L-1

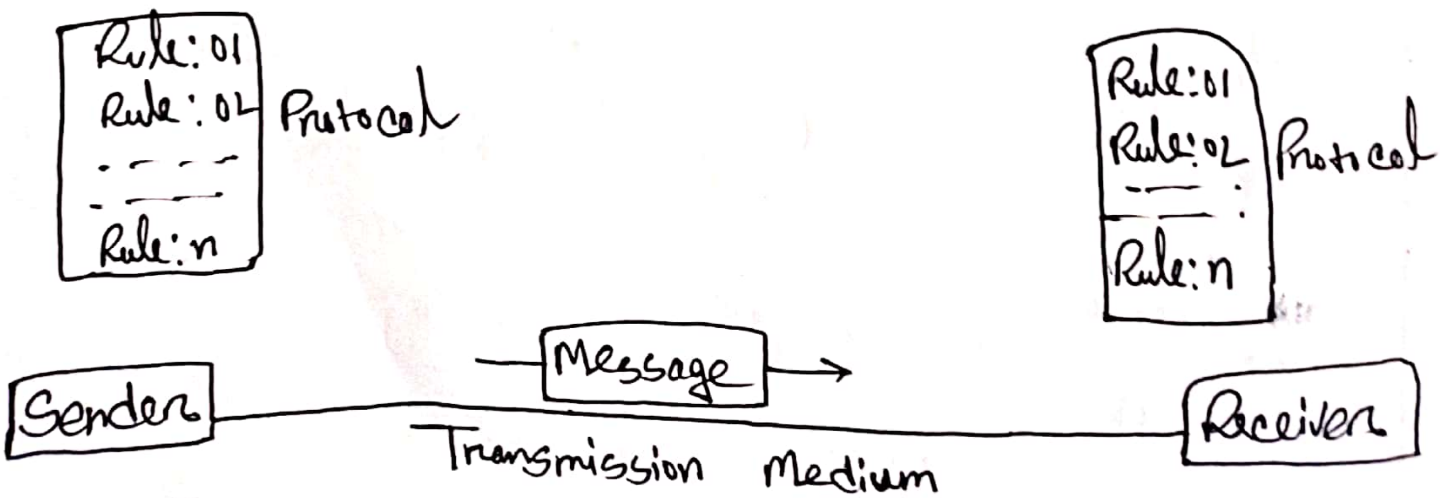
Mid Exam Preperation

* Data Communication Effectiveness depends on-

1. Delievery
2. Accuracy
3. Timeliness

* Communication System components-

1. Message
2. Sender
3. Receiver
4. Transmission medium
5. Protocol



L-5,6,8

- Bandwidth (hertz) → refers to the range of frequencies in a composite signal or the range of frequencies that a channel can pass.

- Bandwidth (bps) → refers to the speed of bit transmission in a channel or link.

- The throughput is a measure of how fast we can actually send data through a network.

- Throughput $= \dfrac{\text{frames} \times \text{bits}}{\text{time}}$

- Propagation speed measures the distance a signal or a bit can travel through a medium in one second.

- Propagation time measures the time required for a signal (or a bit) to travel from one point of the transmission medium to another.

- $\boxed{\text{Propagation time (delay)}} = \frac{\text{distance}}{\text{speed}}$

- Transmission ~~time~~ speed is the speed at which all the bits in a message arrive at the destination.

- $\boxed{\text{Transmission delay}}$ is the time to transmit a whole packet over a link.

- Transmission time (delay) = $\frac{\text{size (bits)}}{\text{bandwidth (bps)}}$

- Latency = Propagation delay + Transmission delay + Queuing time + Processing time

- Queuing time is the required time for each intermediate end device to hold the message before it can be processed.

- $\boxed{\text{Noiseless Channel: Nyquist Bit Rate}}$

$$\underset{(bps)}{\text{Bit Rate}} = 2 \times \text{Bandwidth (Hz)} \times \log_2 \text{levels}$$

- $\boxed{\text{Shannon Capacity (for a noisy channel)}}$

$$\underset{(bps)}{\text{Capacity}} = \text{Bandwidth (Hz)} \times \log_2 (1 + SNR)$$

- $SNR_{dB} = 10 \log_{10} SNR$

$\Rightarrow SNR = 10^{SNR_{dB}/10}$

- A digital signal, periodic or nonperiodic, is a composite analog signal with frequencies between zero and infinity.

☐ Baseband transmission means sending a digital signal over a channel without changing the digital to an analog signal.

☐ Broadband transmission or modulation means changing the digital signal to an analog signal for transmission.

☐ The process of converting digital data to digital signal is called as line coding.

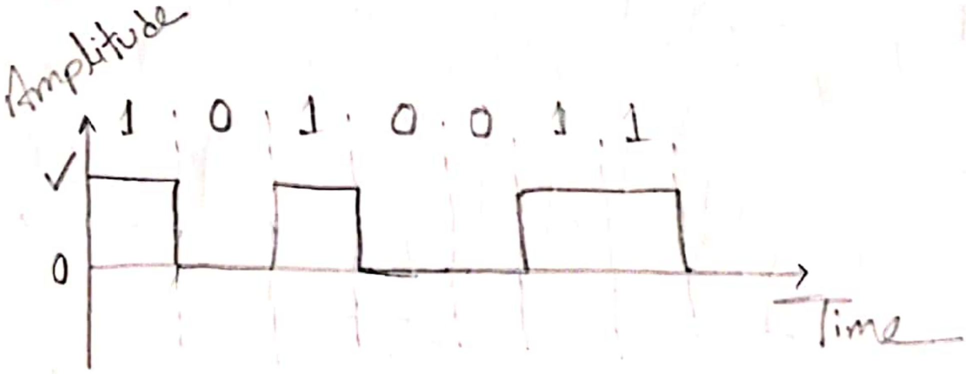
☐ When the voltage level remains constant for long periods of time, there is an increase in the low frequencies of the signal called DC component.

