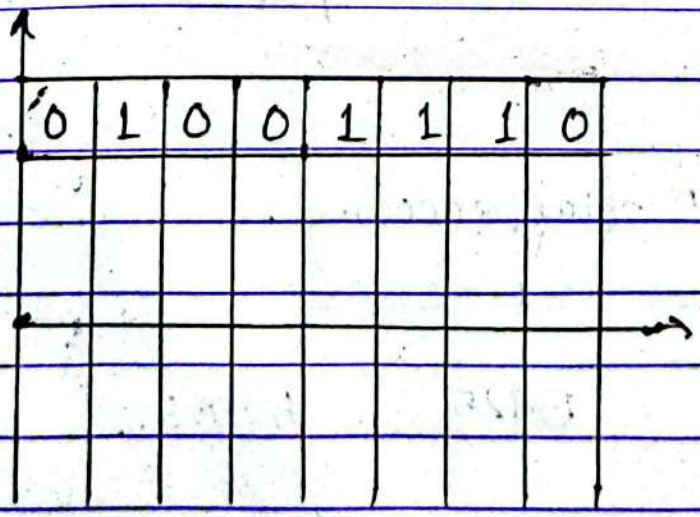
→ In this types of coading, the transition is done at the middle of the bit interval.

→ A negative to positive transition represent binary 1 and positive to negative transition represent binary 0.



ii) Differential Manchester.

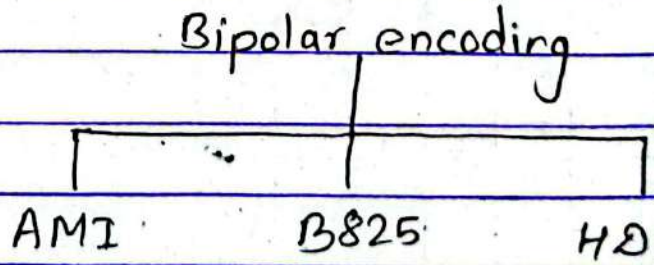




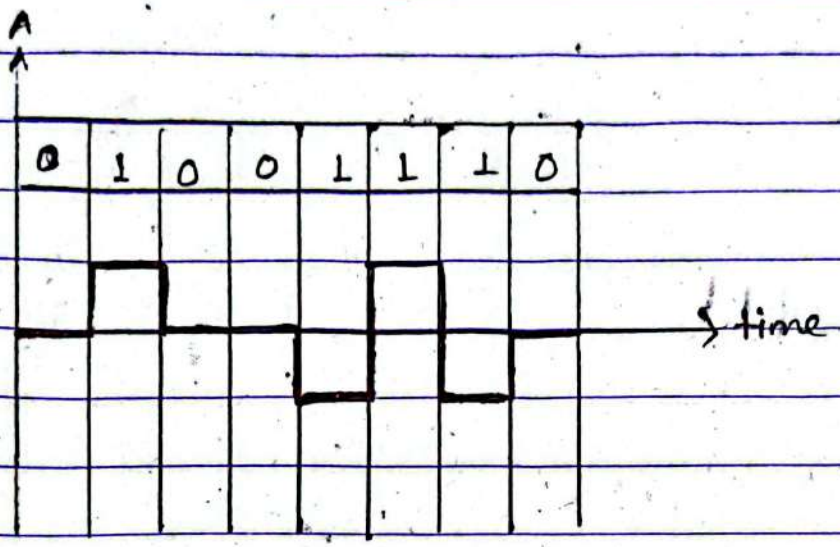
* Advantage of biphase encoding
→ It offers synchronization facility at receiver and thus called as self clocking codes.
→ It provides error detection by detecting detecting absence of expected transition.

* Disadvantage of biphase encoding.
→ It required more bandwidth.
→ It is used for shorter distance (LAN).

Bipolar encoding
→ It uses three volt positive, negative and 0.
→ The 0 level is used to represent binary 0, and negative and positive voltage represent alternating ones.



i) ~~HDB3~~ AMI (Alternate Mark Inversion)
→ Alternative 1 inversion
→ Natural zero voltage = binary 0.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0 1 0 0 1 1 1 0
time

✱ ~~Digital~~ Modulation:

→ It is the process of increasing the frequency content of a signal.

→ De-Modulation is exactly opposite process to the content of a signal.

* Need for Modulation:

→ The need for modulation can be summarized as follow:

① pratical antenna length (L)

→ The audio frequency range from 20Hz to 20kHz.

→ Suppose a frequncy of 20kHz is to be radiated directly into space.

→ The length of antenna will be calculated as:

$$V = f * \lambda$$

$$\text{or, } 3 \times 10^8 = 20 * 10^3 * \lambda$$

$$\lambda = 15 \text{ km}$$

So, the height of antenna will be $\lambda/4 = 15/4$

$= 3.75 \text{km}$.

which is practically impassible.

→ Now the carrier wave of 1000 kHz is used then height of antenna will be.

$$3 * 10^8 = 1000 \times \lambda$$

$$\lambda = \frac{3 \times 10^8}{1000} = 300 \text{km}$$

So, the height of antenna will be

$$\lambda/4 = \frac{15}{4} = 3.75 \text{ km}.$$

So, the modulation is necessary.

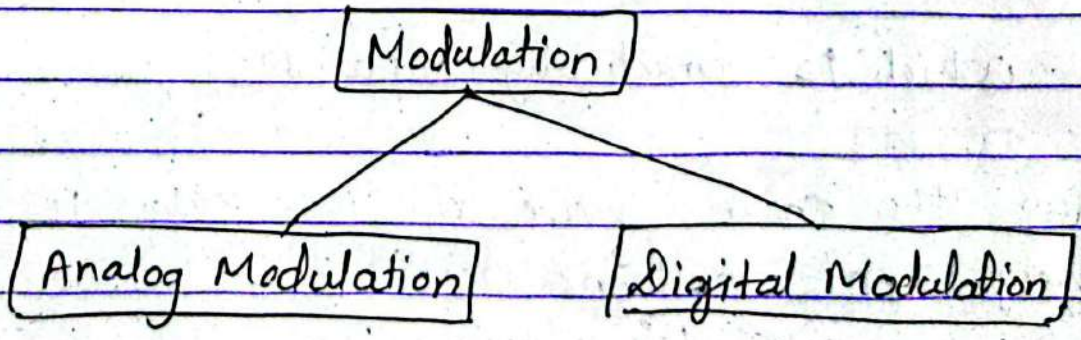
(ii) To increase the bandwidth of signal.

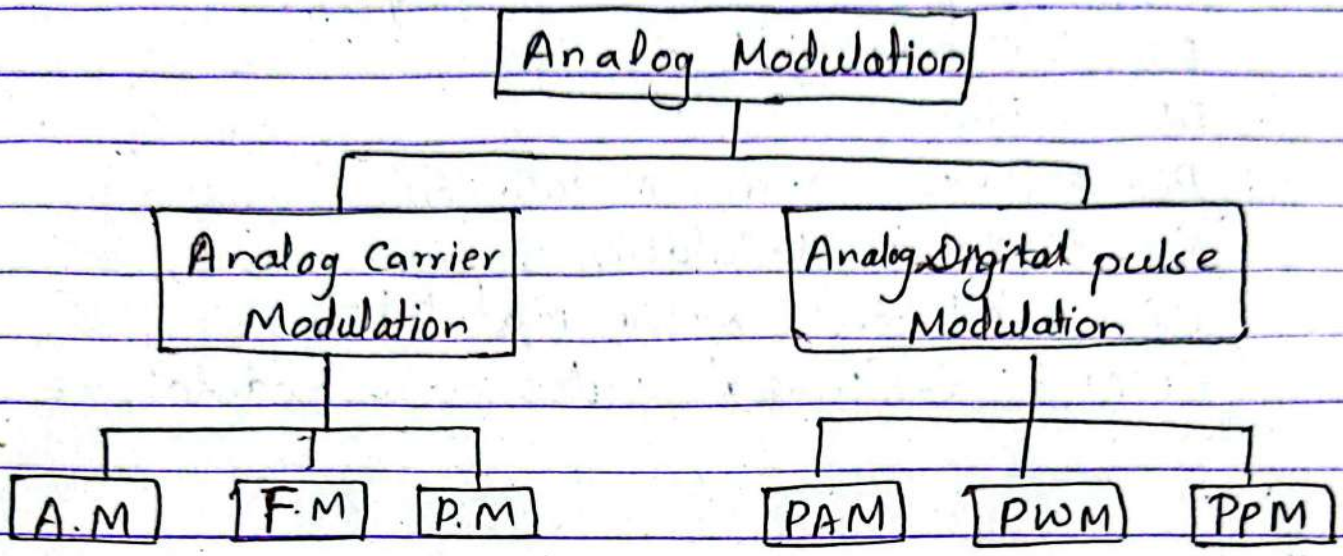
(iii) Multiplexing of more signal on some transmission line by providing different carrier signal.

