04.01.2
Tuesday

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Data Communication

(Imp) OSI / TCP Model (Transmission control protocol)

Digital communication (computer understands this)

Data → Analog
Data → Digital

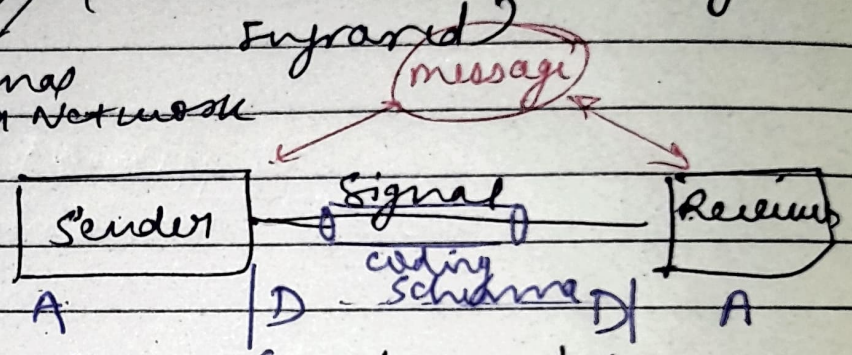
Signal → Analog
Signal → Digital

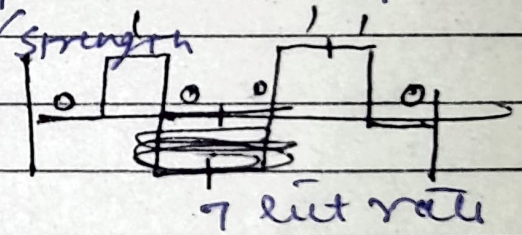
Transmission ~~Medium~~ Medium Technology
- Wired (PAN, LAN, MAN, WAN)
- Wireless / (Wi Fi, Bluetooth, Zigbee, Infrared)

Personal ~~Area Network~~

Computer understands Binary 0/1 (voltage, watt, Ampere)

0 Low / off / 0 volt
1 high / ON / +5 Volt
strength





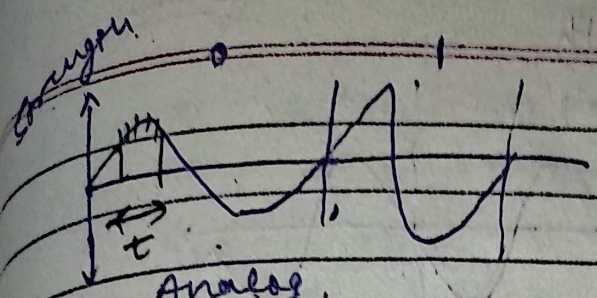
Bit rate = No. of bit transmitted / seconds

Analogue (whatever we speak)
Digital

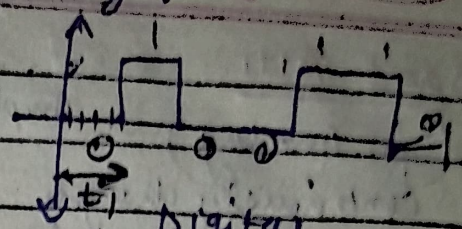
(Coding scheme)

Computer Hertz
3.2 GHz
32×10^9 Hz per sec.
instruction = in ns

Protocol
↓
Set of instructions which is used to communicate.



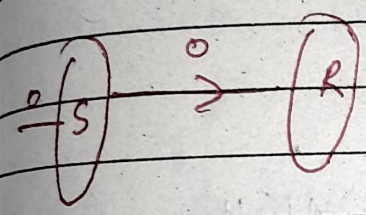
Analog.
(continuous)



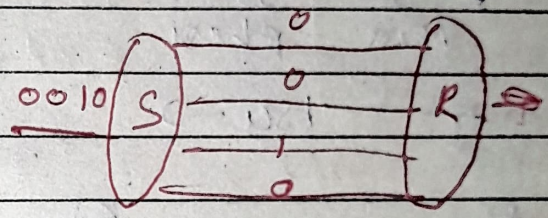
Digital
(Discrete)

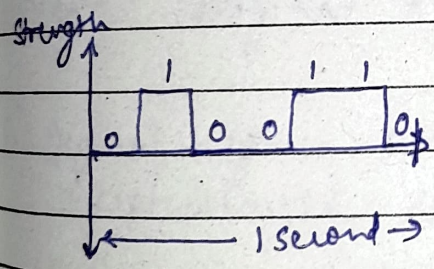
Signal will transmit through channel.
or Bus

Serial



Parallel





Bit Rate =
7 bits per second.

Band Rate =
(~~m~~ depends on medium acc. of protocol)

IP Address :- (Internet Protocol Address) → 128 bit address (new)

MAC Address :- Hardware address (48 bit address)

Can be changed

Can't be changed

~~Mac~~ Media Access Control

12 : B2 : AB : 12 : 3F : A1
= 1010 0101 (6 pairs)

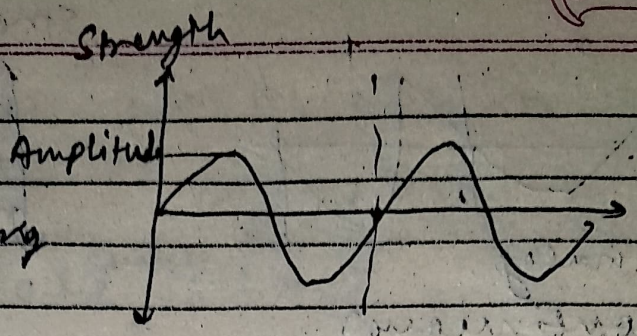
0 - 0000 Hexadecimal.
(4 bits)

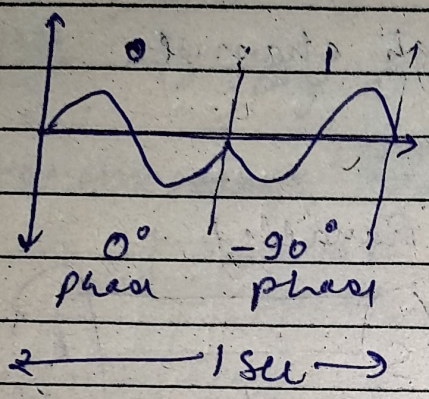
0 to $2^N - 1$

F 15 - 1111

Band Rate:

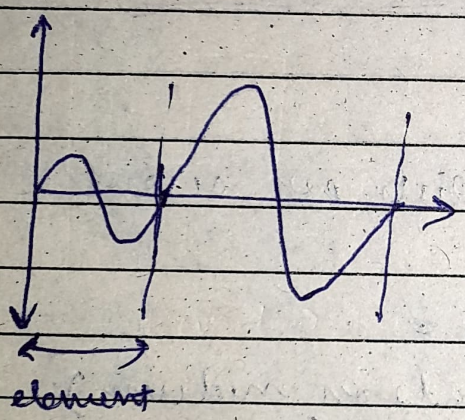
(for Analog) Continously changing Amp., freq., time



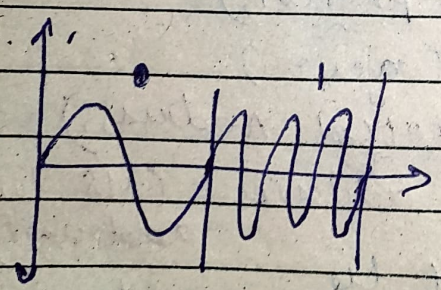


① Phase shift

Bit rate = 2 bits per second



② Amplitude shift



③ Frequency change

Data communication refer to the transfering digital data ~~bit~~ (analog & digital) betn two or more computer or computer networks

Network allows data to send.