Line Coding
- Unipolar
- Polar
- Bipolar
- Multilevel
- Multitransition

Unipolar: NRZ

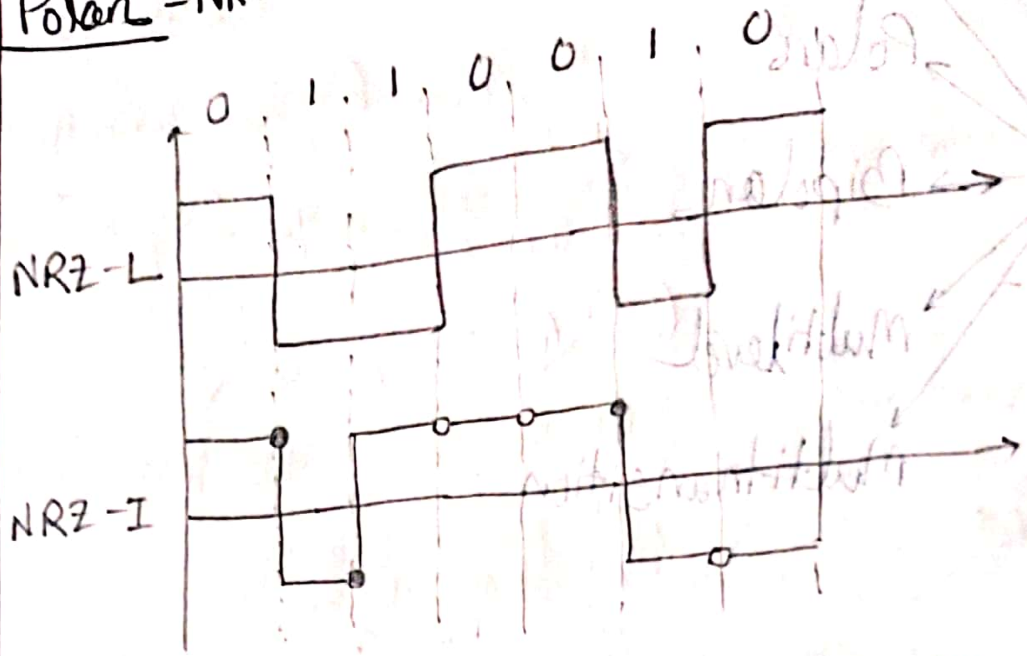
1 → +V

0 → 0V



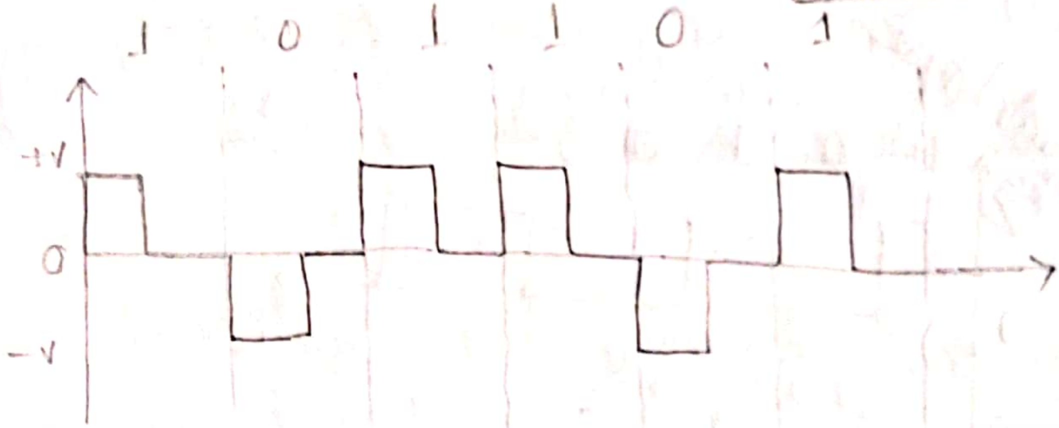
1 → −V
0 → +V

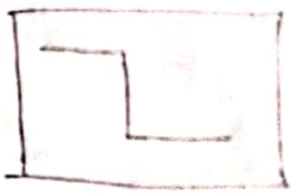
Polar -NRZ



0 → No invertion
1 → Invertion

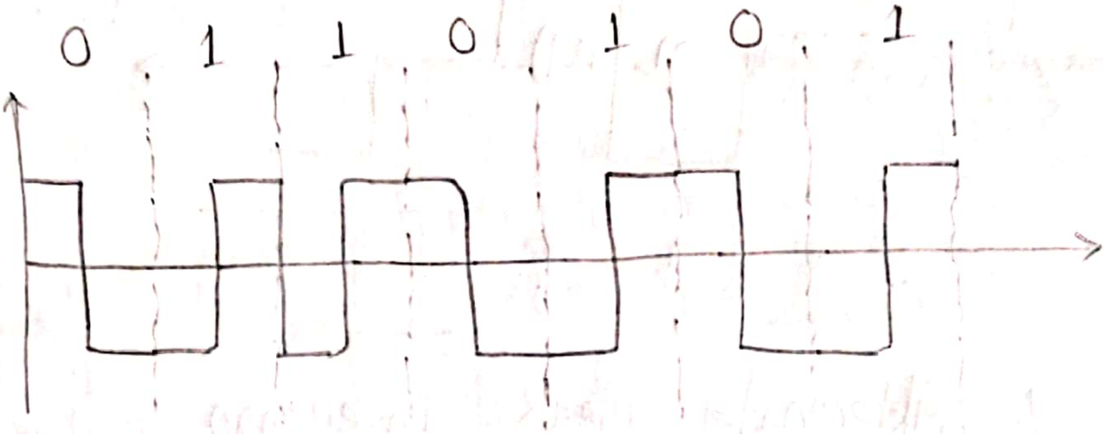
Polar-RZ





Manchester Coding

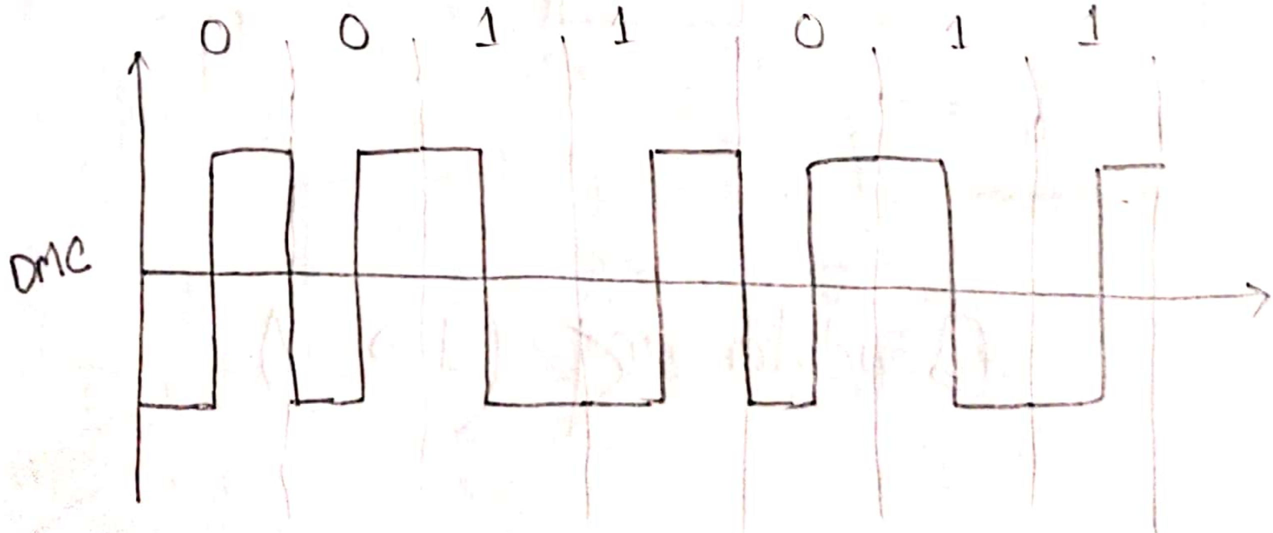
0 is  1 is 



Differential Manchester Coding

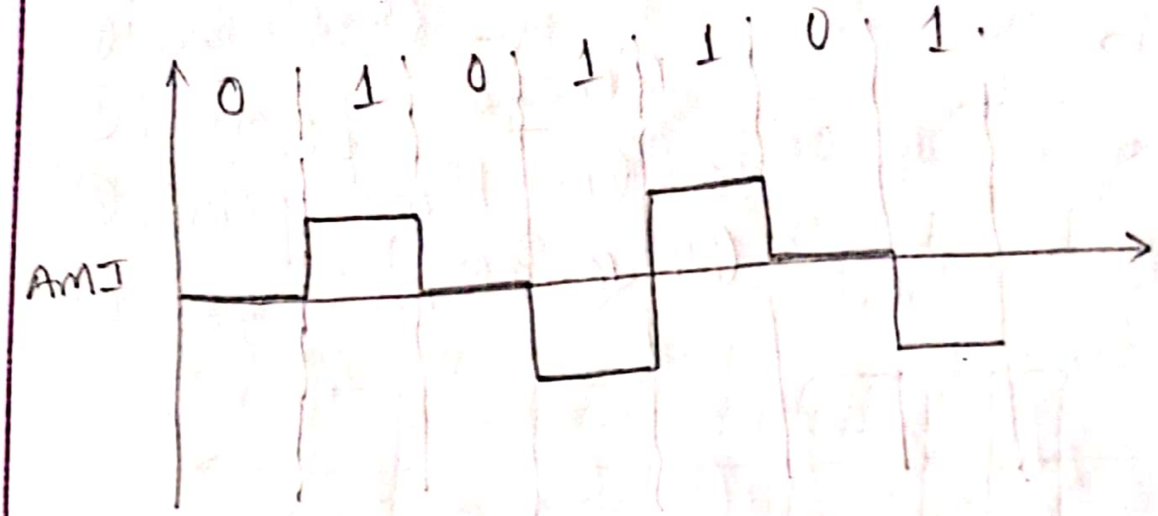
0 → Invention

1 → No invention

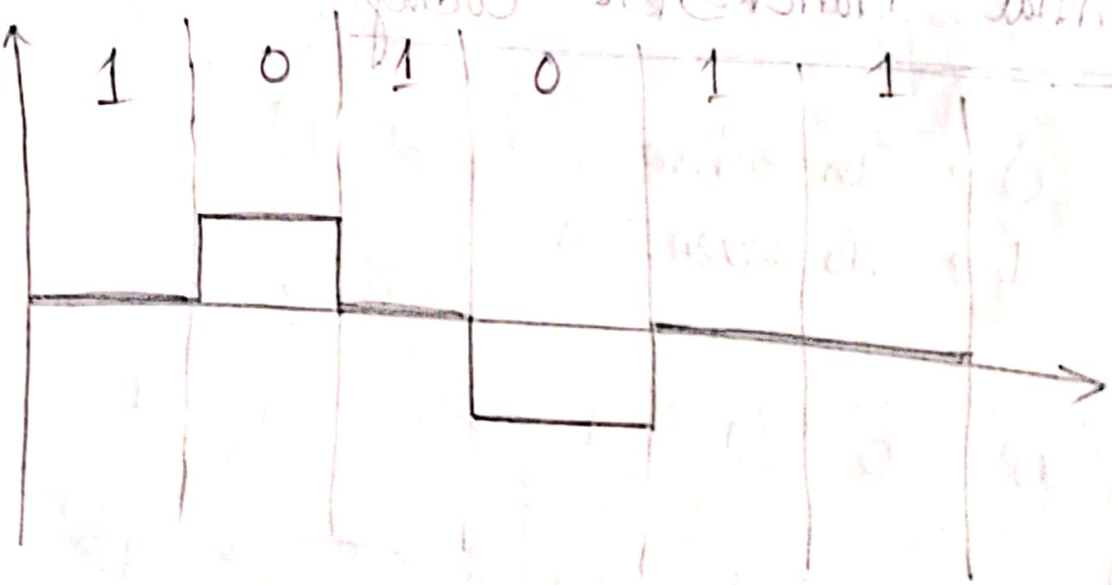


Bipolar

0 → 0V



Alternate Mark Inversion



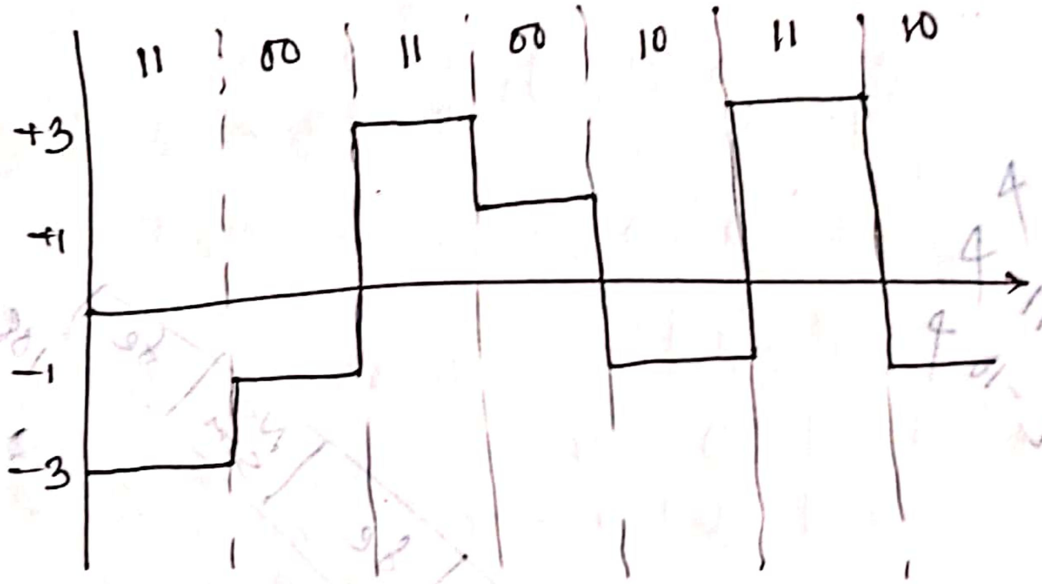
Pseudoternary (1 → 0V)

VBOVB

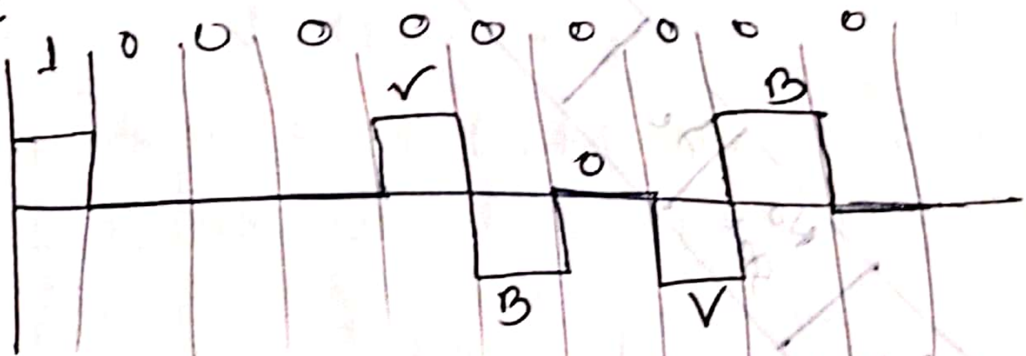
2B1Q Multilevel

$\boxed{2^m \le L^n}$

Next bit	If previous level is positive: Next level	If previous level is negative: Next level
00	+1	−1
01	+3	−3
10	−1	+1
11	−3	+3



B8ZS



HDB3

L-14 15

Practise

VRC (Vertical Redundancy check)

10101100 → Parity bit

Accepted,

11100001 ✓

11111100 ✓

11101100 ✗

LRC (Longitudinal Redundancy check).