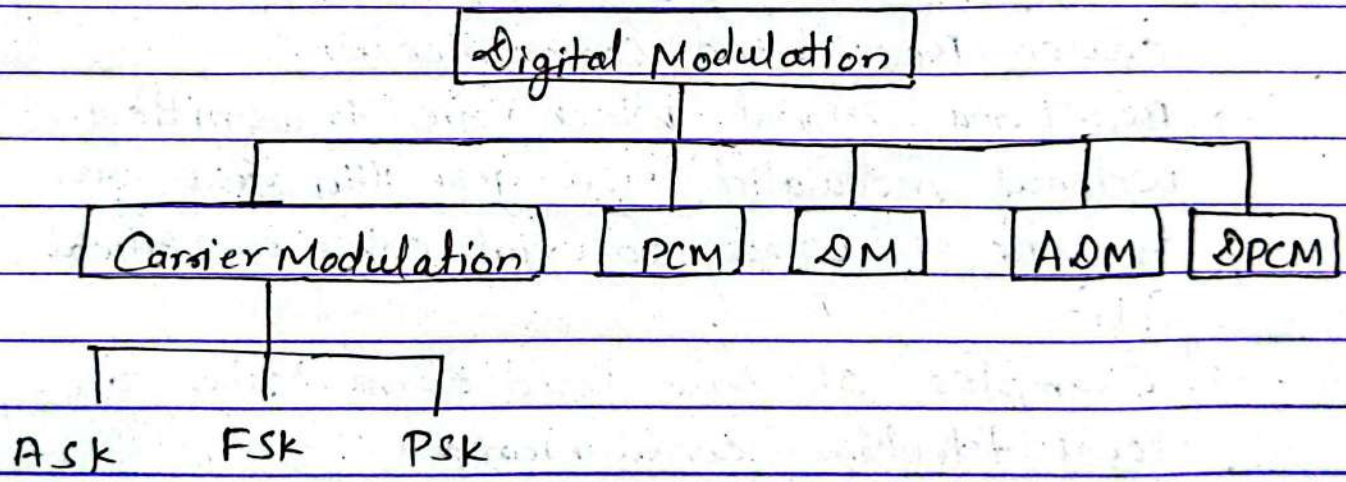
(iv) The rate of interferance is also reduced due to modulation.

(v) If improves the quality of services (QOS) and security in transmission.

Basic Modulation scheme







AM = Amplitude Modulation.
F.M = Frequency "
P.M = Phase "
PAM = Phase Amplitude Modulation
PWM = Pulse Width "
PPM = Pulse Position "

ASK = Amplitude shift keying.
FSK = Frequency " "
PSK = Phase " "
PCM = Pulse code Modulation
DM = Delta Modulation
ADM = Adaptive Delta Modulation.
DPCM = Differential pulse code Modulation.

Base-band Modulation.

→ Transmission without any modulation is called Base-band communication.

→ Base band signal which are transmitted without modulation are generally sent over a pair of wires, co-axial cable or optical fibre.

→ Examples of base band communication are local telephone communication.

Types of Modulation:

→ A sinusodial carrier wave can be expressed by:

$$e_c = E_c \cos(\omega_c t + \theta).$$

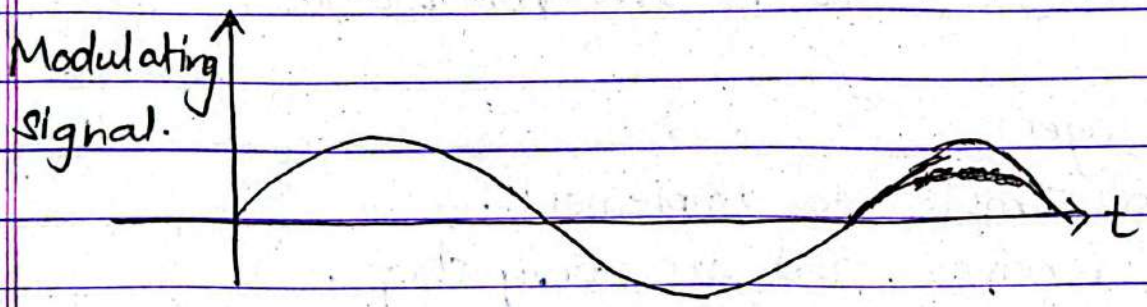
→ The three types of modulation are.

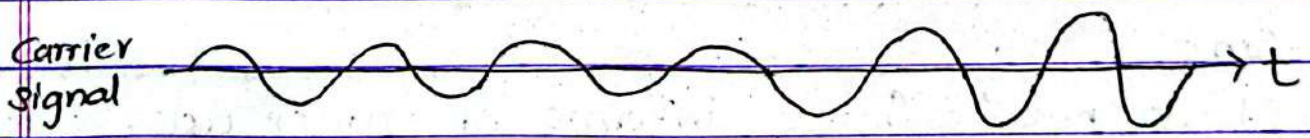
a) Amplitude Modulation:

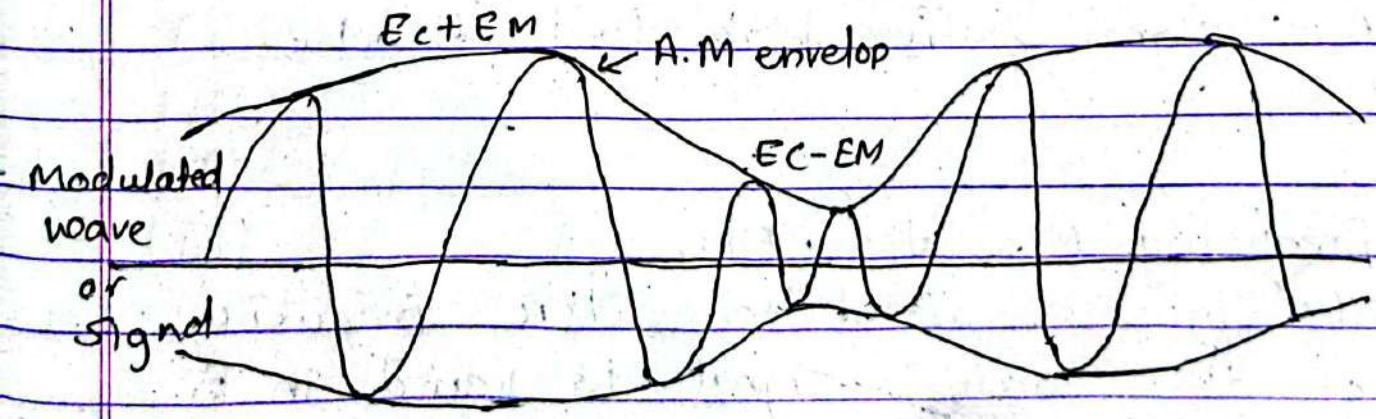
→ A type of modulation where the amplitude of the carrier signal is varied in accordance with the message signal or modulating wave while the frequency and phase are kept constant is called amplitude Modulation

* AM envelop

→ The modulated output wave-form for an AM modulator is called A.M. envelop.







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※ A.M Modulation Index : (M)

→ It is defined as the ratio of

$$M = \frac{Em}{Ec}$$

(Em = amplitude of modulating signal
Ec = amplitude of carrier signal)

→ When M = 0, then, there will be no modulation.

→ When M = 1, full modulation takes place.

→ When M > 1 ; it is over modulatted.

* Advantages:

→ It is simple to implement.

→ A.M. receiver are very cheap.

→ Covery area is very wide.

* Cons:

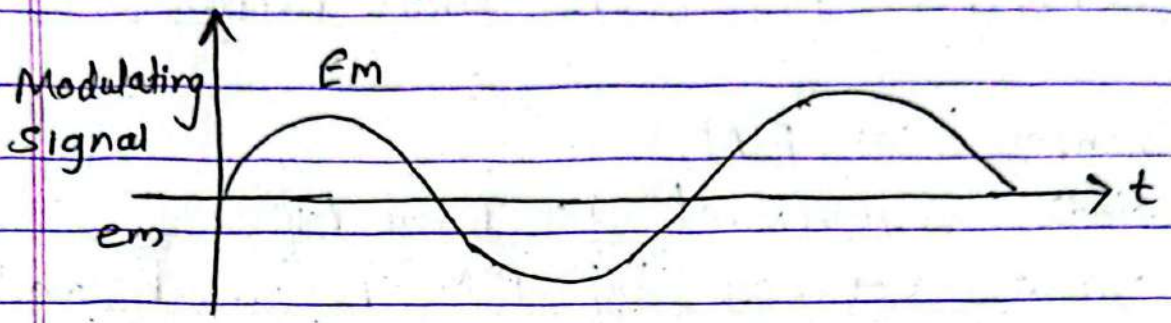
→ It is not efficient interms of power use.

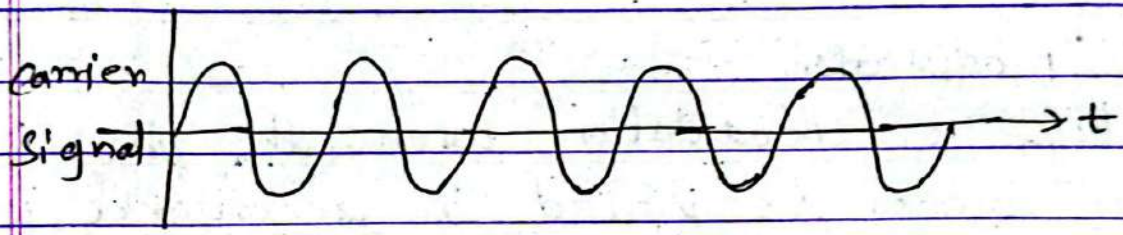
→ A.M signal suffer high level of noise.