OSI / TCP → - Stack of Model

Bottom two

Physical layer
Data link layer (In syllabus)

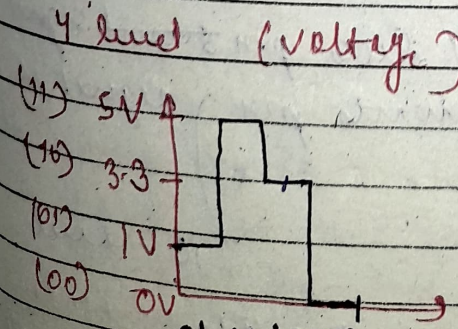
When data is send over physical medium, it needs to be first converted into Electromagnetic signal.

Data can be Analog (Human voice) or Digital (C program code)

Both A & D Data can be represented using Digital or Analog signal.

Digital signal are discrete in nature. Represented by sequence of Voltage pulse

Baud Rate: The no. of signal ~~you need~~ (signal element) per second ~~in order to~~ that are required to represent these bits.



Baud Rate = 8 bits/second
Bit rate = 4 bits/second

$\boxed{\text{Baud rate} \leq \text{Bit rate}}$

equality in binary signal (max. can be double)

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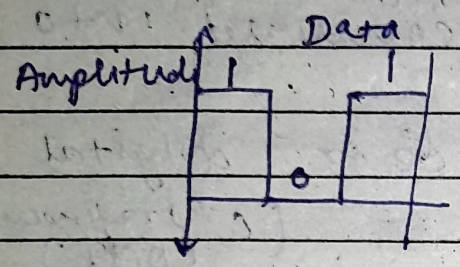
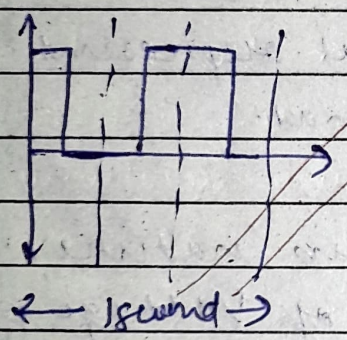
$$\frac{\overset{r}{\text{Bit Rate}}}{n} = \overset{R}{\text{Baud rate}}$$

$$r = \frac{R}{n} \quad \text{or} \quad R = nr$$

Q) For one signal element is signal with ~~single~~ amplitude. (constant)



Bit Rate = 3 bit rate
Baud rate = 3



Bit Rate = 3
Baud rate = 6

For Analog signal, one signal element is signal with the same phase or same amplitude or same frequency.

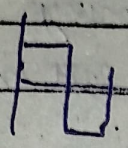
Q) Analog signal carries 4 bits per ~~second~~ signal element. If 1000 elements per signal is send, find the bit rate.

Sol: $\cancel{\frac{1000}{4}} = \cancel{250 \text{ Bit rate}}$ 16 level

4000 bit rate.

Find bit rate & baud rate if 1000 signal elements are transmitted in 1S & each bit signal carries 6.

1000



If bit rate is

HW Q.1) Bit Rate and Baud Rate
Q.2) Analog and Digital Signal
Q.3) 5 Numericals on Bit and Baud rate

A1. Bit Rate :- Bit Rate is the transmission of a no. of bits per second
(Emphasized computer efficiency) → can't determine Bandwidth
Unit :- Kbps, Mbps, Gbps etc.

Baud Rate :- No. of signals per second.
Higher Baud Rate ⇒ Faster the data is sent or received

$$\boxed{\text{Bit Rate} = \text{Baud Rate} \times \text{No. of bits per baud}}$$

$$\text{Baud Rate} = \frac{\text{No. of signal elements}}{\text{Total time (in S)}}$$

$$\text{Bit Rate} = \frac{\text{No. of bits transmitted}}{\text{Total time (in s)}}$$

A2. Analog signal :- The continuous wave signals that change with time period.
Represented by sine waves
~~Human~~ Can be defined by using Amplitude, time period

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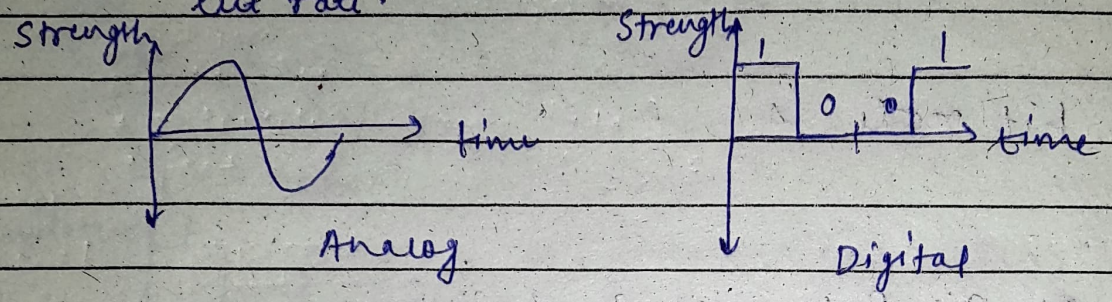
Digital signal :- The discrete signal in nature.
They are represented by square waves.
Carries data in the form of binary
signals are determined by a bit interval as well as a bit rate.



A-3.

① An analog signal has a bit rate (r) of 8000 bps and baud rate (R) of 1000.
The AS has ____ signal elements & carry ____ data elements in each signal

Sol: For AS $\boxed{r = R \log_2 m}$ m: signal elements

$\Rightarrow 8000 = 1000 \log_2 m$

$\Rightarrow m = 2^8 = 256$ 256 signal elements

No. of bits = 8

② The bit rate ~~is~~ of signal is 3000 bps. If each signal unit carries 6 bits, the Baud rate of the signal is ____

Sol: $r = R * n$ r = bit rate R = Baud rate n: No. of bits in signal

$\Rightarrow 3000 = R \times 6$

$\Rightarrow \boxed{R = 500 \text{ baud/sec}}$

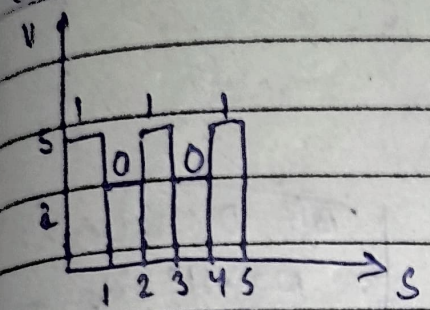
③ If AS carries 4 bits in each signal unit. If 1000 signal units are sent per second the Baud rate & bit rate are

Baud Rate : 1000 baud/s (Defn of Baud)

$r = B \times n$

$r = 1000 \times 4$ ⇒ $\boxed{r = 4000 \text{ bps}}$ = Bit Rate

Calculate Baud rate & Bit rate from diagram.