জোড় হলে 0

বিজোড় " 1

Checksum

Sender side

```
    10101001
    00111001
------------
Sum 11100010
```

1's compliment 00011101 (checksum)

The Pattern sent is 10101001 00111001 00011101

Recievers Side

10101001
00111001
00011101

Sum 11111111

1's compliment 00000000 [That means the patten is OK]

(Cyclic Redundancy check).

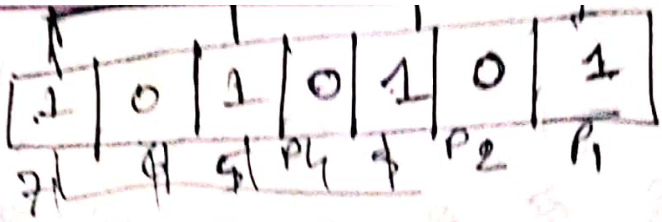
CRC

```
              Quotient
               11110
Divisor 1101 ) 1001000000    <- [Data plus extra zeros]
               1101
               ----
                1000
                1101
                ----
                 1010
                 1101
                 ----
                  1110
                  1101
                  ----
                   0110
                   0000
                   ----
                    1100
                    1101
                    ----
                     [001]  Remainder
```

CRC: 001

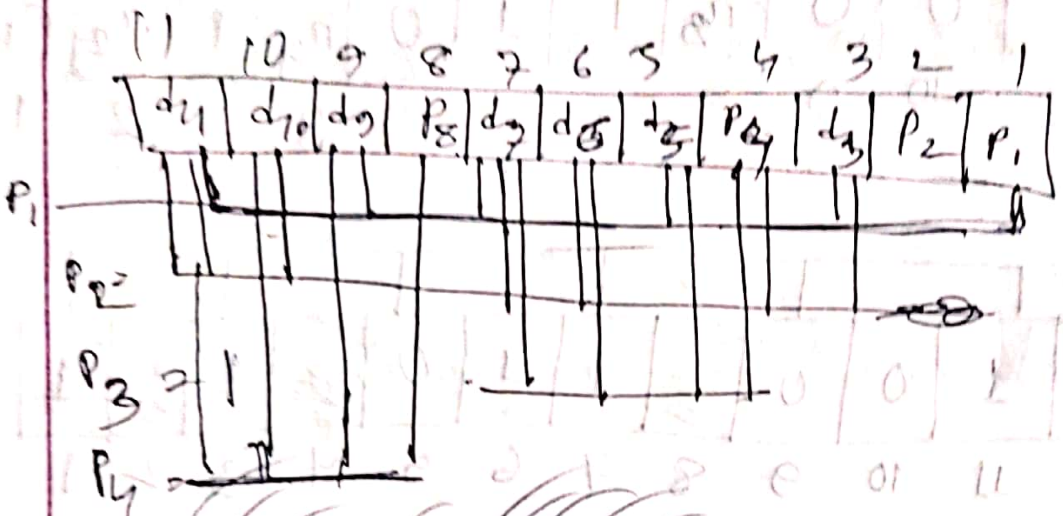
Data Transmitted:

1001000001



$P_1 = D_3 D_5 D_7$

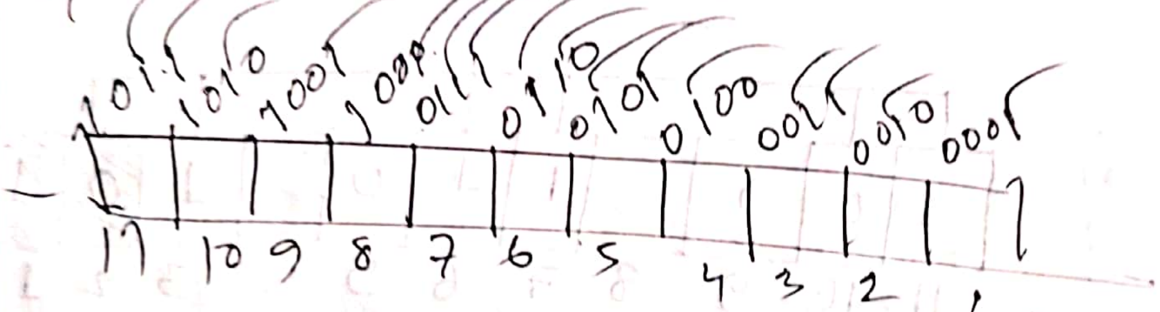
$= 1\ 1\ 1\ 1$



$P_2 = D_3 D_6 D_7$

$= 0\ 1\ 0\ 1$

P_3



$P_1 =$

Quotient

Divison 000 | 000 → Data plus extra zeros

$P_2 =$

$P_3 =$

$P_4 =$

7 6 5 4 3 2 1

1 0 0 1 0 0 0 1 1

Data:

1001101

1011	1010	1001	1000	0111	0110	0101	0100	0011	0010	0001
1	0	0	r_8	1	1	0	r_4	1	r_2	r_1
11	10	9	8	7	6	5	4	3	2	1

Adding r_1

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

Adding r_2

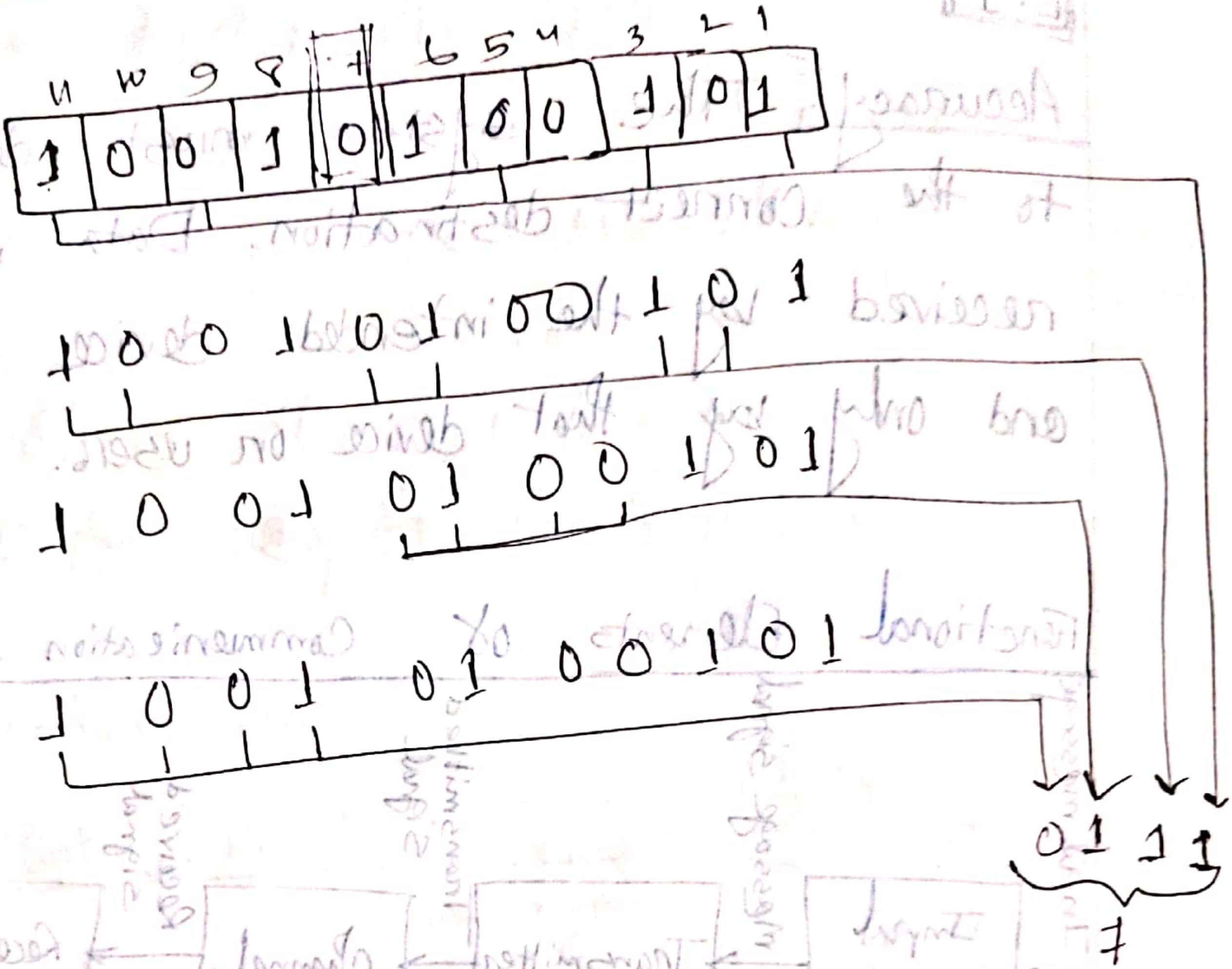
1	0	0		1	1	0		1	0	1
11	10	9	8	7	6	5	4	3	2	1