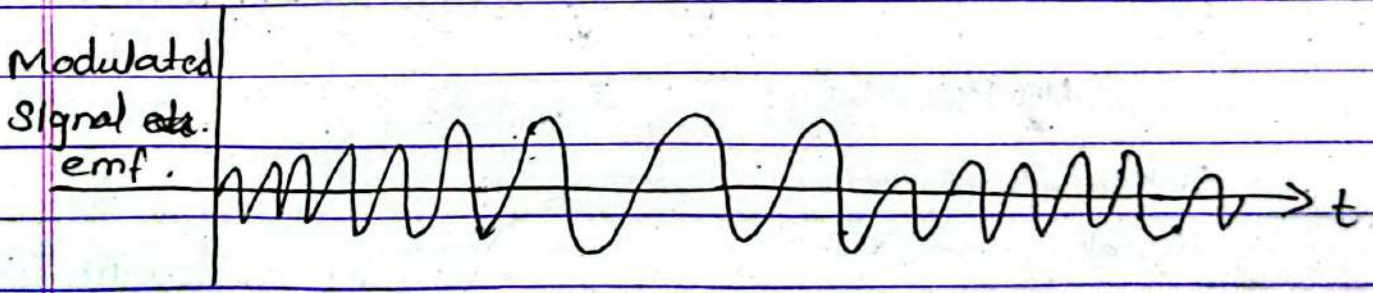
b) Frequency Modulation (F.M).

→ The type of modulation where frequency of the carrier signal is varied in a

accordance with the message signal or modulating wave while Amplitude and phase are constant.







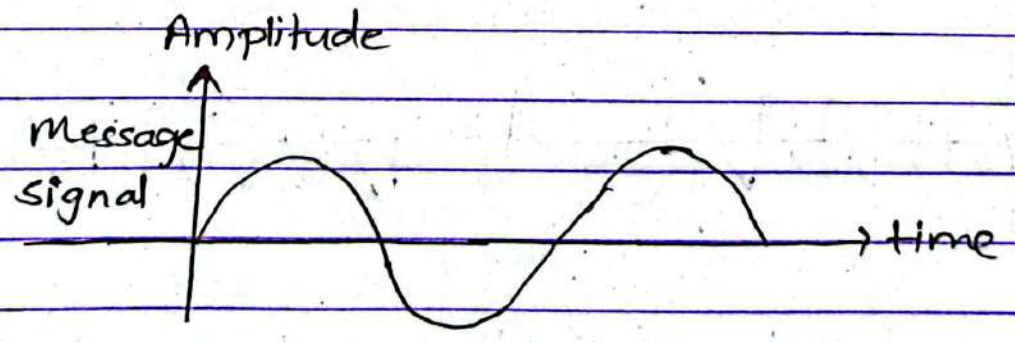
→ The bandwidth of F.M signal is given by:

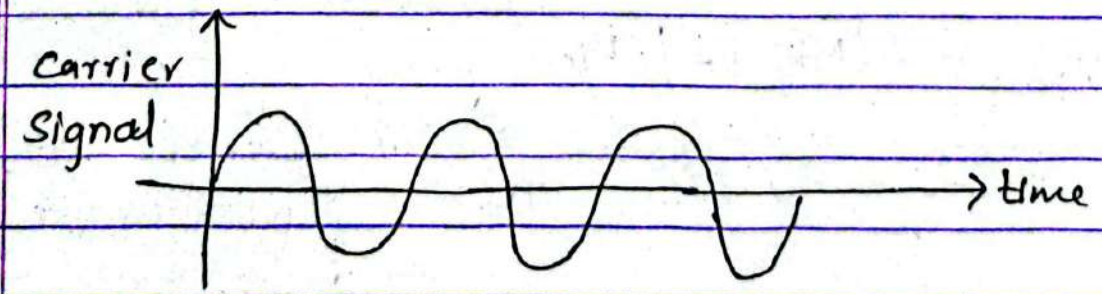
$$B_{FM} = 2[Mf + 1]\ FM$$

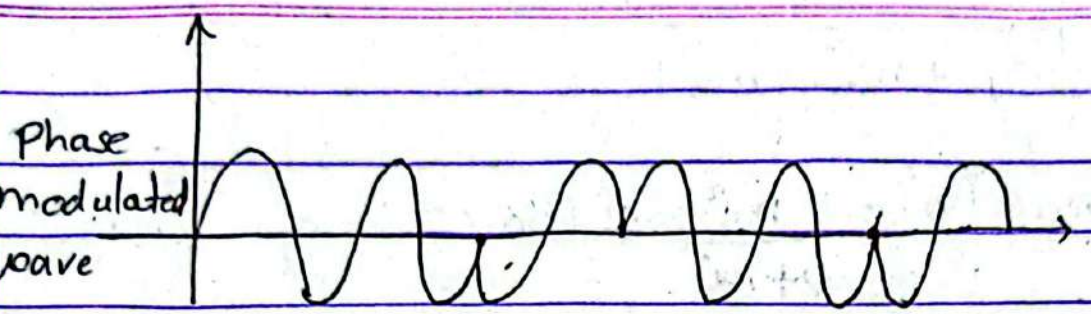
* Advantages of F.M over A.M
→ Better noise immunity is provided.
→ The transmitted power is more useful.

* Disadvantages of F.M.
→ Bandwidth requirement is very high.
→ The area covered by F.M is much smaller than A.M.

c) * Phase Modulation
→ The type of Modulation where the phase carrier signal is varied in accordance with the message signal or modulating wave while amplitude and frequency are constant.







* Advantages of P.M.

→ Phase modulation and demodulation is easy to implement compared to frequency modulation.

→ A phase modulated signal is more immune to noise effect.

* Disadvantages of P.M.

→ Frequency multiplier are needed.

→ The system cost is quite expensive.

Formula:

Modulation Index $(M) = \frac{E_M}{E_c}$

Average carrier power $P_c = \frac{E_c^2}{2R}$

Average side band power $= \frac{M^2}{4} P_c = P_{LSB} = P_{USB}$ (Upper side band.)

Total power $P_t = P_c \left(1 + \frac{M^2}{2}\right)$

$$M_t = \sqrt{M_1^2 + m_2^2 + m_3^2 + \cdots}$$

$$\text{Efficiency } (\eta) = \frac{m^2}{2 + m^2} * 100\%$$

Q^n: The carrier frequency for A.M. Modulator is 500 kHz. The maximum modulating signal is 1kHz. Find.

(i) Upper and lower side frequency.

(ii) The bandwidth.

Soln:

$F_m = 1\,kHz$

$F_c = 500\,kHz$

(i) $F_{USB} = F_c + F_m$

$= 500 + 1$

$= 501\,kHz$

$F_{LSB} = F_c - F_m$

$= 500 - 1$

$= 499\,kHz$

(ii) The bandwidth is twice the frequency of modulating signal.

i.e 2FM

Q. The carrier frequency of 5MHz and peak value of 5V. is amplitude modulated by 4kHz sine wave of amplitude 3V. Determine the modulation index, the upper and lower side band frequency and their amplitude.

→ Soln:

$F_c = 5MHz$

$E_c = 5V.$

$E_M = 3V$

$M = \frac{3}{5} = 0.6$

Upper side band frequency = $f_c + f_m$

$= 5 * 10^6 + 4 * 10^3$

$= 5$

Q. For a A.M wave with a peak carrier voltage of 8 volt, load resistance of 8Ω and modulation Index unity. Determine power of the carrier and side band, and total sideband power also the total power of un-modulated wave and efficiency percentage.

⇒ Given,

① amplitude of carrier signal $(E_c) = 8V$

Load Resistance $(R) = 8\Omega$

$M = 1$

$$P_t = \frac{E_c^2}{2R} = 4W$$

② Side band power $= \frac{M^2}{4} P_c = 1W$

③ Total side band power $= (P_{LSB} + P_{USB})$

$= 1 + 1 = 2W$

④ Total power $(P_t) = P_c \left(1 + \frac{M^2}{2}\right)$

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

$= 6$

$\eta = 33.33$

Q. An A.M transmitter with carrier power of 150 W is modulated simultaneously by 4 modulating signal with modulation indices 0.3, 0.4, 0.5 and 0.6 Find:

(i) Total Modulation Index
(ii) Total transmitted power
(iii) Each side band power

→ Soln:

$$M_t = \sqrt{M_1^2 + M_2^2 + \cdots}$$

(i) $$M_t = \sqrt{(0.3)^2 + (0.4)^2 + (0.5)^2 + (0.6)^2}$$

$$M_t = 0.92$$

(ii) Total transmitted power:

$$P_t = P_c\left(1 + \frac{M_t^2}{2}\right)$$

$$= 150\left[1 + \frac{(0.92)^2}{2}\right]$$

$$= 213.5 \text{ W}$$

(iii) Side band power $= \frac{M^2}{4} P_t$

$$= 31.74 \text{ W}.$$

Q. An audio signal of $10 \sin 1000\pi t$ is used for A.M with a carrier of $50 \sin 200000\pi t$. Calculate:

(i) Modulation Index.