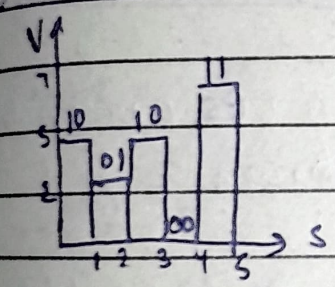
Sol:

Baud Rate = 1 Baud/s

Bit Rate = 1 bps

[only 2 voltage levels so only 1 bits per second]

Calculate Baud rate & bit rate



Sol: Baud Rate = 1 Baud Rate

(No. of signal element/second)

Bit Rate = No. of bits per s.

= 2 bps

(2 bits per sec)

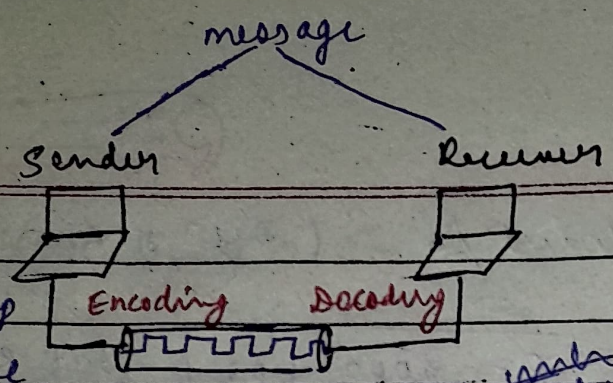
Digital Data (0,1) → Binary if 2 Voltage level

high (+5V) → 1

low (-5V/0V) → 0

For 3 levels of voltage we require 2 bits

For N voltage level we require $\lceil \log_2 n \rceil$ bits



abc.cpp
abc.exe
(binary)
0110100

medium should be
- reliable
- fast

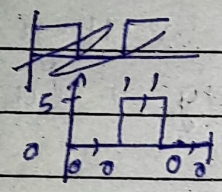
~~encoding~~ decoding error

0010100 (expected)
00100 ✗

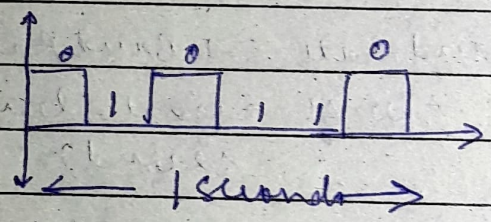
(same data) on S & R

"There are diff. encoding schema (manchester coding)

Digital Signal



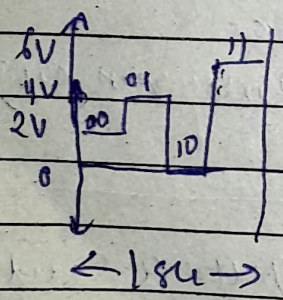
Bit Duration = ~~No. of bits in~~ Time to transfer 1 bit



Bit rate = 6 bits per second

~~Baud~~ Bit duration = $\frac{1}{6}$ s

Baud rate = 6 bands/s.



Bit rate ≥ Baud rate
(equality when binary signal)

Baud rate = 4 bands/sec.

Bit rate = 4 × 2 = 8 bits/s

Bit rate (r) = n × Baud Rate (R)

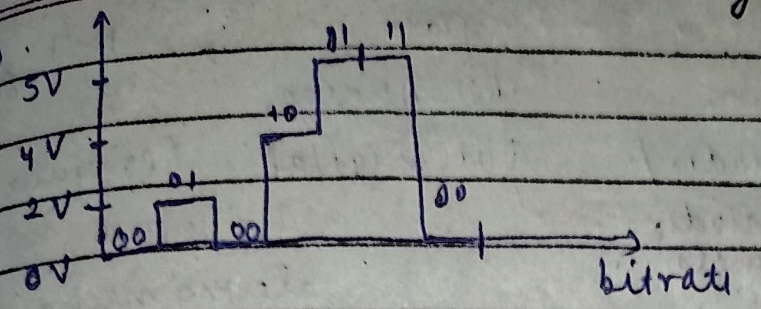
⇒ $r = \log_2 N \times$ Baud Rate

(Numerical imp comp)

Signal level
strength level /
voltage level

Bit rate ≠ Baud rate

Multi level signal



In 1 sec.
9600 bits are transferred

$r = n \times R$ $\quad n = \log_2 N$

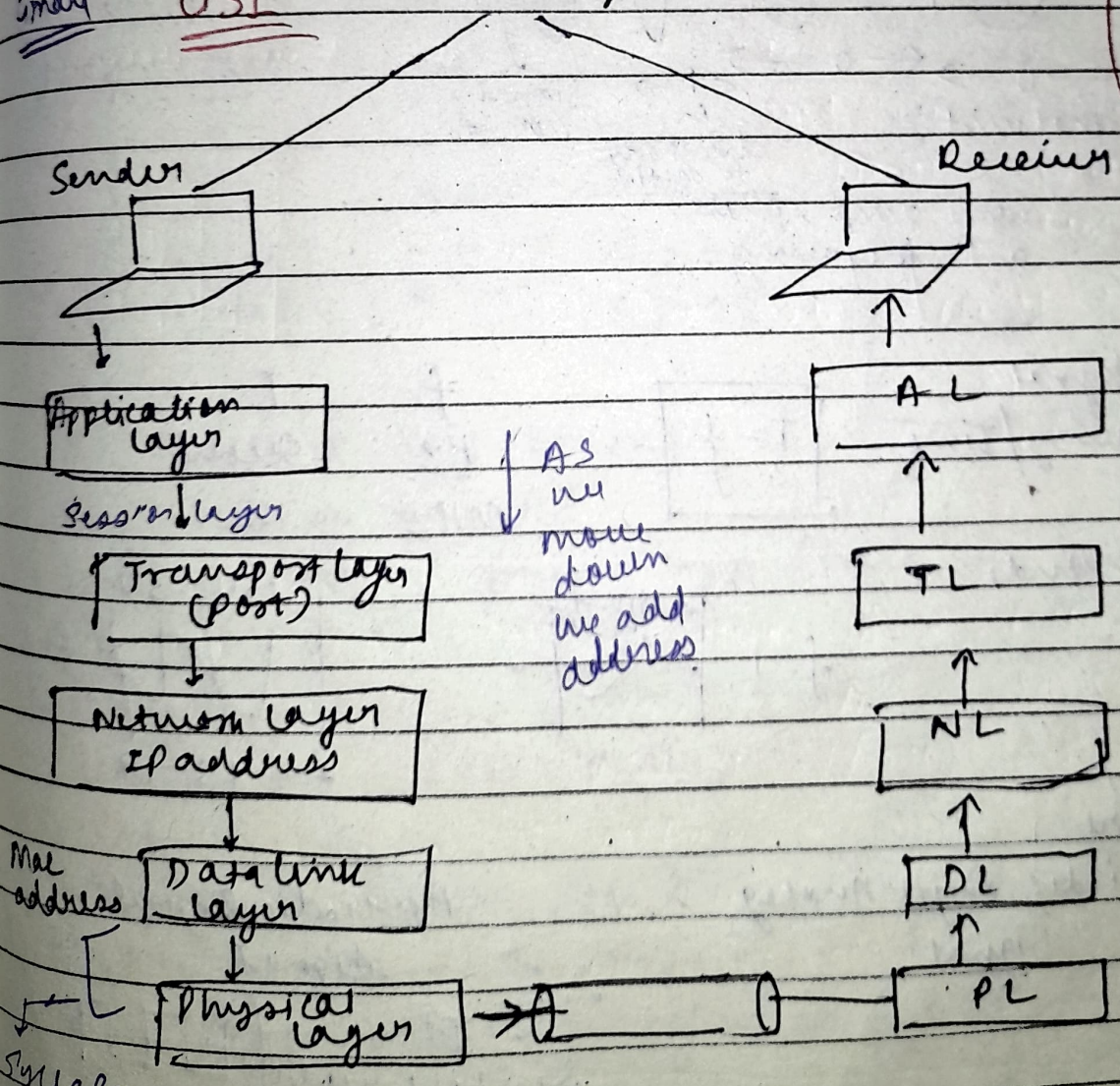
$\Rightarrow 9600 = 2 \times R$ $\quad (n = 2 \text{ bits})$.