Adding r_3

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

Adding r_4

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

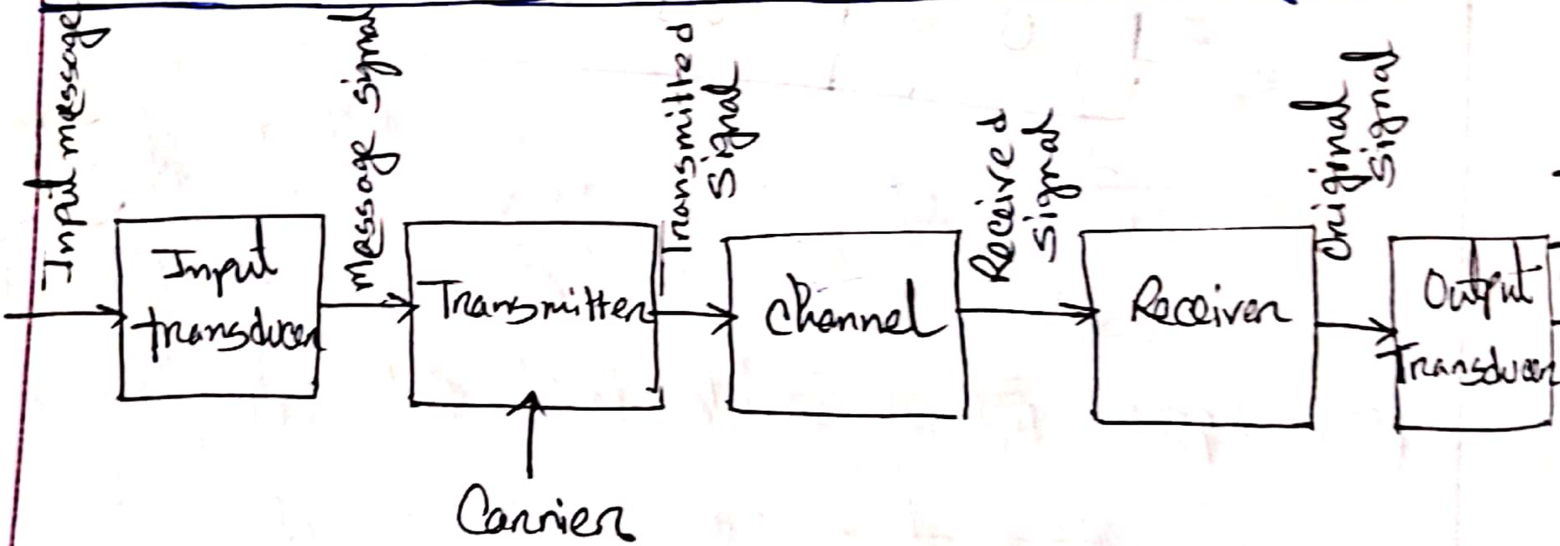

11 10 9 8 7 6 5 4 3 2 1
1 0 0 1 0 1 0 0 1 0 1
1 0 0 1 0 1 0 0 1 0 1
1 0 0 1 0 1 0 0 1 0 1
1 0 0 1 0 1 0 0 1 0 1
0 1 1 1
7

F Prep

L-1

Accuracy: The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.

Functional Elements of Communication System:



there three major subsystems:

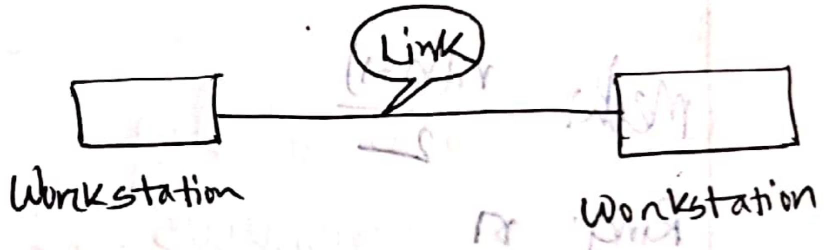
1. A Transmitter
2. The channel
3. And a receiver.

Direction of flow

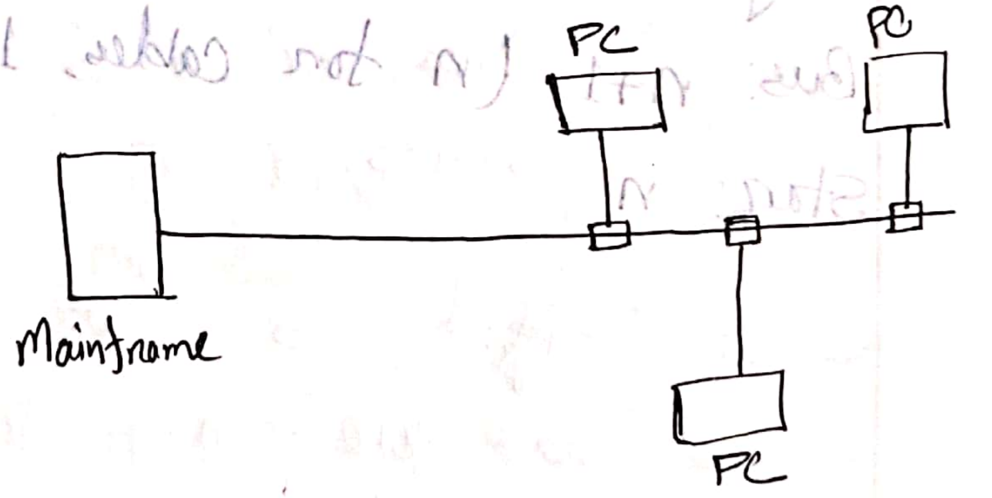
1. Simplex mode. Ex: Keyboard, monitor.
2. Half-Duplex " . Ex: Walkie-talkies, CB (Citizens band)
3. Full Duplex "/ Duplex mode. Ex:

* Line configuration.

① Point-to-point:



② Multipoint:



Network topology: A network topology is the physical and logical arrangement of nodes and connections in a network. Nodes usually include devices such as switches, routers and software with switch and router features. Network topologies are often represented as a graph.

Mesh: $\frac{n(n-1)}{2}$

Ring: n

Bus: $n+1$, (n for cables, 1 for backbone)

Star: n

Mesh:

If the number of devices are connected with each other in a mesh topology is = n. then the total number of physical channel = to links required to connect them is = $^nC_2$

we know,

$$^nC_r = \frac{n!}{r!\,(n-r)!}$$

$$\therefore\ ^nC_2 = \frac{n!}{2!\,(n-2)!}$$

$$= \frac{n(n-1)\cancel{(n-2)!}}{2\cdot 1\ \cancel{(n-2)!}}$$

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

(Proved)

☐ internet: The term "intenet" is a generic term used to mean an interconnection of networks.

☐ Internet: The Internet is the name of specific worldwide network.

$\boxed{\text{L-2}}$

* The term $\boxed{\text{Analog Data}}$ refers to information that is continuous. Ex: Analog clock.
* $\boxed{\text{Digital Data}}$ refers to information that has discrete states. Ex: Digital clock.

☐ A $\boxed{\text{Signal}}$ is formally defined as a fcn of one or more independent variables that conveys information on the nature of a physical phenomenon.

☐ Examples of $\boxed{\text{independent variables}}$

time, distance, position, tempature and pressure.

* A $\boxed{\text{periodic signal}}$ is one that repeats the sequence of values exactly after a fixed length of time, known as the period.

* A signal is considered to be $\boxed{\text{non-periodic}}$ or aperiodic signal when it does not repeat its pattern over a period.

Ex: ① $f = 60$ Hz

$$\therefore T = \frac{1}{60} = 0.0166 \, s$$

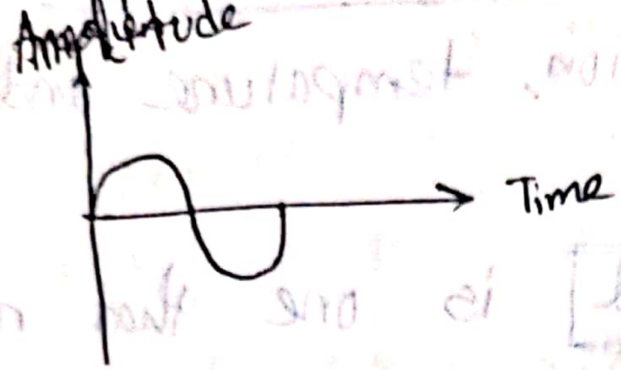
$$= 16.67 \text{ ms} \quad \text{Ans}$$

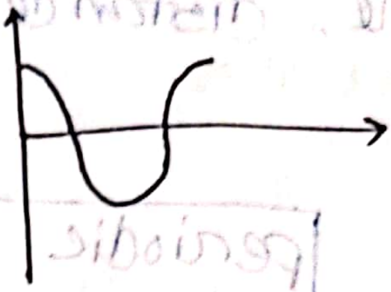
② $T = 100$ ms $= 0.1$ s

$$f = \frac{1}{T} = \frac{1}{0.1}$$

$$= 10 \text{ Hz} = 0.01 \text{ KHz} \quad \text{Ans}$$

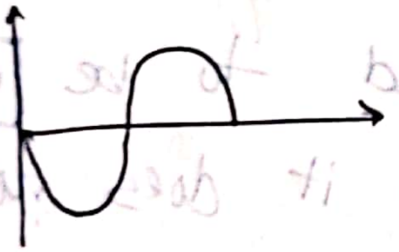
Phase

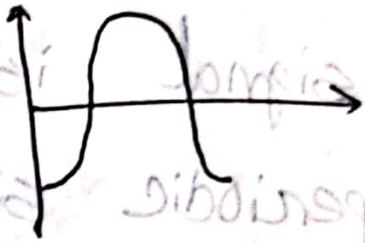




0°

90°





180°

270°

Ex: We know that 1 complete cycle is 360°.

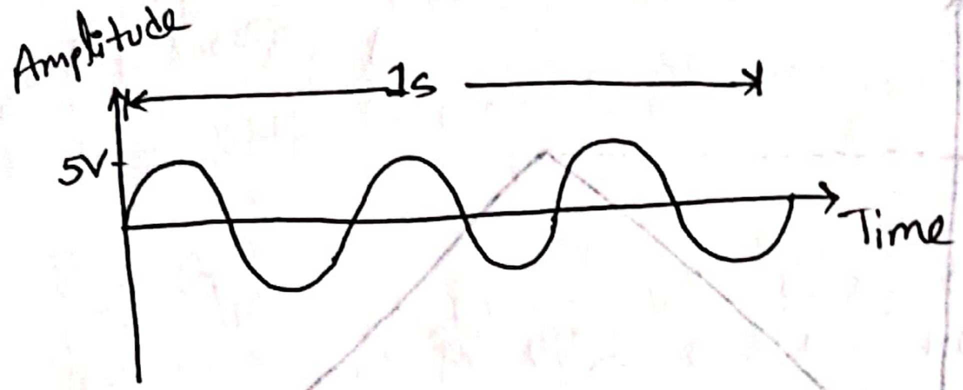
$$\frac{1}{6} \times 360^\circ = 60^\circ$$

$$= 60 \times \frac{\pi}{180}$$

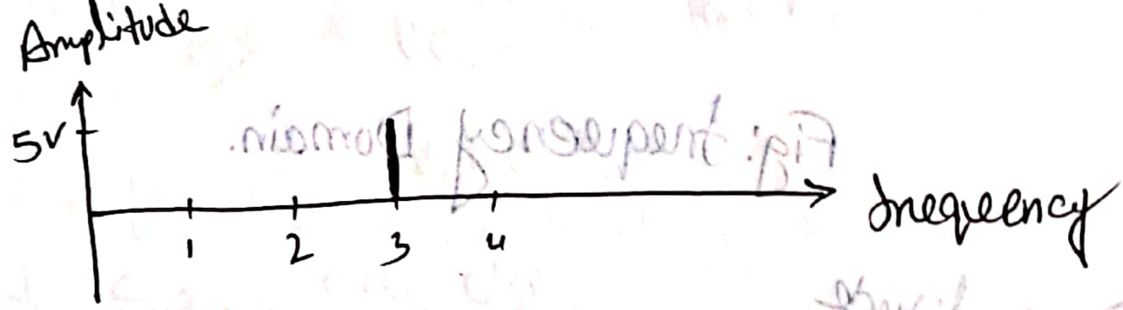
$$= 1.0472 \text{ rad}$$

Ans

L-3



Time Domain



Frequency Domain

* The bandwidth of a composite signal is the difference between the highest and the lowest frequencies contained in that signals.