(ii) Required B.W

(iii) Total power using load resistance is 800 W

(iv) Efficiency of A.M.

→ Network signal $(e_m) = 10 \sin 1000\pi t$

comparing with standard eqn.

$$e_m = E_m \sin \omega t$$

$$E_m = 10V$$

$$\omega_m = 1000\pi$$

$$2\pi f_m = 1000\pi$$

$$F_M = 500 Hz$$

$$(E_c) = 50 \sin 200000\pi t$$

On comparing with standard eqn,

$$e_c = E_c \sin \omega t.$$

$$E_c = 50V$$

$$\omega_c = 200000\pi$$

$$2\pi f_m = 200000\pi$$

$$f_c = 100000 Hz$$

(i) $M = \frac{Em}{Ec} = 0.2$

(ii) $B.W = 2fm$

$= 2 * 500$

$= 1000\ Hz$

(iii) $P_c = \frac{Ec^2}{2R} = 1.5625$ watt

$P_t = P_c \left(1 + \frac{M^2}{2}\right) = 1.59375$ watt

(iv) $\eta = \frac{M^2}{2+m^2} * 100\%$

$= 1.96\%$

Q. A single tone F.M is represented by a voltage eqn as $V(t) = 12 \cos(6 * 10^8 t + 5 \sin 1250 t)$

Determine:

(i) Carrier frequency

(ii) Modulating frequency.

(iii) Modulating index.

(iv) Max. frequency deviation.

Soln:

Given,

$V(t) = 12 \cos(6 \times 10^8 t + 5 \sin 1250 t) \ldots (i)$

the standard eqn of F.M wave is given by:

$f_m = E_c \cos(\omega_c t + m_f \sin \omega_m t)$ ---(ii)

where,

E_c = amplitude of carrier signal.

ω_c = Angular frequency of carrier signal.

m_f = modulation index of F.M.

Comparing eqn (i) & (ii)

$E_c = 12V$.

$\omega_c = 6 \times 10^8$

$2\pi f_c = 6 \times 10^8$

$f_c = \frac{3 * 10^8}{\pi}$ Hz

$m_f = 5$

$\omega_m = 1250$

$2\pi f_m = 1250$

$f_m = \frac{625}{\pi}$ Hz

(i) $f_c = \frac{3 * 10^8}{\pi} = 95.5 * 10^6$ Hz

(ii) $F_m = \frac{625}{\pi} = 199$ Hz

(iii) $M_f = 5$

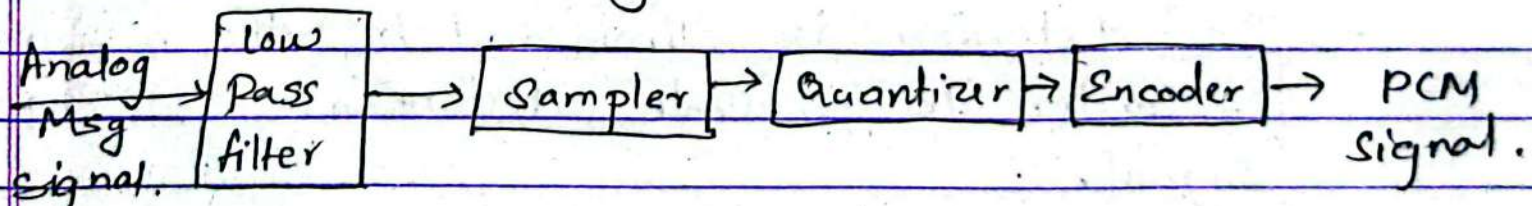
(iv) $\delta = m_f * f_m$
$= 5 * 199$
$= 995\ Hz$

Analog data, digital signal
→ Digital pulse Modulation generally is of two types:
i) Pulse code Modulation (PCM)
ii) Delta Modulation

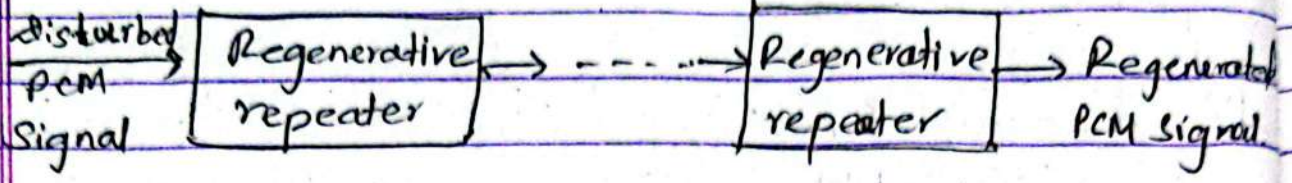
① Pulse code Modulation (PCM)
→ PCM allows the representation of the continious time message signal as a sequence of binary coded pulse.

→ The binary form permits only two possible state i.e. 0 and 1.

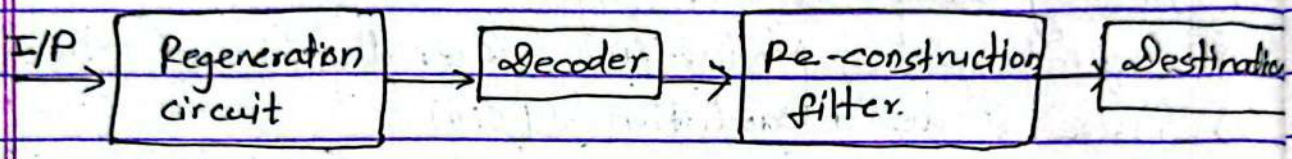
* Elements of PCM system:

→ 

as PCM transmitter



b) Transmitter path



c) Receiver.

→ Sampling is the operation in which analog signal is sampled according to the sampling theorem resulting in a discrete time signal.

→ The quantizing and encoding operation are usually performed in the same ckt which is known as ADC (Analog to digital converter)

→ The distortion is eliminated by the re-generat in order to provide distortion less PCM signal.

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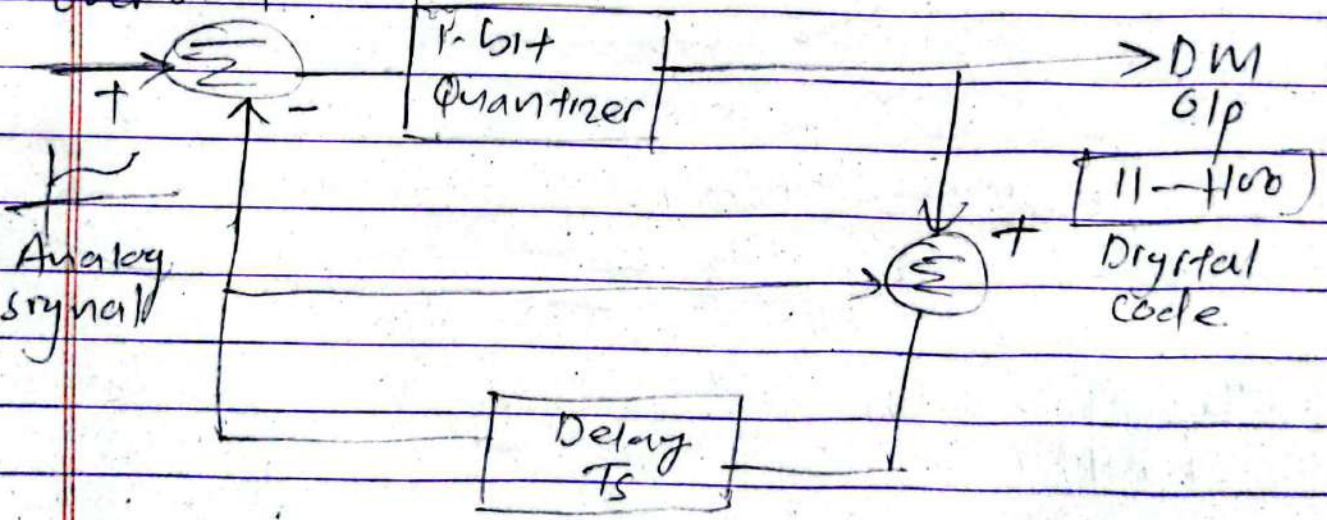
Disadvantages of PCM:-

→ It require larger bandwidth compared to other system.

→ Synchronization is req'd both transmitter and receiver

Delta Modulation (DM).

→ DM is simple modulation used to transmit one bit per sampling frequency



→ It comprises of one bit quantizer and delay ckt using two summer ckt (Σ).

PCM	DM
→ B.w.	→ B.w
→ full form	→ full form
→ fty	→ fty.