$\Rightarrow \boxed{R = 4800 \text{ baud/s}}$

OSI (Open System Interc) Internet

Imp OSI

Protocols
SMTP
TCP/IP
FTP
HTTP



09.01.2023
Monday

Data communication & Networking by Fogler.

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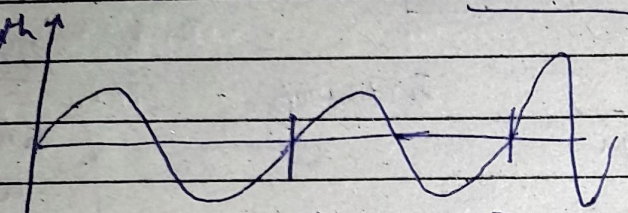
Signal
- Periodic
- Aperiodic / Non Periodic signals

Data
(i) Analog → sine wave
(ii) Digital (computer)
↳ 101011
electro mechanical signal

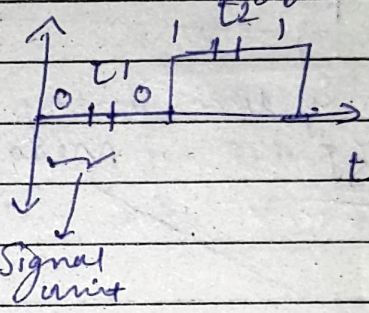
Analog
0011
Strength



Signal unit
Same amp., phase and frequency.

Digital
0011

Signals are moving in form of energy.

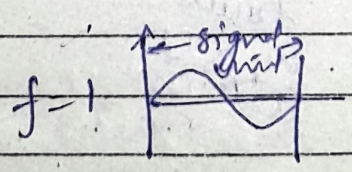


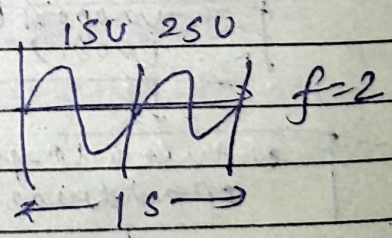
$t_1 t_2 = \{0, 0, 1\}$
$= \{0, 1\}$

Analog signal
(i) frequency/Time
(ii) Phase
(iii) Amplitude

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

f	T
Hz	Second
MHz	mi





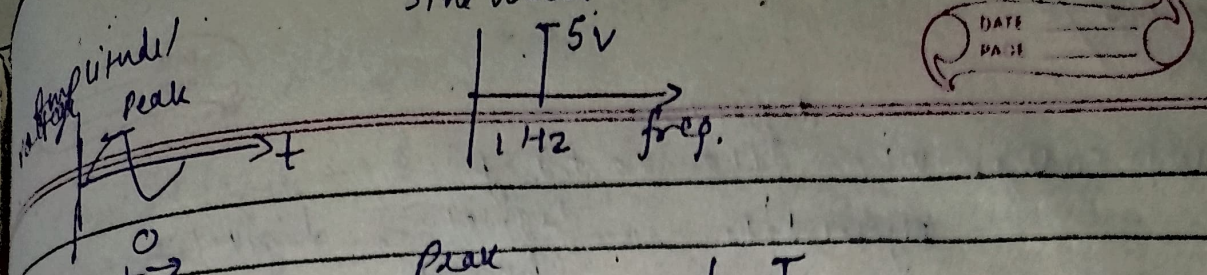
We require
Periodic ~~Digit~~ Analog Signal & Aperiodic Digital Signal

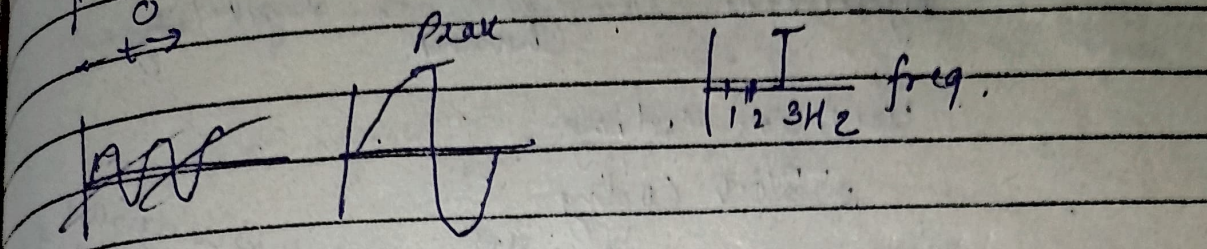
∴ To Digital Periodic
↳ Don't carry much info

Time domain

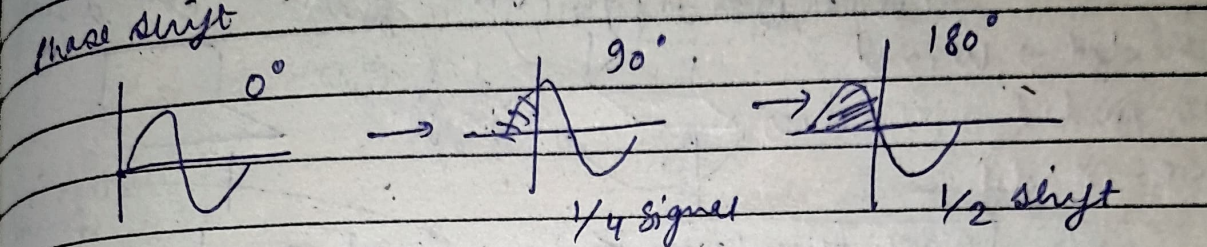
freq. domain

Sine wave





Phase shift



Q) 1/6 Signal shift
What phase shift

Sol: $\frac{360°}{6} = 60°$

Q) If freq ↑ then time period ↓ als.

