represent dig data by dig signals

Digital to digital conversion

3 techniques : 1) Line coding (always need)
2) Block coding
3) Scrambling

Signal Element

smallest entity :
digital signal

what we can send

Data Element

bit

what we need to send

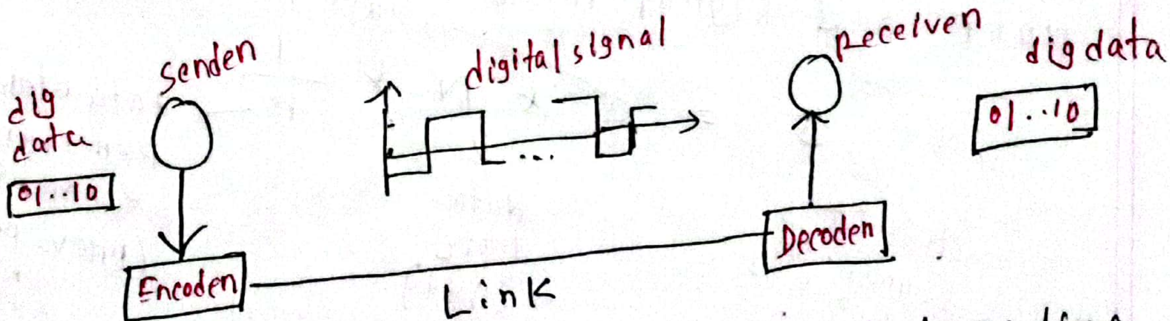
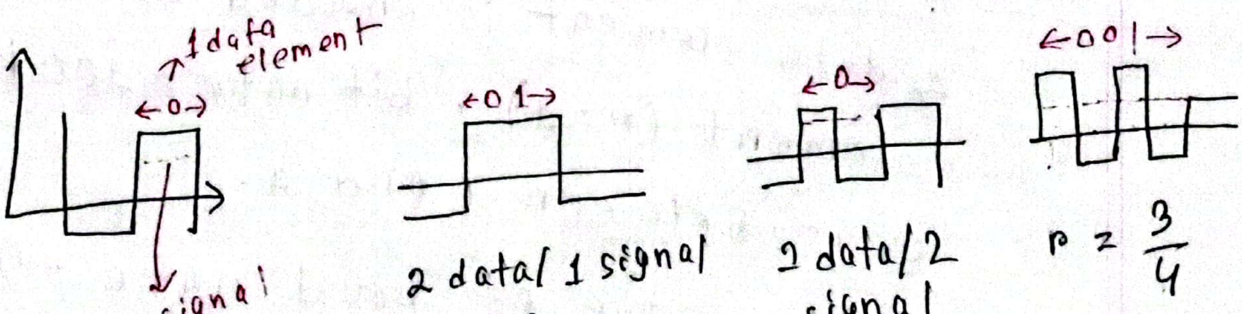


Fig : Line coding and decoding



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

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

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

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

Data rate (N)	Signal rate (S)
no. of data elements (bits) sent in 1 s.	no. of signal elements sent in 1 s
unit: $\boxed{\text{bps}}$	unit: baud
bit rate	✓ pulse rate ✓ modulation rate ✓ baud rate

Relationship between data rate and signal rate

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

c → case factor

S → no. of signal elements (baud)

N → data rate (bit)

r → data elements per signal element (prev. page pics)

Ex: A signal is carrying data in which 1 data element is encoded as 1 signal element ($r = 1$). bit rate = 100 kbps

c is between 0 and 1.

avg. value of baud rate = ?