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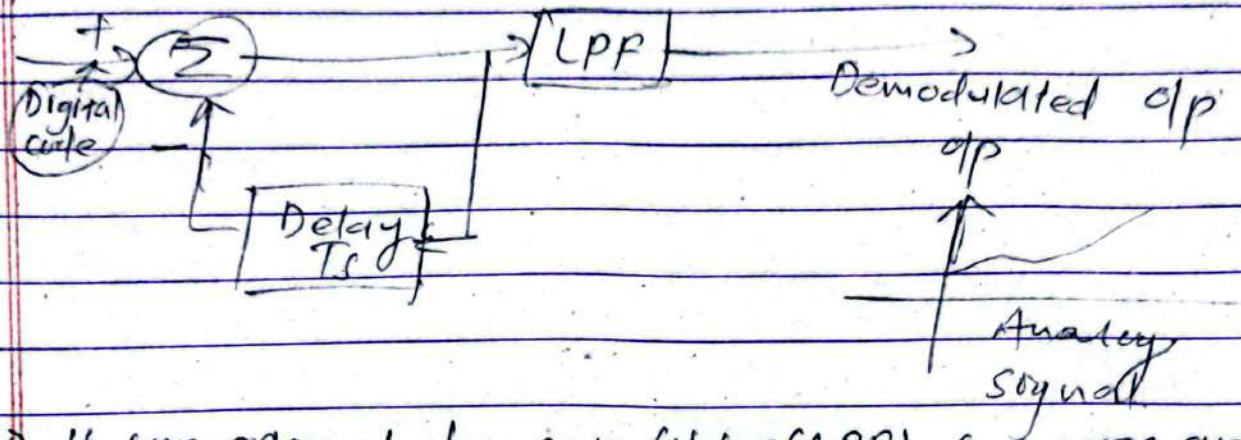
Delta Demodulator.

→



→ It comprises of low pass filter (LPF), summer and delay ckt.

→ A binary sequence will be given as a input to the demodulator.

→ Noise is eliminated by low pass filter and hence o/p is received.

Advantages of DM over PCM.

→ Bandwidth requirement is less than PCM.

→ It provides higher signal to noise ratio other than conventional modulation technique.

Disadvantages of D.M.

→ Production of granular noise which usually occur as the result of large step size.

→

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Digital data, analog signal :-

→ A

① Amplitude shift keying (ASK) :-

→ S

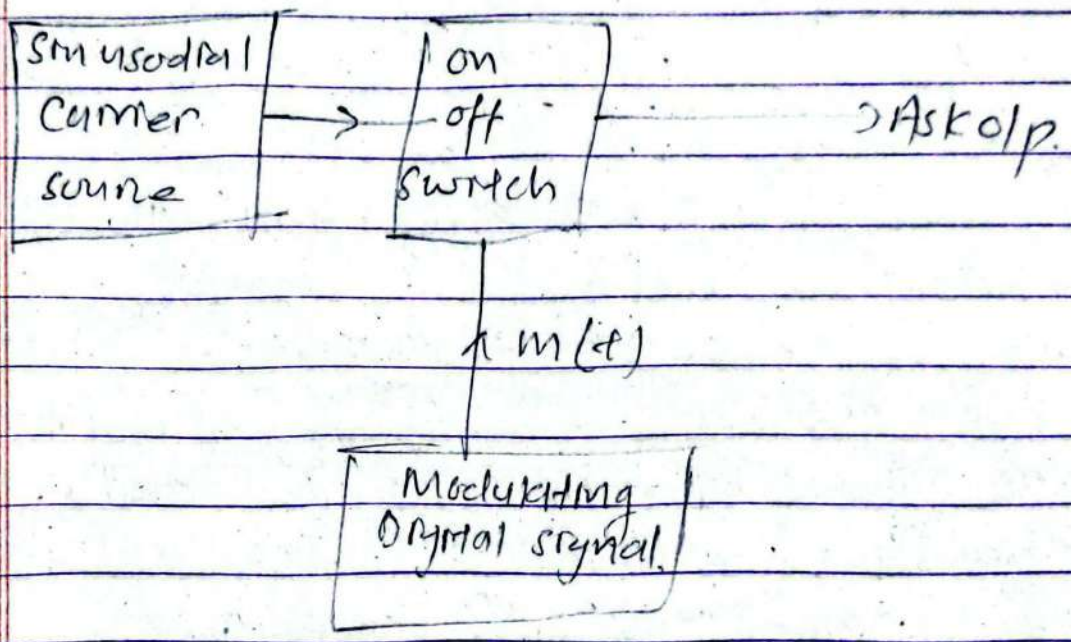

fig:- Block diagram of Ask Modulator.

→ It consists of sinusoidal source which is usually an oscillator and generates the required carrier signal

→ The second source is the modulating digital signal which has the digital information that is to be modulated.

→ Both the signals are connected to on off switch.

→ The o/p is turned on when the binary bit

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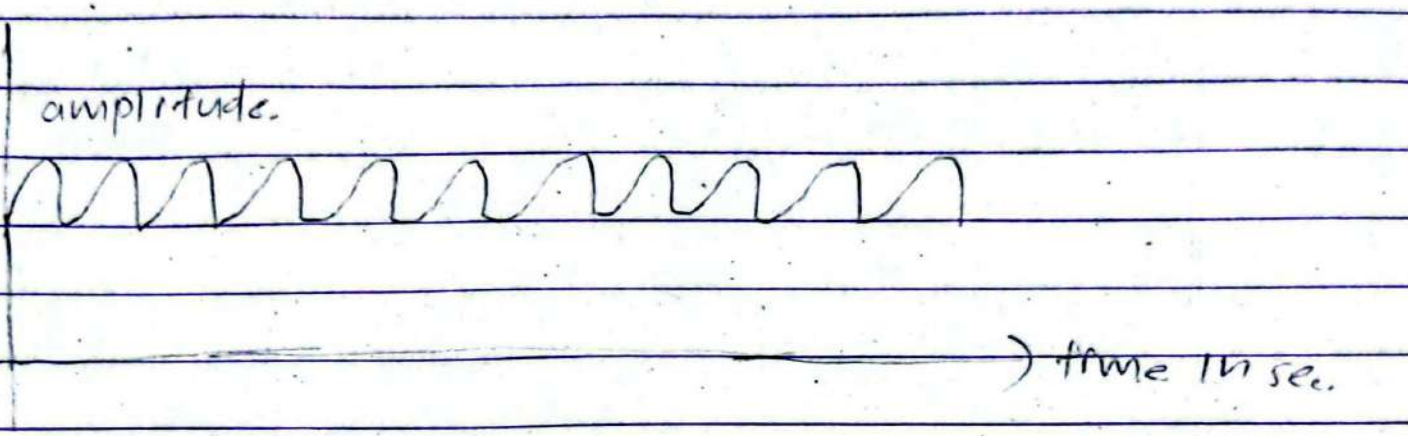
is one and turned off when the binary bit is zero.



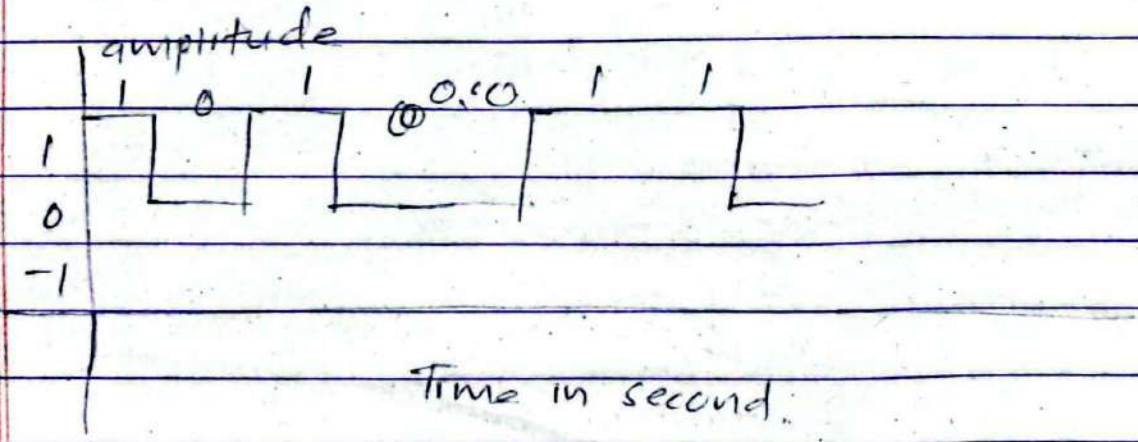


fig:- Modulating signal.