Ex: ① Amplitude

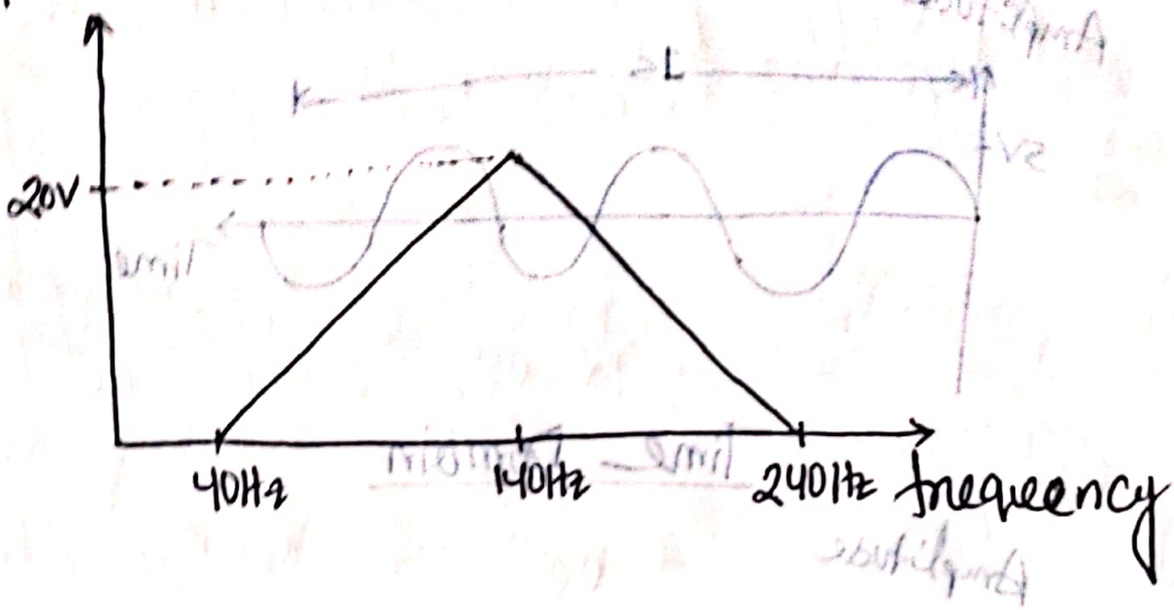
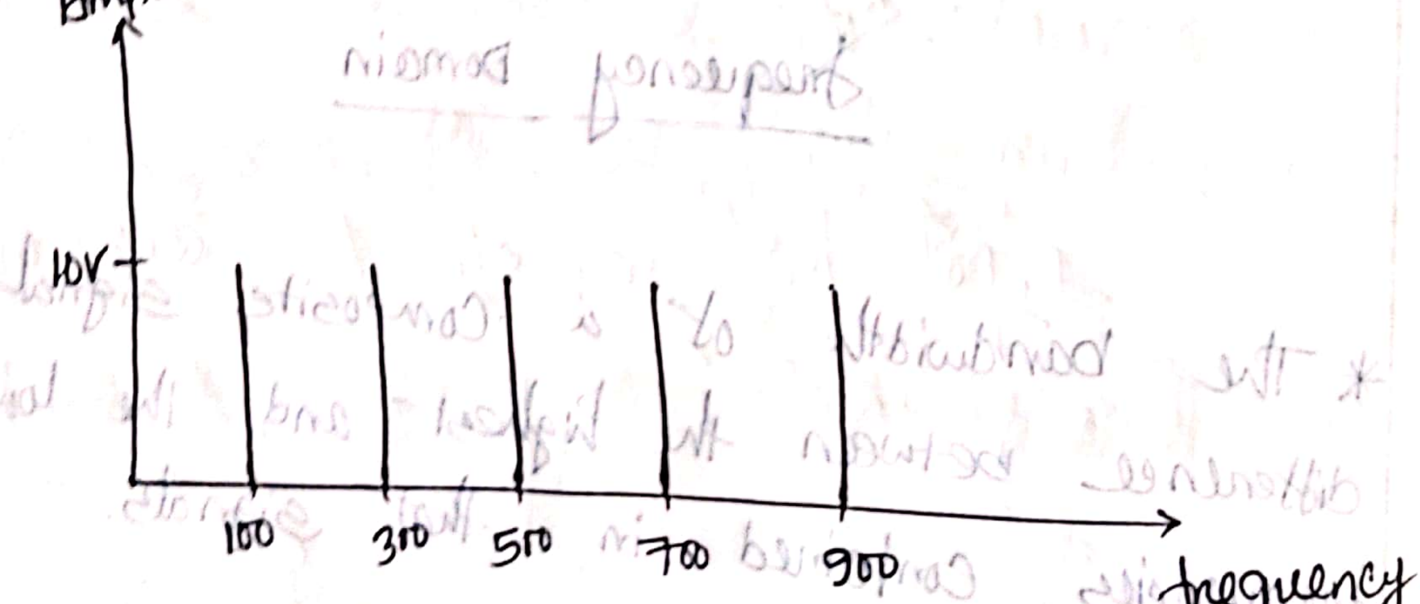


Fig: frequency Domain.

② Amplitude



$B = f_h - f_L$

$= (900 - 100)$ Hz

$= 800$ Hz Ans

② Here,

$B = 20\,Hz$

$f_h = 60\,Hz$

$f_L = f_h - B$

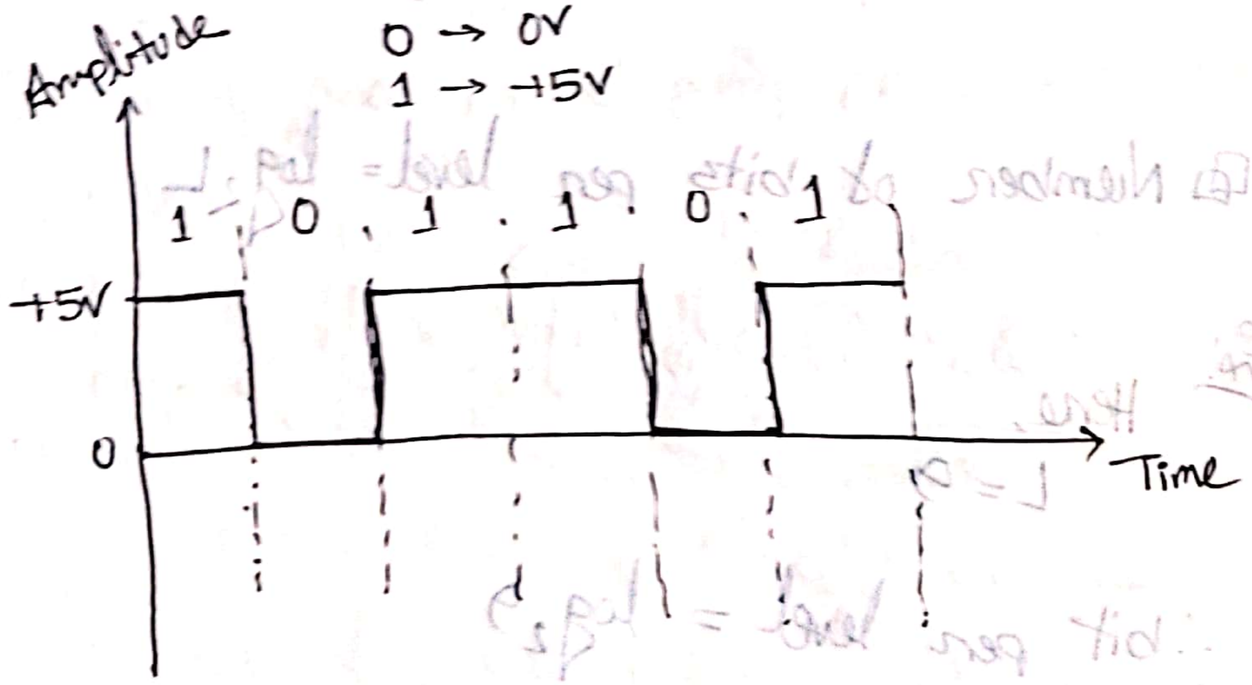
$= 60 - 20$

$= 40\,Hz$ Ans

Digital Signals

$0 \rightarrow 0V$

$1 \rightarrow +5V$



$\boxplus$ Bit interval $= \dfrac{1}{\text{bit rate (bps)}}$

Ex: Here,

bit rate $=$ 2000 bps

$\therefore$ Bit interval $= \dfrac{1}{2000}$

$= 5 \times 10^{-4}$ s

$= 0.5$ ms

Ans

$\boxplus$ Number of bits per level $= \log_2 L$

Ex: Here,

$L = 9$

$\therefore$ bit per level $= \log_2 9$

$= 3.17$

$\therefore$ 4 bits can represent one level.

L-4

Transmission Impairment

① Attenuation: Attenuation means loss of energy.

② Distortion: Distortion means that the signal changes its form or shape.

③ Noise: Noise is another cause of impairment.

Ex: Thermal noise, Induced noise, crosstalk, impulse noise.

Attenuation:

Attenuation and amplification are measured in decibel (dB).

$$dB = 10 \log_{10}\left(\frac{P_2}{P_1}\right)$$

P_2 → find Power

P_1 → initial powers.

Ex: (1) The Attenuation (loss of power) / The Amplification (gain of power)

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

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

$$= 10 \log_{10} 10$$

$$= 10 \, dB$$ Ans

(2) $dB = -3 + 7 - 3 = +1 \, dB$ Ans

(3) $\boxed{dB_m = 10 \log_{10} P_m}$ Power in milliwatts.