Sol.

modem

Analog signal ⟶ Digital signal
Digital signal ⟵ Analog signal

$\frac{1}{n}$ th Signal shift

Phase shift $= \frac{360}{n}$

To represent dif. voltage levels in AS
change Amp., freq., Phase or comb^n of any
composite signal

3 Coding Schema
Unipolar (only 1 polar)
Polar +, −
Bipolar (Both pole)

Why coding schema is required?
When digital data is transferred to digital channel

16.01.2023
Monday

ASP TNF DP

Line coding: when digital data is transmitted

Digital data —digital channel→ digital signal

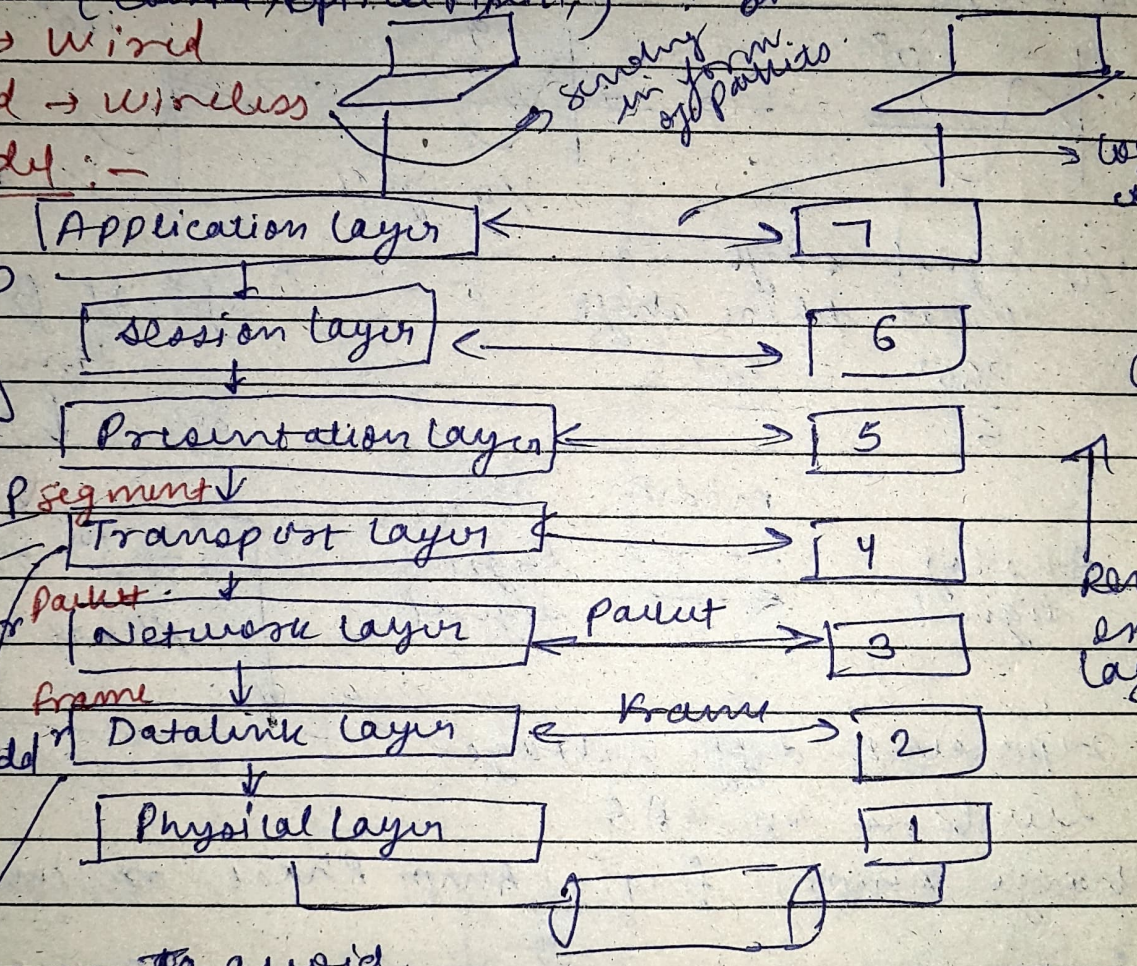
Use 1) Line coding
2) Block coding

(Coaxial, Optical fiber, UTP) ; Sender & Receiver are connected directly

Guided → Wired
unguided → wireless

sending in form of packets

OSI Model :-



Flow control & error control

To avoid overflow

Sender

Receiver

Noise

Signals
Periodic
Non Periodic / Aperiodic

Both are responsible

Given by ISO

TCP/IP
↳ protocol merged upper 3 layers
5 layer protocol

Actual H/w interaction

Physical layer → transferring of data / Transmitting data
Data link layer → Coding / Encoding of data.

3 way of transferring the data:-

1001 → 0110 Highly Noisy layer.
4 bit corruption

DL layer can detect & correct ~~too~~ upto 1 bit
Data detect

Even Parity: $1 \oplus 0 \oplus 0 \oplus 1 = 0$

1001	0

→ 0

≠

0110	1

1

∴ corrupted

Request to send data again.

Transmission Impairments (medium can be noisy or impairing)
① Attenuation distortion ② Dispersion, ~~Dispay~~ Delay ③ Noise ④ ~~Cross~~

Thermal Noise, Cross talk, Intermodulation, Impulse
→ cannot control

At the receiver side data must be sent completely. Receiver can't corrupt
When signal travels through ~~layer~~ long channels it can happen that signal loose strength (Attenuation)

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Tuesday

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② Dispersion :- Signal can spread & overlap. The amt of dispersion depend on the freq used, data is overlapping.

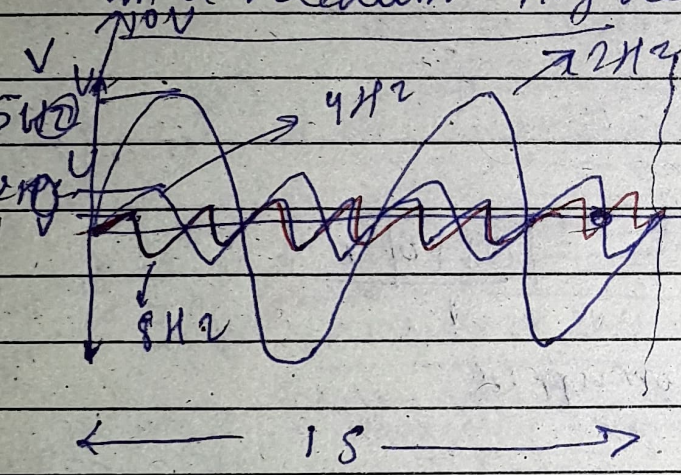
③ Delay distortion :- In transmission, ~~Rappa~~ may ~~that~~ arrive at other

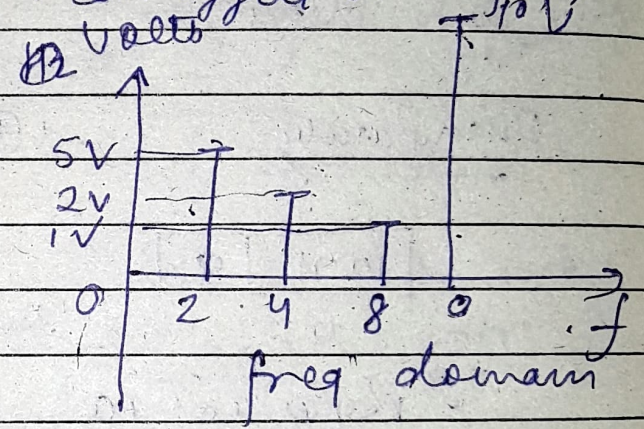
④ ~~Any~~ Noise :- Some random disturbance

Thermal Noise → Cooler

Cross Talks → ~~Any~~ → Foreign signal comes ↓ to ...