$\Rightarrow S = \frac{0+1}{2} \times (100 \times 1000) \times \frac{1}{1} = 50000$ baud

N.B: Bandwidth of digital signal
→ actual = ∞
effective → finite

Ex: max. data rate, N_{max} (bit rate) $= 2 \times B \times \log_2 L$ (nyquist)

Does this agree with prev. formula? → yes

prev.: $S = c \times N \times \frac{1}{r}$

$N = \frac{S r}{c}$

→ $1/2 = c$ (assume)

$$\boxed{N_{max} = \frac{1}{c} \times B \times r} = \underline{\underline{2}} \times B \times \log_2 L$$

c ↙ 1/2

$$B_{min} = \frac{N c}{r}$$

* **Baseline**: In decoding a digital signal to digital data, the receiver calculates avg. of recieved signal power

long stning of 0's and 1's sent

Baseline wandening: make difficult fon neceiven to decode connectly.

not good line coding scheme

Ex: the necieven clock is 0.1% fasten than senden clock. How many extna bps does the neceiven necieve, data nate = 1 kbps and 1 Mbps

$\Rightarrow$ 1) N = 1000 bps
+ 1 (extna)
1001 bps

$1000 \times \frac{0.1}{100} = 1$

2) N = 1,000,000
+ 1000
1001000 bps

$$\boxed{1{,}000{,}000 \times \frac{0.1}{100} = 1000}$$

DC components: v = constant, f → low

NRZ-L → Level
NRZ-I → Inversion

bit level এর mid এ zero back করে না ← NRZ — Non-return to 0
AMI – Alternate Mark Inversion

Line coding schemes (5)

1) Unipolar — NRZ
2) Polar — NRZ, RZ, biphase
   - NRZ: NRZ-L, NRZ-I
   - biphase: Manchester, ~~Differential~~, Differential Manchester
3) Bipolar — AMI, pseudoternary
4) multilevel — 2B/1Q, 8B/6T, 4D-PAM5
5) multitransition — MLT-3

Unipolar: all signal levels — on 1 side of time axis

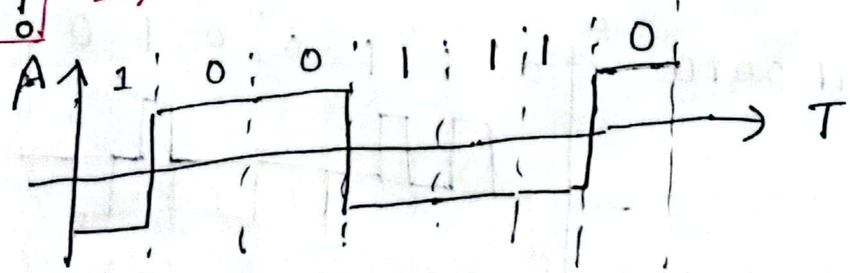
positive V – 1
zero V – 0

Polar:

NRZ:

$\boxed{\text{NRZ-L}}$: 1 → neg V
0 → pos V

$\boxed{1001110}$ → convert to dig. signal



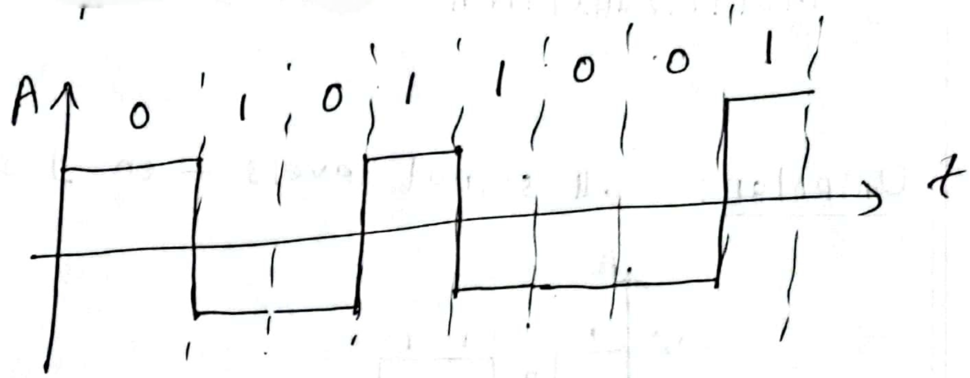
NRZ-I

1 → transition
0 → no "