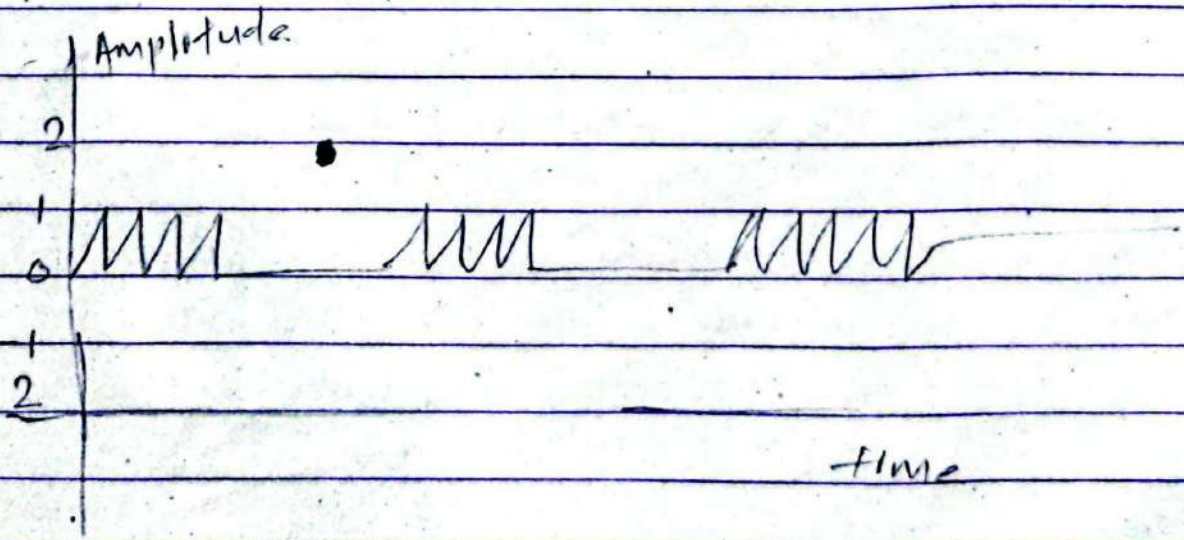


fig:- Ask waveform for 1010011O (Ask o/p)

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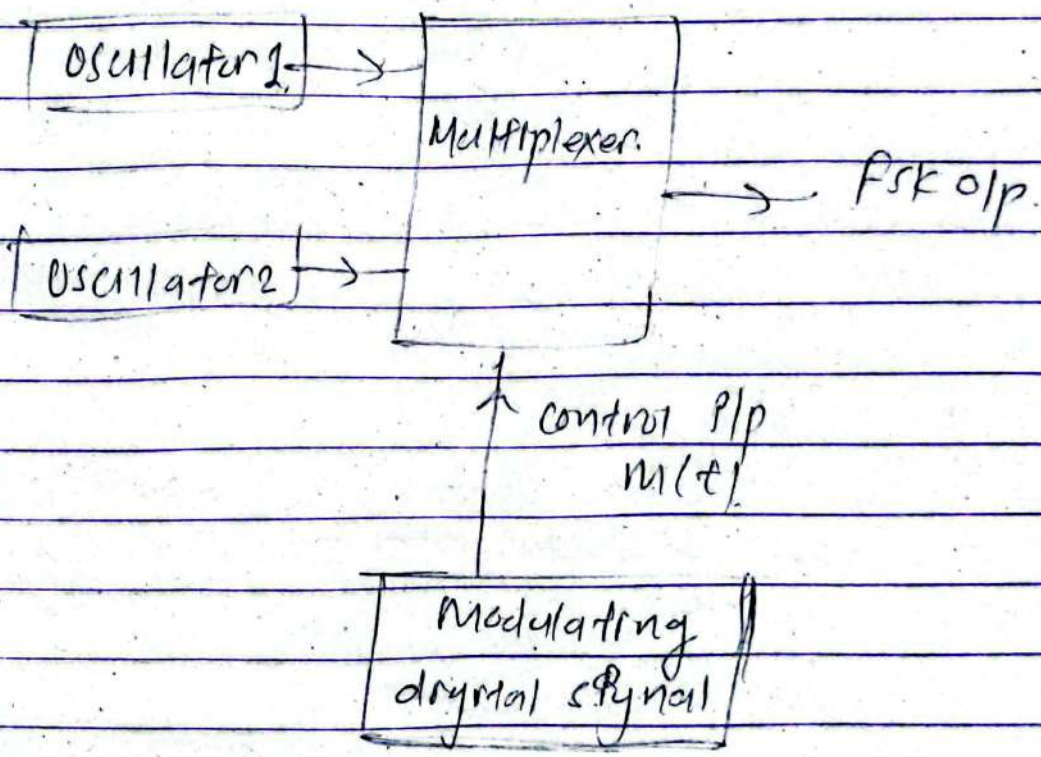
② Frequency shift keying (FSK) :-

→ In this method, the instantaneous frequency of the carrier signal is switched between two different frequencies.



→ The two carrier signal are given as I/p to the multiplexer which is based on control signal.

→ It will direct anyone of a carrier signal to the o/p of FSK modulator.

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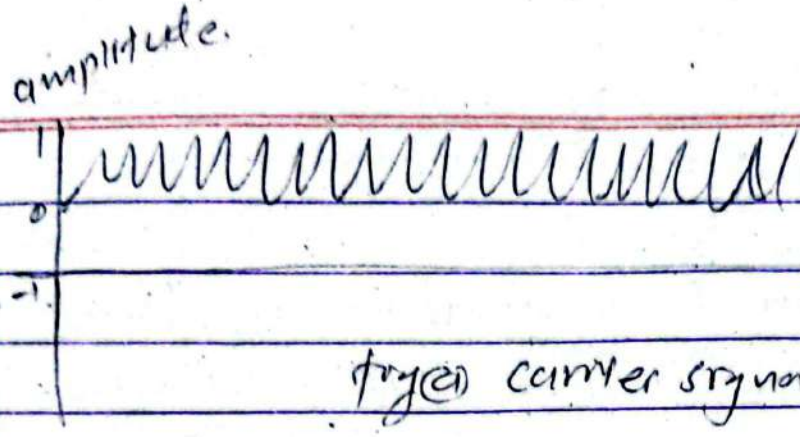
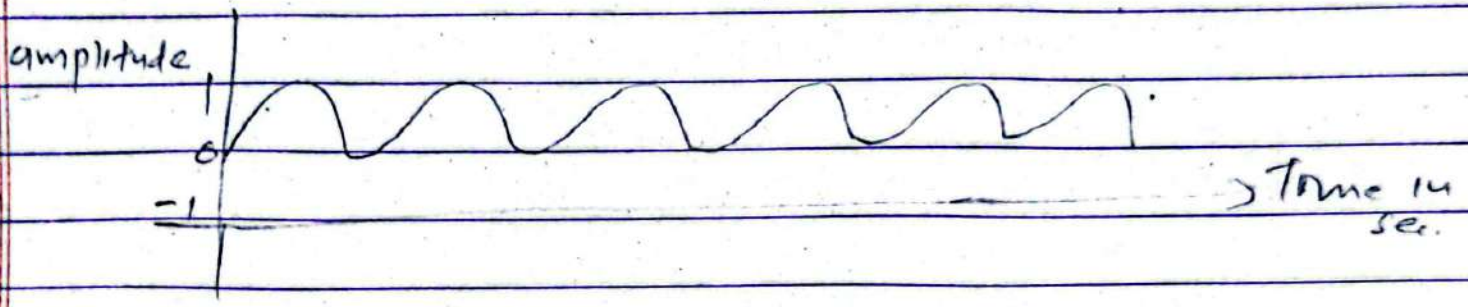


fig:- carrier signal (fmit)



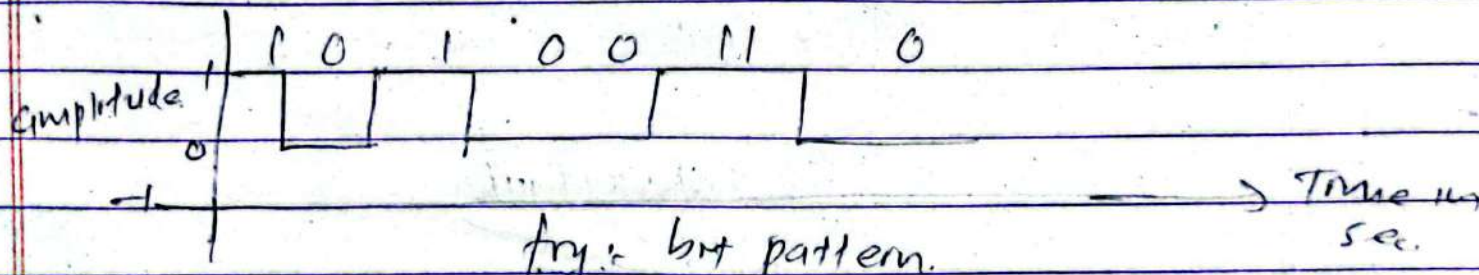


fig:- bit pattern.

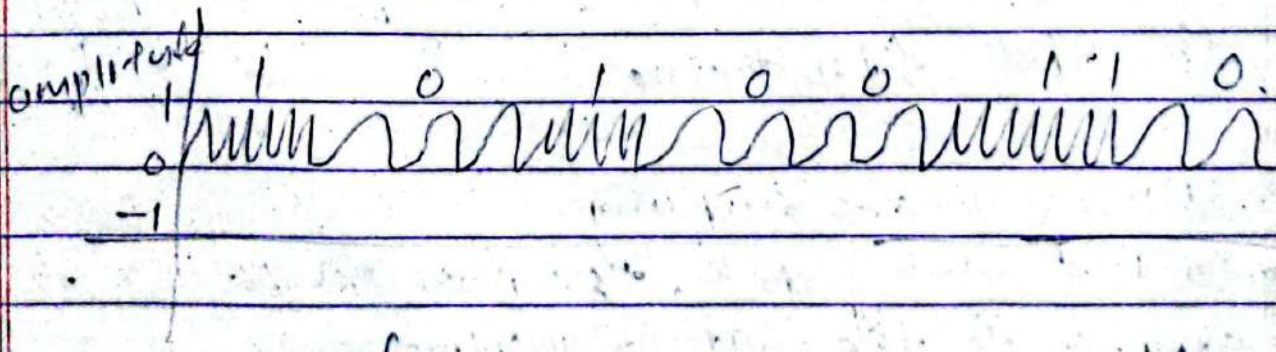


fig:- fsk o/p.