⑤ Intermodulation → when multiple freq. share in a medium Higher freq. can affect lower freq.

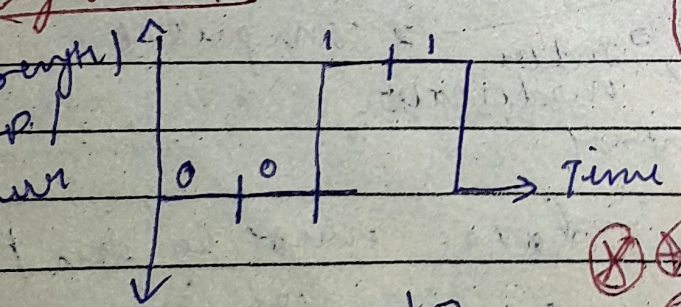




Impulse : Sudden change in spikes.

Stationary → DS, AS

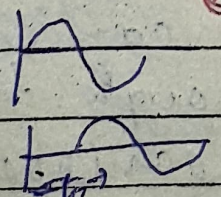
Digital data



f_{to} = Bit Rate = freq. = 4 bps

t_{of} = Bit Interval = Time Period = $\frac{1}{4}$

$BR = \frac{1}{B.T.}$ or $B.T. = \frac{1}{B.R.}$



Bit length = wavelength

Dist. travelled in time to = $c\,t_o = c/f$

3×10^8 m/s
Speed of light

$S = D/T \Rightarrow D = ST \Rightarrow$ wavelength $= C \times t_0$ (Bit interval)
$= C/f$ (Bit rate)

unit is m.

Bit Interval : How long a bit lasts on a transmission media

Bit Rate : No. of bits per second.

Bit length : $\frac{\text{Speed}}{f_0} = \text{Speed} \times t_0$

Q) Find bit length of digital signal $b_r = 6$ mbps (bitrate)

Sol: $b_r = 6$ mbps $= 6 \times 10^6$ bps

$b_l = \frac{c}{b_r} = \frac{3 \times 10^8}{6 \times 10^6} = \frac{100}{2} = 50$ m

Q) Find b_r of 1 bit if which lasts for 1 μs on transmission media.

Sol: ~~$b_l =$~~ ~~$b_r =$~~ ~~b_r~~ $b_i = 1$ μs

$b_r = 1/b_i = 10^6$ bps

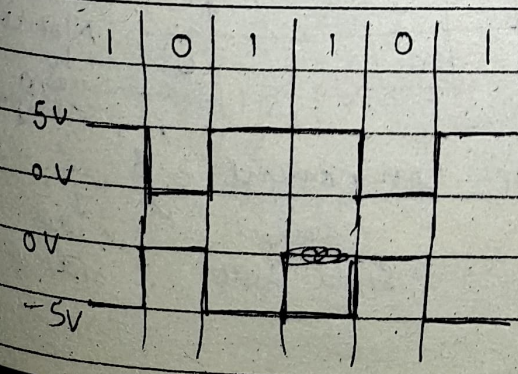
Signal Encoding Technique. (4 in No.)

(1) Digital Data to Digital Signal.

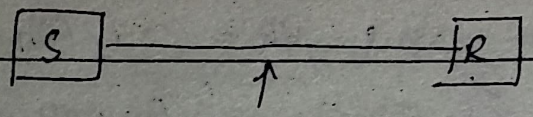
(Unipolar Schema)
(only either +ve or -ve at a time)

Bipolar Schema
+ve Voltage, -ve Voltage.

| 1 | 0 | 1 | 1 | 0 | 1 |

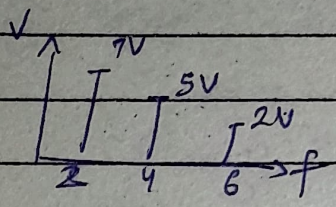


only on at a time
(Not both.)
at a time.



Channel
(Broad band / Baseband)

Channel
- Broadband → Analog data
- Baseband → Digital Data



6 - 2 = 4

- Less Collision (like highway)
- More Collision (like railway)

Diff. of highest & lowest allowed

Digital data to Digital Signal

(Nature optimization)

- Comp. to Comp. (Line Encoding)

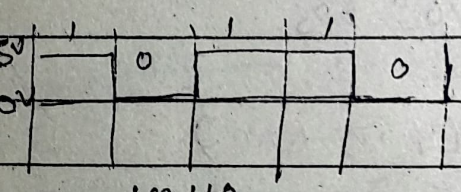
Both side voltage level

+5 = 1 , -5 = 0

(signal level can be both sides of Time Axis)

Unipolar (1 polarity)

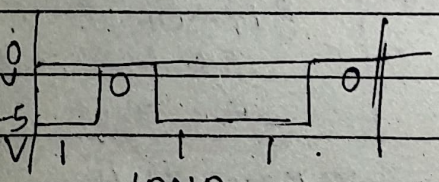
Polar (More than 1 polarity)



10110

- NRZ (Non Return to Zero)
  - NRZ-L level (0)
  - NRZ-I level (Inverted)
- Return Zero RZ → level come to zero
- ~~Bipolar~~ Biphase Coding Scheme

Signal level can be both side of time axis

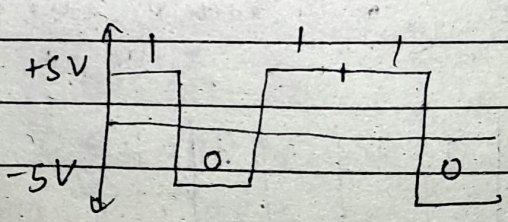


10110

either level +ve / -ve but not both

All signal level that are 1 side of time axis.

0 → Reset



10110

Not coming to zero as in unipolar

DC Component = 3 - 2 = 1

+ve side peak — -ve side peak

Net Amp. = 0 (our objective)

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Biphase coding has 2 phases
(i) DC component
(ii) Synchronization of continuous 0's & 1's

Biphase Coding Schema

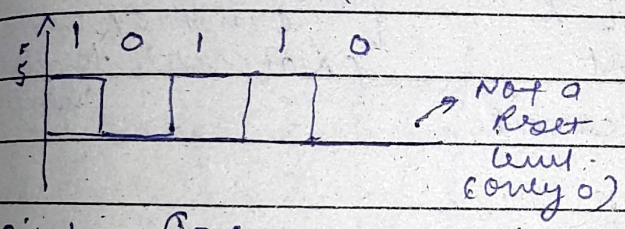
- Manchester encoding
- Differential Manchester encoding