convention: first 0 হলে high হবে
সামনে 1 আসলে 0 add করে নিব

01011001

data to signal

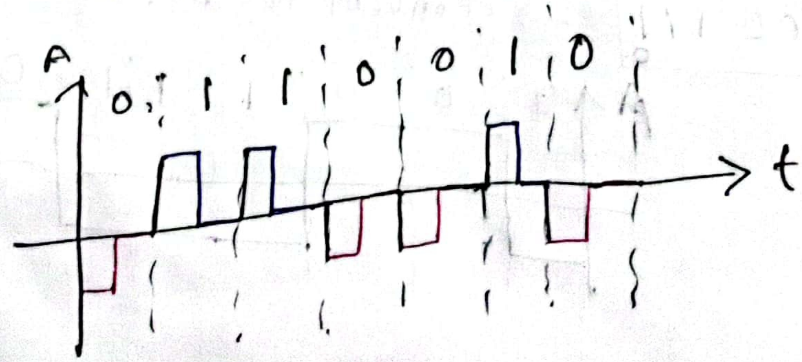


signal to data: edge (লম্বা) পাইলে - 1
বাকিগুলো - 0

RZ:

1 → pos to zero
0 → neg to zero

0110010

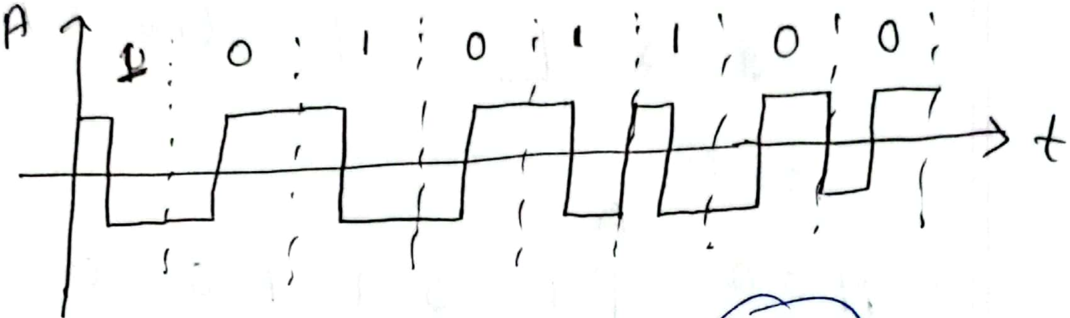


Dr. Thomas

biphase: **manchesten:**

0 → neg to pos
1 → pos to neg

10101100



mention করার দরকার

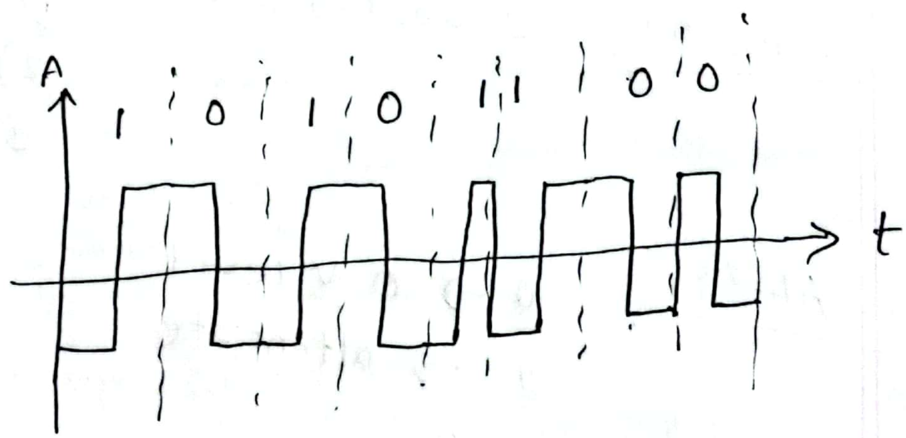
~~Diffenential manchasten~~ / manchesten (IEEE)