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(3) Phase shift keying (PSK)

→ In this method, the phase of the carrier is switched betn 2 or more values based on the input modulating digital signal.

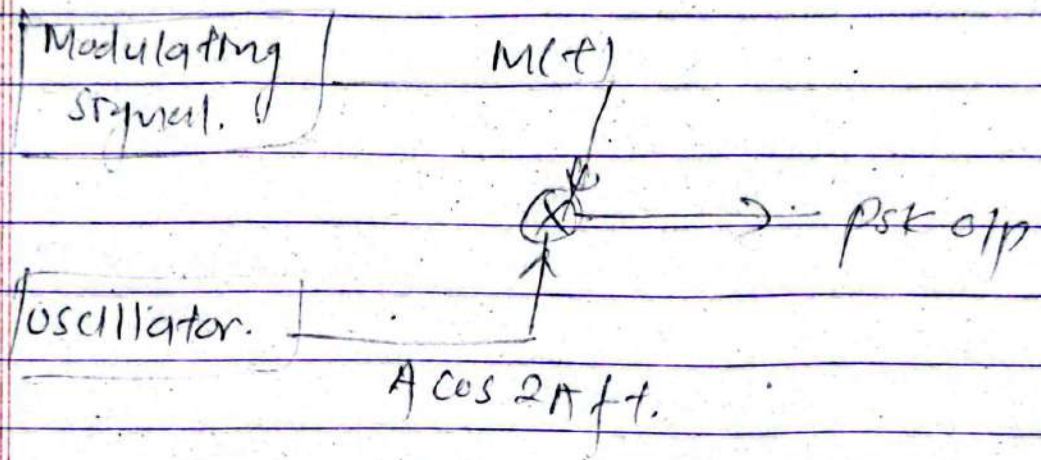


fig :- PSK Modulation.

→ PSK is of two types.

(a) BPSK (Binary phase shifting shift keying)
(b) QPSK (Quadrature " " " ")

(a) Binary phase shifting

→ In the binary PSK, 180° phase shift is applied to the bit transition.
→ It is also called 2 phase PSK or phase reversal keying.
→ When there is a change in the bit value (from zero to one or one to zero),

the phase of the PSK waveform changes by 180° and if there is no change in the bit value, then the waveform continues with no phase change.

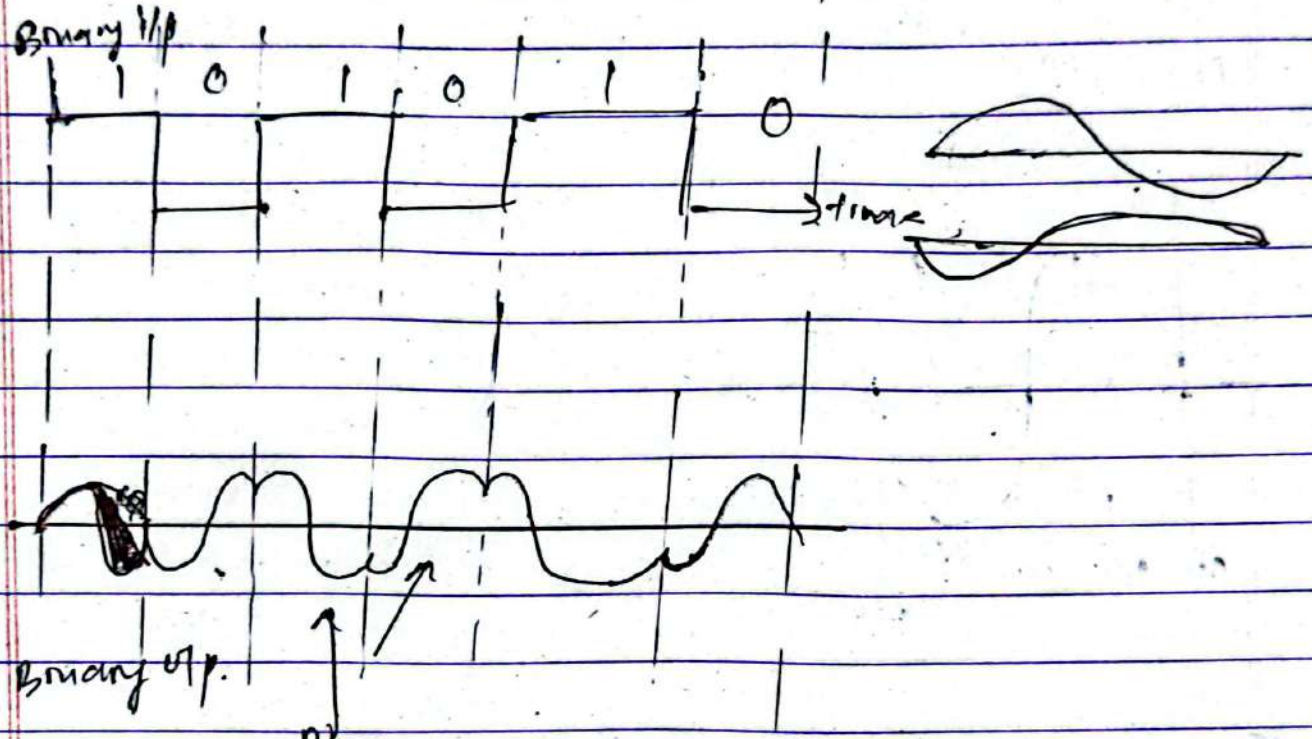


fig:- BPSK waveform.

QPSK :-

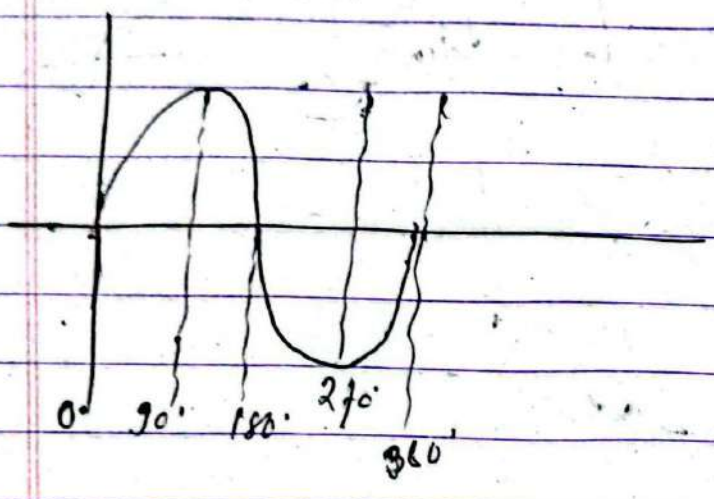
→ This is the phase shift keying in which sine wave carrier takes 4-phases. Such as 0°, 90°, 180° and 270°.

→ Here two bits are modulated selecting one of four possible carrier shift.

→ QPSK allow the signal to carry twice as much information as ordinary QSK.

→ Hence QPSK is the variation of BPSK.

00 — 0
01 — 90°
10 — 180°
11 — 270°



⊛ Advantages of Qpsk system:-
→ It provides good noise immunity.
→ The information transmission rate of QPSK is higher.
→ low error probability compared to other method.

⊛ Disadvantages:-
→ Circuit complexity as compared to other method.

~~→ Qpsk is as~~

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- QPSK is usually preffered for application where high bit rates and speed transfer of data are reqd. Hence QPSK is used for satellite transmission, cable modem, video conferencing, cellular phone system.

- Differential PSK (DPSK)
- It is a common type of phase modulation that conveys data by changing the phase of the carrier wave.
- In the receiver, the previous received bit are used to detect the present bit.
- In DPSK waveform, when data bit is low i.e zero the phase of the signal is not reversed and is continued.
- When data bit is high i.e 1, the phase of the signal is reversed.