Unipolar

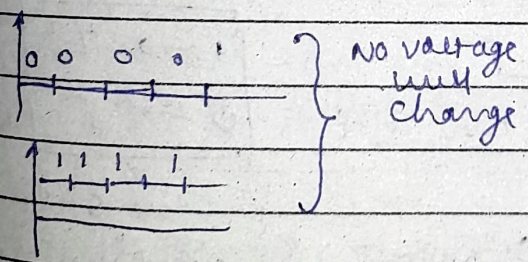
Unipolar NRZ

1 → +ve voltage (5V)

0 → ~~+ve~~ 0 level



Disadv.: ① DC component is not zero



② No synchronization can detect (clock) out of order नहीं होना चाहिये।

No synchronization left continuous 0's & 1's

~~Adv.: Simple Coding Schema~~

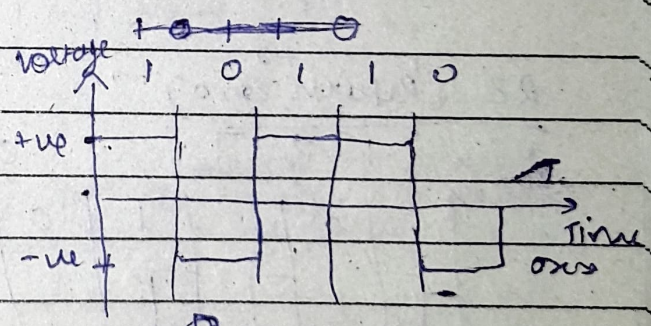
Polar NRZ-L

Change level when 0 level or vice versa

1 → +ve 5 V

0 → −ve −5 V

or vice versa

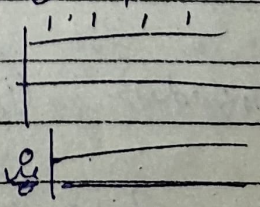


Disadv.:

① DC component ≠ 0 (3 − 2 = 1)

No. of 1 ≠ No. of 0

②



Synchronization still not achieved

Bit is observed by observing voltage change

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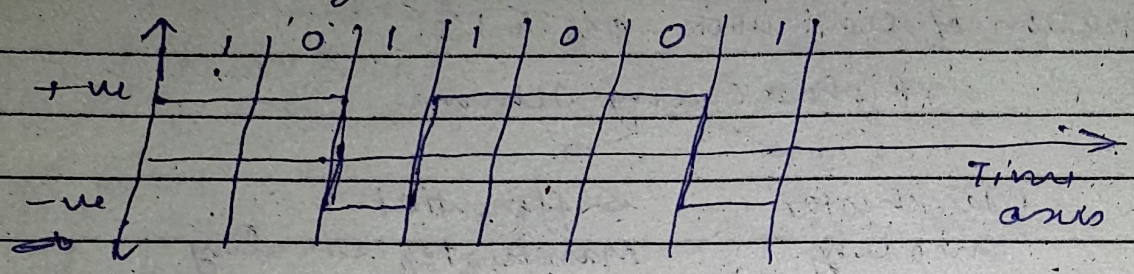
Polar NRZ-I (Invert.)

1 → change the curve 0 → No change



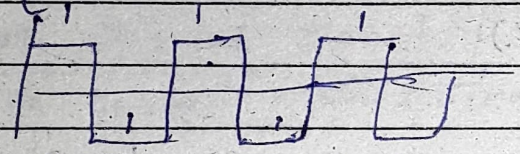
{1 → Then start from negative?

Disadv. ① DC component ≠ 0

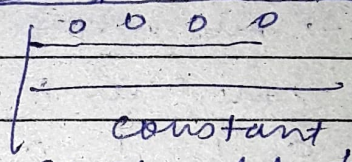
② Synchronization achieved only for continuous 1 but not for continuous 0

Adv. ←

No Reset cond^n



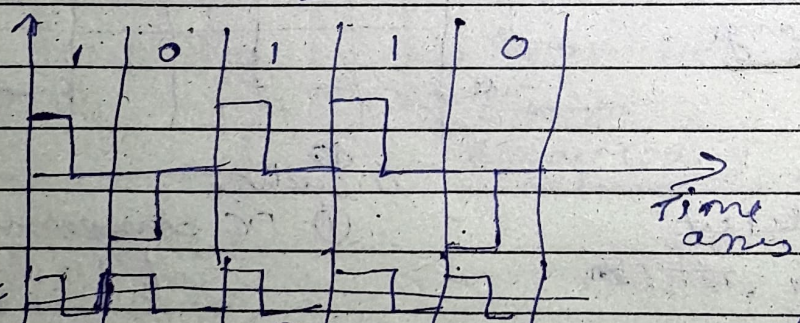
Clock can detect every next will cancel first



constant voltage (Not able to detect change)

RZ (Return to zero)

1 → ⊔ 0 → ∫



+ve side

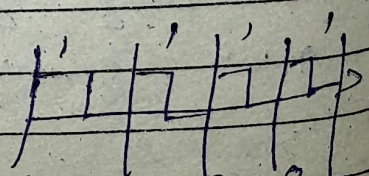
1 →	⊔
0 →	∫

-ve side (returns zero)

Adv. : ① Synchronization each time signal comes to zero.

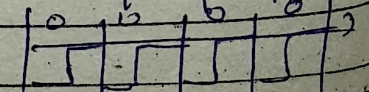
Disadv. : ① DC component ≠ 0

1111



② Problem of continuous 1 & 0 solved (Synchronization achieved)

0000



HW. IEEE 802.3

01.2023
Monday

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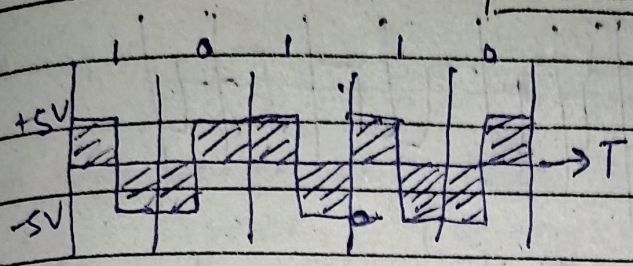
Manchester Encoding (Ethernet LAN) IEEE 802.3
(monitor common standards)

0 → ⎍
1 → ⎣

(same as RZ)

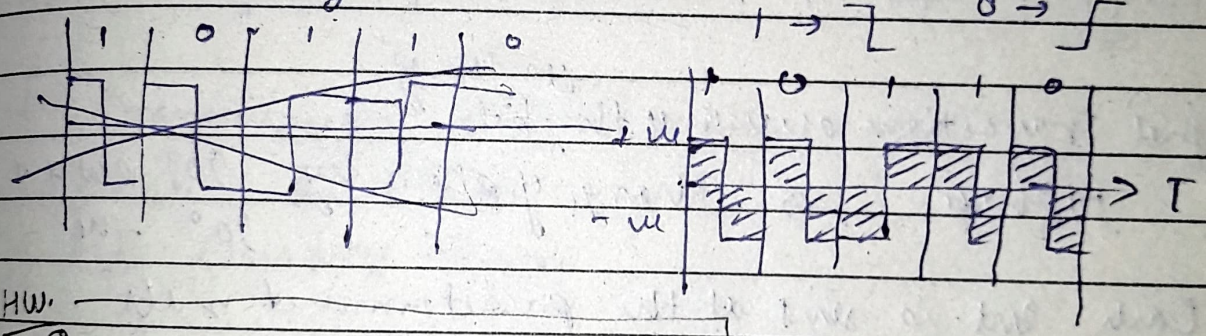
Manchester Encoding = RZ + NRZ-L



Adv :-
① DC component = 0
(each ~~+ve~~ 0 +ve & -ve.
② Synchronization of 0's & 1's

Differential Manchester Encoding :- RZ + NRZ-I

1 → change 0 → same



HW.
① Manchester Encoding
② Benefits of Digital over Analog :- → carry info with less noise, distortion & interference.