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

$$\Rightarrow \log_{10} P_m = -3$$

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

$$\therefore P_m = 1 \times 10^{-3} \, mW$$

Ans

$\boxed{\text{SNR}}$

$$SNR = \frac{\text{signal Power}}{\text{noise}}$$

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

Ex:

$$SNR = \frac{10{,}000 \mu W}{1 \mu W}$$

$$= 10{,}000$$

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

$$= 10 \log_{10} 10{,}000$$

$$= 40 dB$$

Ans

In a Noise-less channel:

$$SNR = \frac{\text{signal power}}{0} = \infty$$

$$SNR_{dB} = 10 \log_{10} SNR = 10 \log_{10} \infty$$

$$= \infty$$

L-5

Ans

$$\text{Propagation time} = \frac{\text{distance}}{\text{propogation speed}}$$

$$= \frac{2000 \times 1000}{2 \times 10^8}$$

$$= 10\ ms = 0.01\ s$$

$$\text{Transmissio time} = \frac{\text{Size (bits)}}{\text{bandwidth (bps)}}$$

$$= \frac{5 \times 10^6}{5 \times 10^6}$$

$$= 1\ s$$

Queuing time $= 10$ routers $\times\ 2\ \mu s$

$$= 20\ \mu s = 2 \times 10^{-5}\ s$$

Processing time $= 10$ routers $\times\ 1\ \mu s$

$$= 10\ \mu s = 1 \times 10^{-5}\ s.$$

$\therefore$ Latency $= 0.01 + 1 + (2 \times 10^{-5}) + (1 \times 10^{-5})$

$$= 1.01003$$

Ans

L-6

Ex: In a nyquist channel (Noiseless channel)

①

$$\text{Bit Rate} = 2 \times \underset{(Hz)}{\text{Bandwidth}} \times \log_2 L$$

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

$$= 6000 \text{ bps}$$

Ans

② $$\text{BitRate} = 2 \times 3000 \times \log_2 4$$

$$= 12,000 \text{ bps}$$

Ans

③ $$265 \times 1000 = 2 \times 20 \times 1000 \times \log_2 L$$

$$\Rightarrow \log_2 L = 6.625$$

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

$$\therefore L = 98.70$$

If we have 128 levels, the bit rate is 280 Kbps

" " " 64 " " " " " 240 "

Ans

④ Capacity = Bandwidth $\times \log_2(1 + SNR)$

$= \text{Bandwidth} \times \log_2(1+0)$

$= 0$

Ans

⑤ Capacity $= 3000 \times \log_2(1 + 3162)$

$= 34881.23$ bps

$= 34.88$ Kbps

Ans

⑥ $SNR_{dB} = 10 \log_{10} SNR$

$\Rightarrow 36 = 10 \log_{10} SNR$

$\Rightarrow SNR = 10^{3.6}$

$\therefore SNR = 3981$

$\therefore$ Capacity $= 2 \times 10^6 \times \log_2(1 + 3981)$

$= 24$ Mbps

Ans

7. BitRate/Capacity $= B \times \log_2(1+SNR)$

$= 1\times10^6 \times \log_2(1+63)$

$= 6$ Mbps.

BitRate $= 2 \times$ Bandwidth $\times \log_2 L$

$\Rightarrow 6\times10^6 = 2\times 1\times10^6 \times \log_2 L$

$\Rightarrow L = 8$ Ans

Baseband	Broadband
Baseband transmission means sending a digital signal over a channel without changing the signal to an analog signal.	Broadband transmission or modulation means changing the digital signal to an analog signal for transmission.
The type of signalling used is digital.	The type of signalling used is analog.
It is bidirectional in nature.	It is undirectional in nature.
Signal can only travel over short distance.	Signals can be travelled over long distance without being attenuated.
It works well with bus topology.	It is used with a bus as well as tree topology.

Manchester and Differential Manchester encoding are used.	Only PSK encoding is used.
It have 50Ω impedance.	It have 70Ω impedance
It is easy to install and maintain.	It is difficult to install and maintain.
It is cheaper to design.	It is expensive to design.

$\boxed{\text{L-5 (Math)}}$

Ex:

① Throughput $= \dfrac{\text{frame} \times \text{bits}}{\text{time}}$

$= \dfrac{12000 \times 10000}{60}$

$= 2$ Mbps

Ans

② Propagation time $= \dfrac{12000 \times 1000}{2.4 \times 10^{8}}$

$= 50$ ms

Ans

Transmission time $= \dfrac{\text{Size (bits)}}{\text{bandwidth (bps)}}$

$= \dfrac{2.5 \times 1000 \times 8}{1 \times 10^{9}}$

$= 0.020$ ms

Ans

$\lambda = \dfrac{c}{f}$

$\boxed{\text{L-9}}$ (Digital to Analog Conversion)

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

N → Bit Rate

r → number of data bits per signal.

S → baud rate

Ex: ① $S = N \times \frac{1}{r}$

$\Rightarrow 1000 = N \times \frac{1}{4}$

$\Rightarrow N = 4000$ bps Ans

② $1000 = 8000 \times \frac{1}{r}$

$\Rightarrow r = 8$ bit/baud Ans

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

$\Rightarrow L = 2^r$

$= 2^8$

$= 256$ signal elements we need Ans

3

ASK $\boxed{B = (1+d)S}$ → always given

The carrier frequency $= \dfrac{200 + 300}{2} = 250\ \text{Hz}$

$100 = (1+1)S$

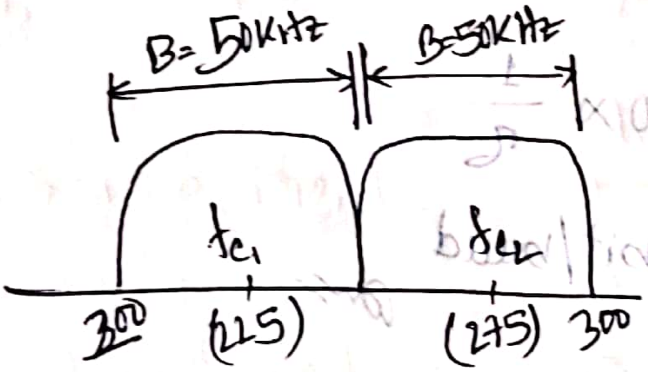
$\Rightarrow S = 50$

$\Rightarrow N \times \dfrac{1}{r} = 50$

$\Rightarrow N = 50\ \text{kbps}$ $\quad [r = 1]$

Ans

4



⑤ FSK

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

$$\Rightarrow 100=(1+1)S+50$$

$$\Rightarrow S=25 \text{ Kbaud}$$

$$\Rightarrow N\times\frac{1}{r}=25$$

$$\Rightarrow N=25 \text{ Kbps}$$ Ans

N → bit Rate

Carrier frequency

$$=\frac{200+300}{2}$$

$$=250 \text{ KHz}$$ Ans

⑥ QPSK

For QPSK, 2 bits is carried by one signal element. This means that $r=2$.

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

$$\Rightarrow S=12\times\frac{1}{2}$$

$$\Rightarrow S=6 \text{ Mbaud}$$

$$\therefore B=(1+d)S \quad [\because d=0]$$

$$=(1+0)6=6 \text{ MHz}$$ Ans

L-12

Serial Transmission	Parallel Transmission
Serial Transmission is the type of transmission in which a signal commucation link is used to transfer the data from an end to another.	Parallel Transmission is the transmission in which multiple parallel links are used that transmit each bit of data simultaneously.
data(bit) flow in bi-direction.	data(bit) flow in multiple lines.
It is cost-efficient.	It is not cost-efficient.
One bit transferred at one clock pulse.	Eight bit transferred at one clock pulse.
It is slow in comparison of Parallel Transmission.	It is fast in comparison of Serial Transmission.

It is used for long distance	It is used for short distance.
The circuit used in Serial Transmission is sample.	The circuit used in Parallel Transmission is relatively complex.

Synchronous	Asynchronous
In Synchronous transmission a common clock is shared by the transmitter and receiver to achieve synchronisation while data transmission.	In Asynchronous transmission each character contains its own start and stop bits.
Data is sent in form blocks or frames.	Data is sent in form of byte or character.
It is fast.	It is slow.
It is costly.	It is economical.
Time interval of transmission is constant.	Time interval of transmission is not constant, it is random.

There is no gap present between data.	There is present gap between data.
Efficient use of transmission line is done in synchronous transmission.	while in asynchronous transmission, transmission line remains emptly during gap in character transmission.
It needs precisely synchronized clocks for the information of new bytes.	It have no needs of synchronized clocks as parity bit is used in this transmission for information of new bytes.
It is easy to design.	It is complex.

L-13

Ex

$$C = B\log_2(1+SNR)$$
$$= 3000 \times \log_2(1+3162)$$
$$= 34860 \text{ bps}$$

Ans

L-14

Guided Media	Unguided Media
① Waves are guided along a physical path.	① Use radio waves of different frequencies and do not need a wire or cable conductor to transmit signals (that is the atmosphere and outer space).
② Use a conductor such as a wire or a fiber optic cable to move the signal from sender to receiver.	
③ Transmission Capacity depends on the distance and on whether the medium is point-to-point or multipoint.	

Twisted Pair Cable

Advantage

① Inexpensive and readily available.

② Flexible and light weight.

③ Easy to work with and install.

Disadvantage

① Susceptibility to interference and noise.

② Attenuation problem.
For analog, repeaters needed every 5-6 km.
For digital " " 2-3 km.

③ Relatively low bandwidth (3000 Hz).

Coaxial Cable

Advantage	Disadvantage
(1) Higher bandwidth (400 - 600) MHz up to 10,800 voice conversations.	(1) More expensive to install compare to twisted pair cable.
(2) Can be tapped easily.	(2) The thicker the cable, the more difficult to work with.
(3) Much less susceptible to interference than twisted pair.	

Types of Propagation

(1) Surface
(2) Tropospheric
(3) Ionospheric
(4) Line-of-sight
(5) Space propagation.

Surface propagation

→ waves moves along the surface of earth.

→ support vertical polarization.

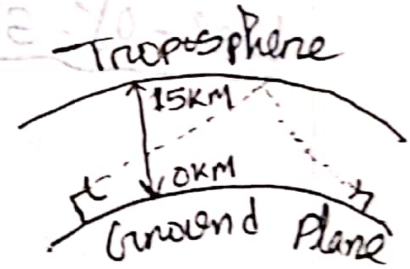
→ 3KH - 3MHz frequency.

→ 100 KM - 1000 KM distance.

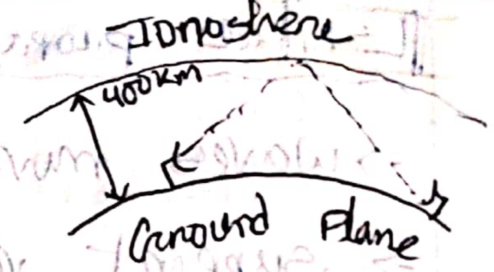
→ Am broadcast during day time.

Tropospheric Propagation

→ small range.