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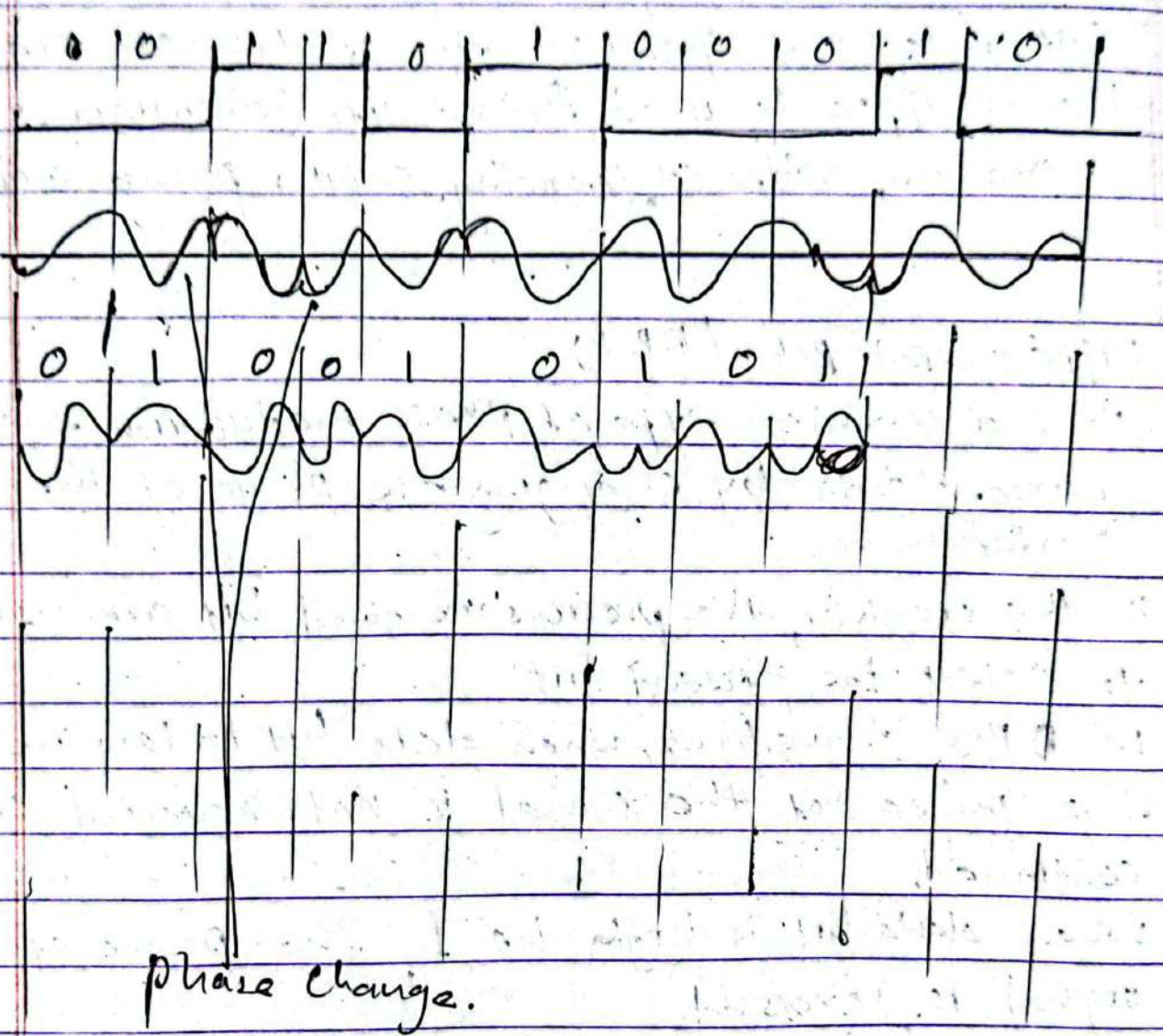

fig: DPSK waveforms

Multilevel Modulation:-

→ It is a digital modulation in which radio frequency signal can assume more values of ~~frequency~~ frequencies, phase or amplitude at the sampling point.

→ It is a measure technique to achieve data rates in wireless transmitter and

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receiver.

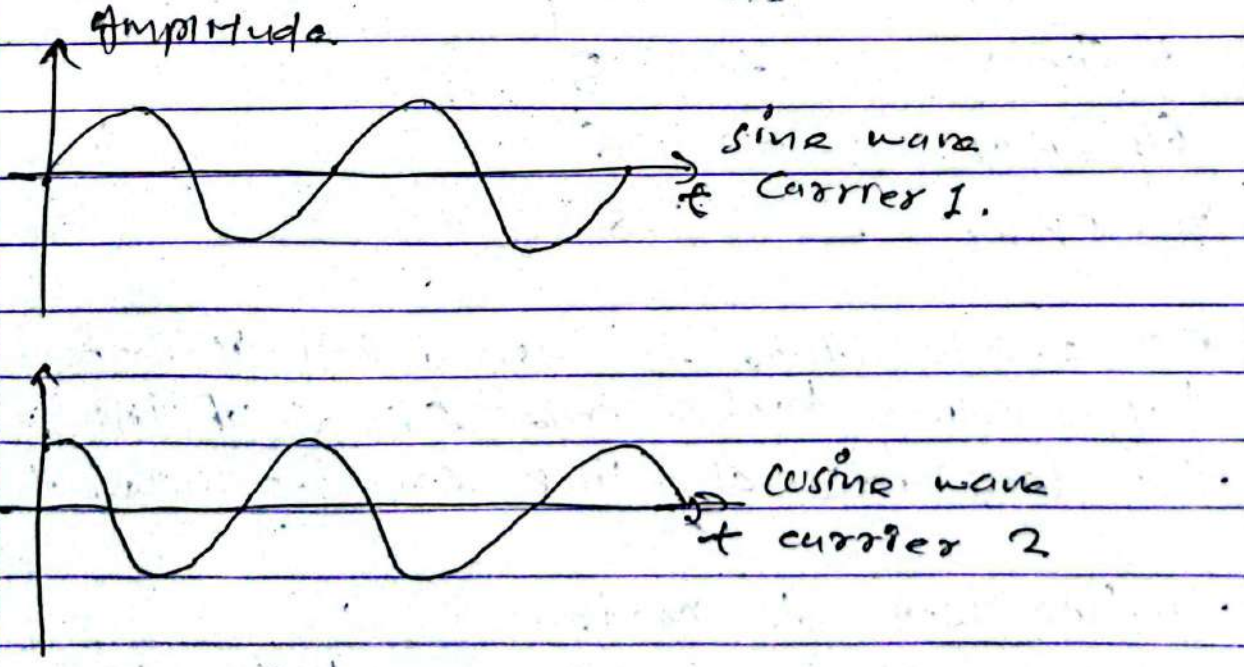
→ one ~~half form of~~ unique form of multi-level modulation is QAM (~~Quadrature~~. Quadrature amplitude modulation)

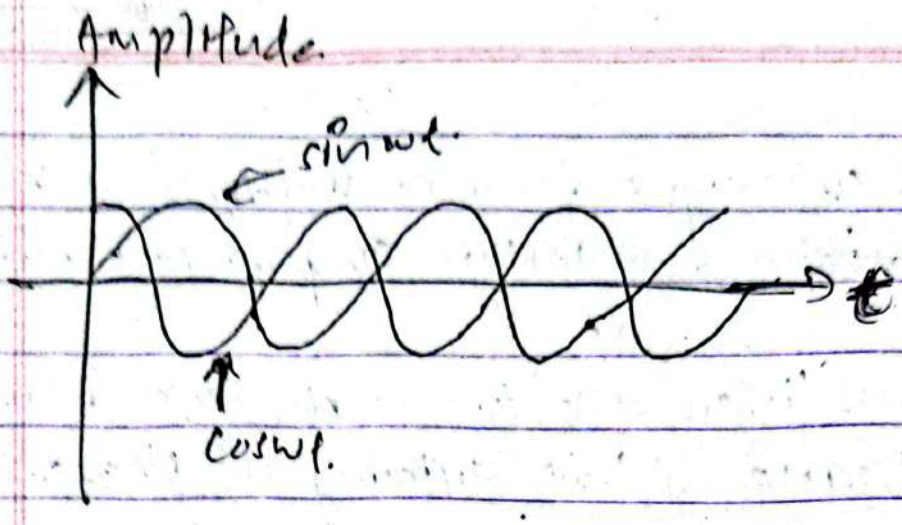
→ In QAM signal there are two carrier each having the same frequency but differing in phase by 90°.

→ Mathematically, one of the signal can be represented by sine wave and other by cosine wave.

→ The two modulated carrier are combined at the source ~~per~~ for transmission

→ At the destination the carriers are seperated and the data is combined into the orginal modulating information.





→ 16 QAM uses a amplitude and phase to achieve 4-bits per Hertz.

Modulation	Bits per symbol
16 QAM	— 4
32 QAM	— 5
64 QAM	— 6
256 QAM	— 8.

→ Hence advantage of using QAM is that by selecting higher order format of QAM, the data rate of a link can be increased.

Higher data rate modem

→ Modem stands for modulator and demodulator.

→ Modem is a device that converts digital signal into analog and vice versa.

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→ Modem helps in transmitting and receiving data both devices over a transmission medium like telephone lines, co-axial cable, or radio waves.
→ Modem are of two types:.

(a) Internal modem.:
→ These modems are used for low speed (Kbps).
→ It is a hardware plate placed inside the computer CPU.

(b) External modem:.
→ These modem is used for high speed (Mbps) such as broad band connection.
→ External modem of many companies are available in the market such as D-link, Tp-link, Nokia, etc.
→ Most modem transfers multiple bits per signal transition.
→ 56-k modem is the fastest solution and speed for dial-up modem.
→ 56-k modem often use bit rate of 8000.
→ High speed data rate satellite modems are device that are used to transmit and receive signal from transponder mounted on satellite.
→ High data rate modem performs data reception, processing, distributing and collecting information that rates up to 2.7 Gbps. from

Low earth orbit (LEO)
Geostationary earth orbit (GEO)

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aircraft, LEO or GEO