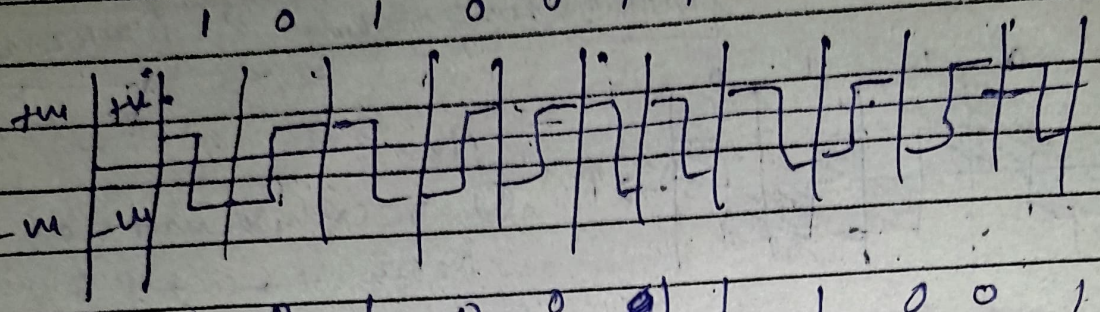
IEEE 802.3 → working group & collection standards defining the physical layer & data link layers's media access control (MAC) of wired Ethernet.
→ Institute of Electrical & Electronics for LAN (Local Area Network) technology with some Wide Area Network (WAN) applications.

Manchester → digital encoding

↳ main advantage → Signal synchronization

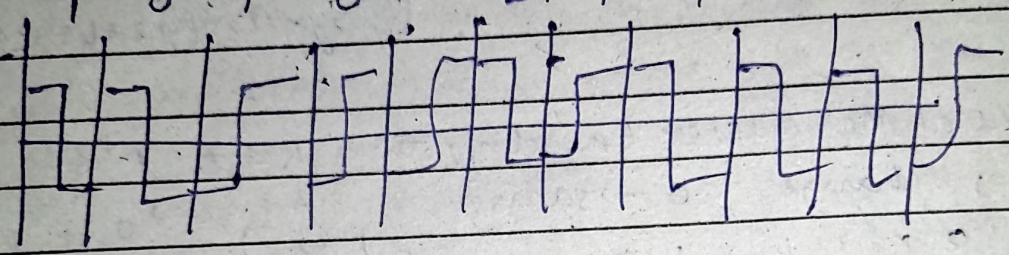
1 → 2
0 → 5

1 0 1 0 0 1 1 1 0 0 1



Manchester

1 0 1 0 0 1 1 1 0 0 1



Differential Manchester Encoding

Signal Transitions occur at the centre of bit.

Biphase → change of phase eg. 90° ~~cw~~ +M
90° -M

Each bit is sent at the predetermined rate

- ME Encoding consumes twice the BW of org. signal

DC component = 0 → Standards that usually do not carry power can transmit this info

Drawback:- Signal Rate = 2 × NRZ's signal rate

Q) In Ethernet when ME is used the bit rate is
Sol: Half the Baud rate

Q) Phase transition for each bit rate is used in
Sol: ME & DME

HW. | Write functionalities of each layer |

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Open system Interconnection Model

OSI Model

Sender → Receiver

Clock — Clock

if (ACK) {
~~then~~ send
}
else {
~~Not send~~
}

due to timeout, data lost ←

Data link error ~~to~~ also checks if there are error in signal. (Error control or flow control) of synchronization

Q What are different types of Noise?

Transport layer also do this but here package can loss.

~~No~~ Transmission medium & Impairment

~~Bit~~ Rate & Band Rate

~~Diff.~~ Encoding Scheme

Imp Benefits of Digital Comm. over Analog Comm. :-

① DS → impact of noise distortion, & interference is less.
thermal, crosstalk

② It is easy to implement & less expensive.

③ Checking & correction of ~~do~~ errors (used in military) are ~~so~~ easy as we are using Channel Encoding

(Hamming dist.)

$$\begin{array}{r} 01101 \\ \oplus\ 10010 \\ \hline 11111 \end{array}$$

→ If any change

④ ~~Ex~~ It is easy to save & retrieve as compare to AS

⑤ There is common coding schema in many ckts.

⑥ The probability of cross talk is very less in DS

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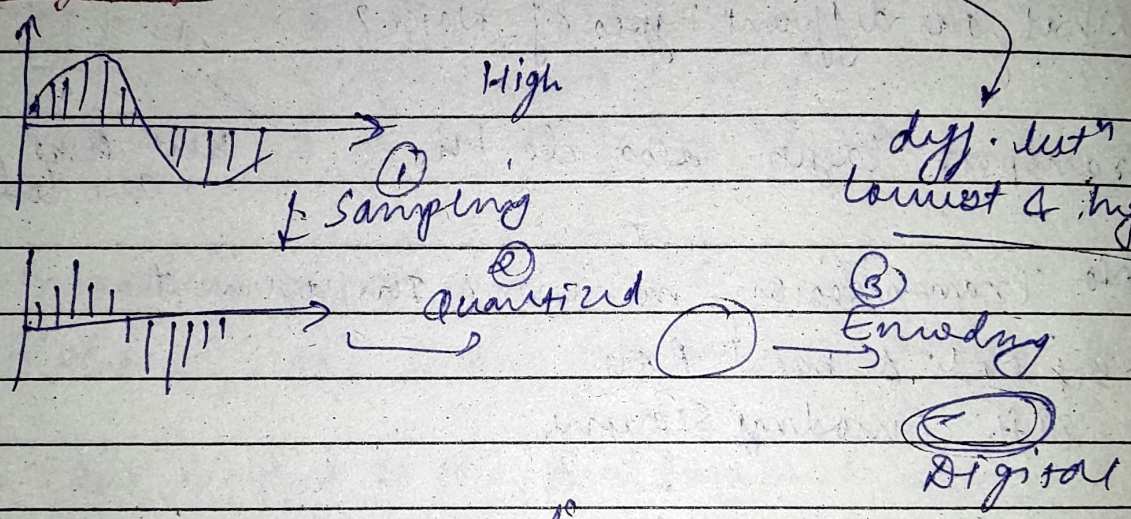
Limitation

① very high power consumption in DS (as bits are changing)

② There is reqd.

③ It requires more ~~tran~~ transmission bandwidth (~~as there is more~~ due to higher bit (diff reqd to convert analog to digital.)

Sampling freq. No. of samples taken per sound.



diff. lev^n lowest & highest.

Which layers ensures "error control"?

~~Application layer protocols~~

No. of bits in MAC? full form MAC