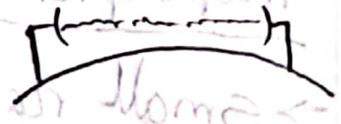
Ionospheric Propagation



→ Large range

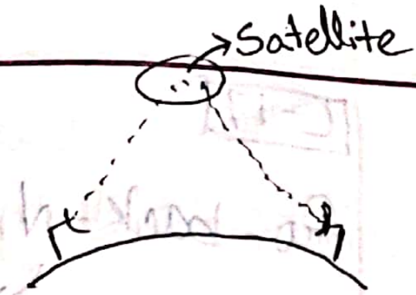
→ 3 MHz - 30MHz

Line-of-sight



Space Propagation

→ > 30 MHz



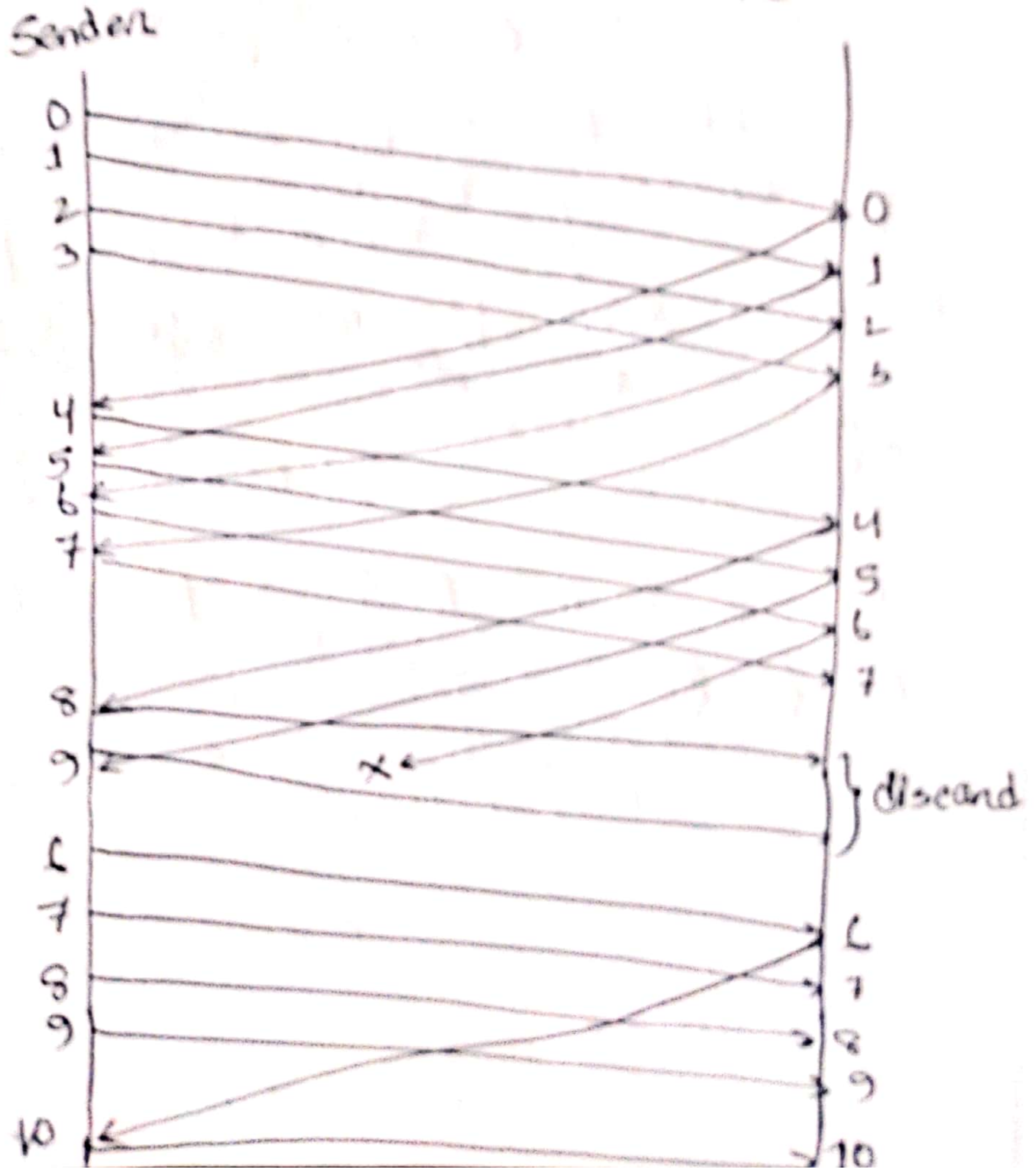
L-17

Go-back-N ARQ → Automatic Repeat Request Protocol

→ window size

10	9	8	7	6	5	4	3	2	1	0

window = 4

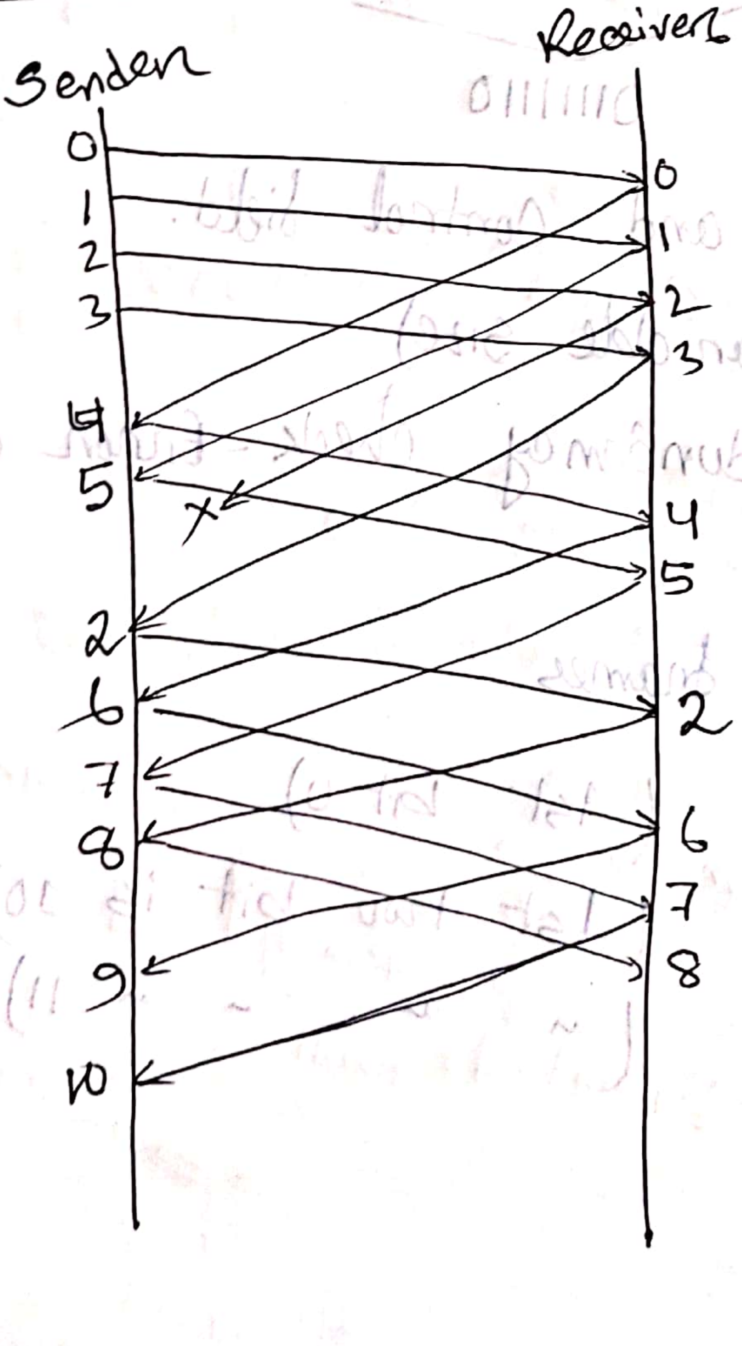


□ number of bit = $\log_2$(windows),

Selective Repeat ARQ

10	9	8	7	6	5	4	3	2	1	0

wind



HDLC

High-Level Data Link Control.

Beginning sequence	Header	Body	CRC	Ending sequence

01111110

Header: Address and Control field.

Body: Payload (variable size)

CRC: Cyclic Redundancy Check - Error detection.

Types of HDLC frames

1. I - frame (1st bit 0)
2. S - " (1st two bit is 10)
3. U - " (" " " " 11)

☐ HDLC is a bit-oriented protocal.

→ A bit-oriented protocal is a Communi
protocol that sees the transmitted data
as an opaque stream of bits with no
semanties, or meaning.

HDLC Station type

① Primary Station
  → Controls operation of link.
  → Frames issued are called commands.

② Secondary Station
  → Under control of primary station
  → Frames issued called responses.

③ Combined station
  → May issue commands and response

HDLC - Link Configuration

① Unbalanced

→ One primary and one or more secondary stations.

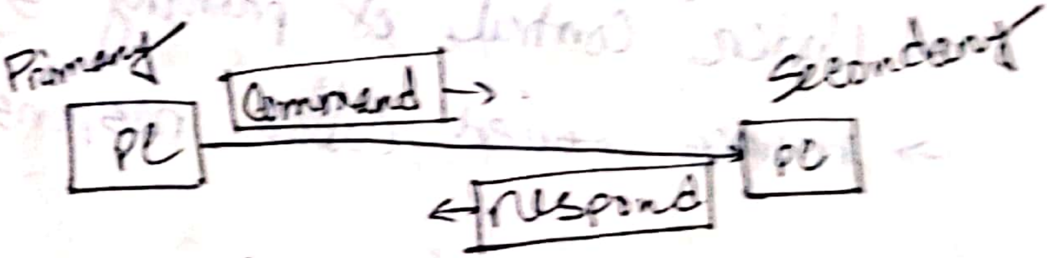
→ Supports full duplex and half duplex.

② Balanced

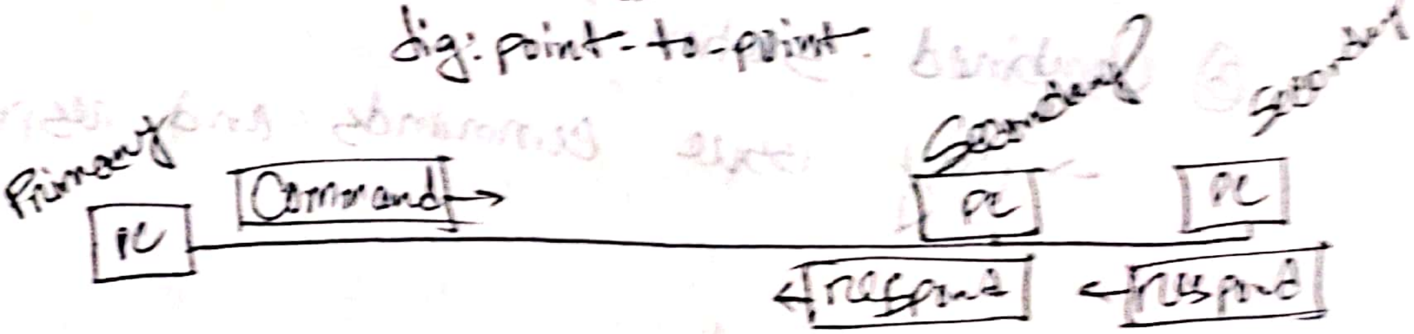
→ Two combined stations.

$\boxed{\text{NRM}}$ Normal Response Mode

→ unbalanced



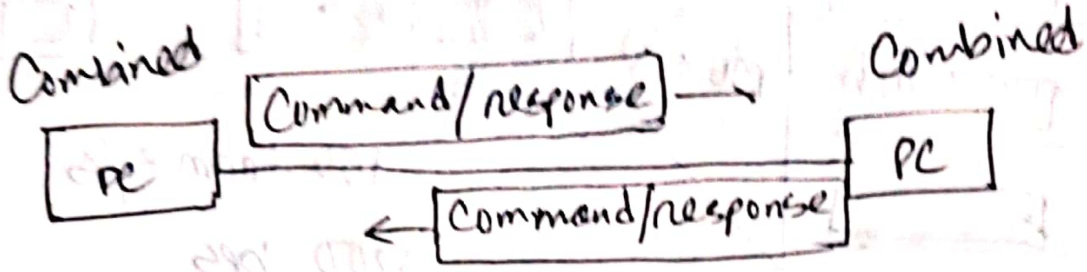
dig: point-to-point.



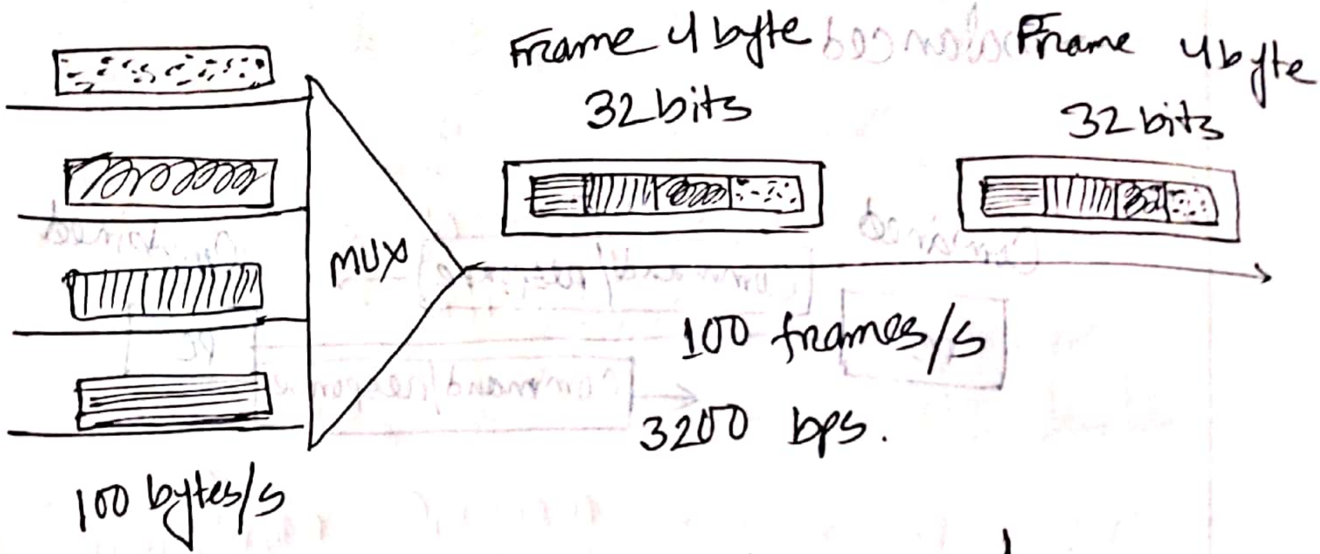
dig: Multipoint.

$\boxed{\text{ABM}}$ Asynchronous Balance Mode

→ balanced



L-21



$$\text{Frame duration} = \frac{1}{100} = 0.01\ s$$

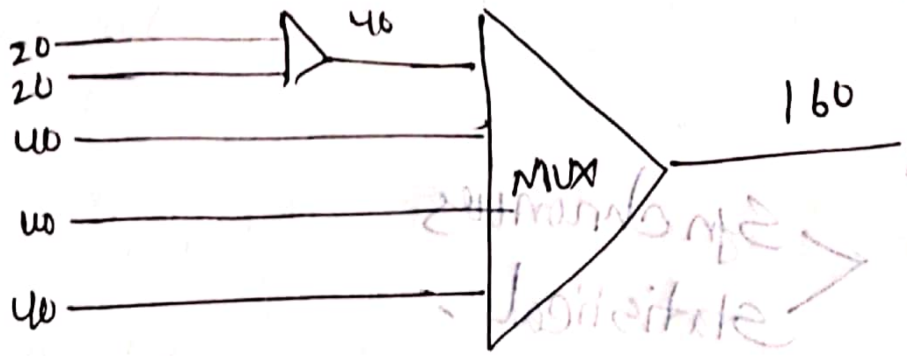
$$\text{Frame Size} = \frac{32}{8} = 4 \text{ byte/frame} = 32 \text{ bit/frame}$$

$$\text{Data rate}_{link} = 4 \times 100 = 400 \text{ bytes/s} = 3200 \text{ bps}$$

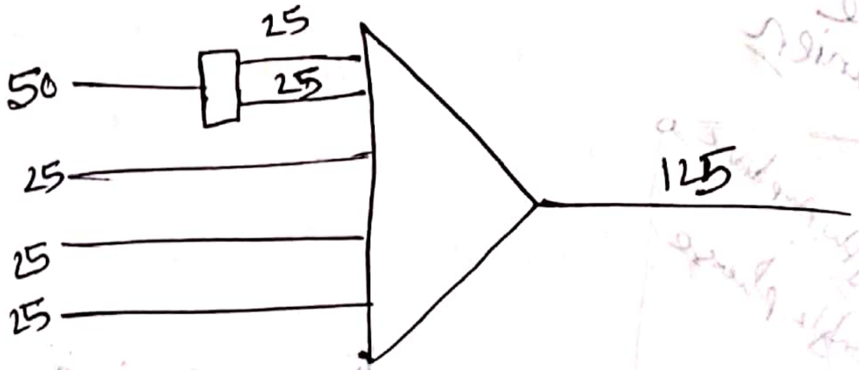
$$\text{Frame Rate}_{link} = \frac{\text{Data Rate}}{\text{Frame Size}} = \frac{3200}{32} = 100 \text{ fram/secon}$$

$$\text{Frame Duration} = \frac{1}{\text{Frame Rate}} = \frac{1}{100} = 0.01 \text{ s/fram}$$

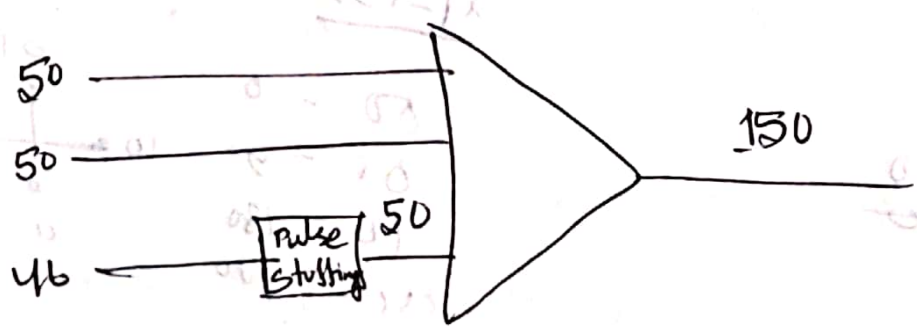
Multilevel



Multiple - Slot



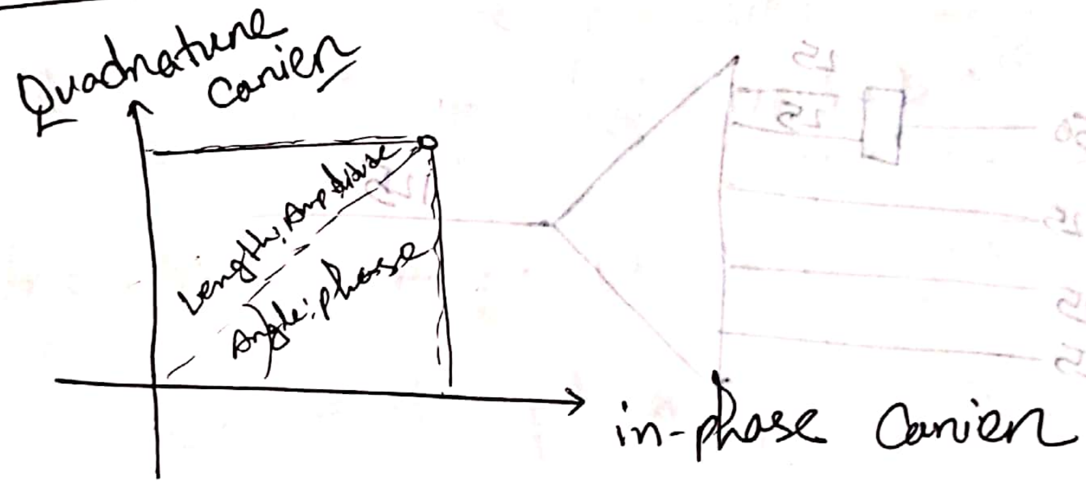
Pulse Stuffing



Multiplexing

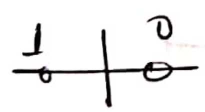
1. FDM
2. WDM
3. TDM < Synchronous / Statistical.

Constellation Diagram



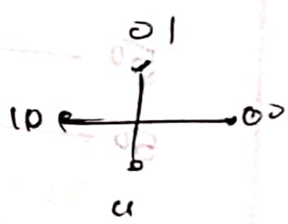
PSK

0 - 0
1 - 180



4-PSK

00 - 0
01 - 90
10 - 180
11 - 270



1101011

11	10	9	8	7	6	5	4	3	2	1
d_{11}	d_{10}	d_9	r_8	d_7	d_6	d_5	r_4	d_3	r_2	r_1
							0100	0011	0010	0001

Adding r_1

1	1	0	r_8	1	0	1	r_4	1	r_2	0	r_1

Adding r_2

									0	0