→ manchasten এর উল্টো

কোনো manchasten follow this

0 → pos to neg
1 → neg to pos

10101100

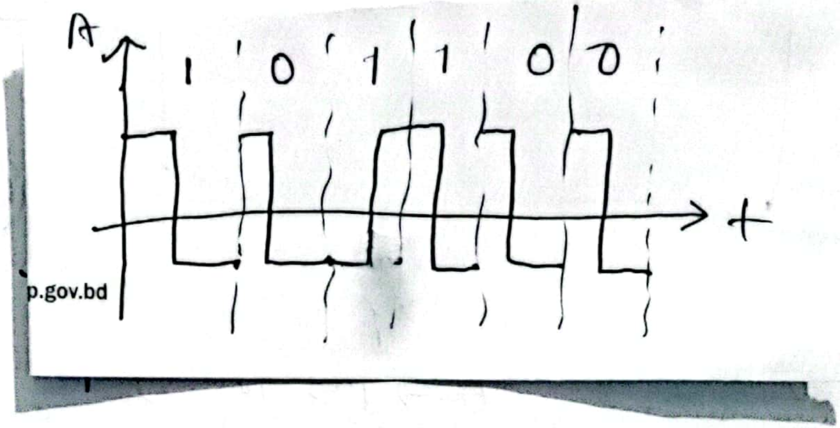


Differenential Manchesen

0 →  (tnansition)

1 →  (no ")

101100

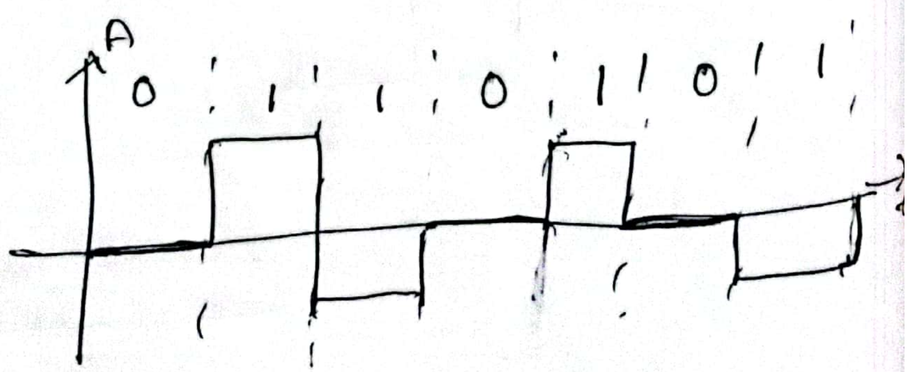


Bipolan: 3 voltage level: 1) pos
2) zeno
3) neg

Altennate mank invension

AMI: 0 → 0 v level
1 → altennate

0110101:

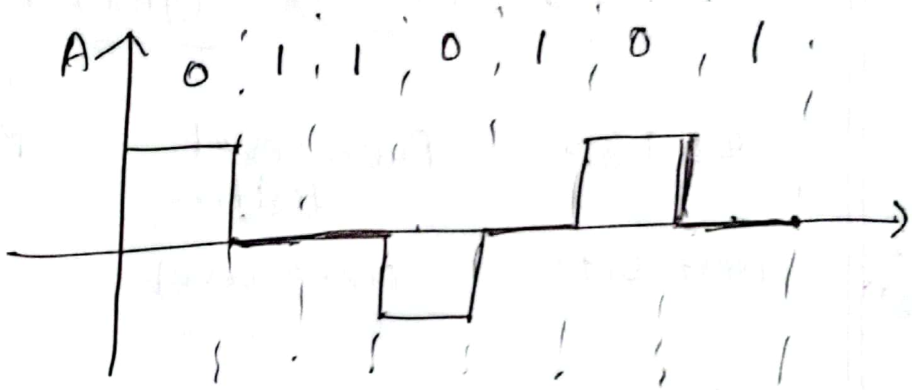


AMI এর উল্টা

Pseudotennany:

1 → zeno voltage
0 → altennate

0 1 1 0 1 0 1



Multilevel: 2B1Q

mBnL

m → length of binany pattenn   no. of data pattenn = 2^m
B → Binany data
n → length of signal pattenn   no. of signal pattenn = L^n
L — no. of levels in signaling
B (Binany) — L = 2
T (Tenneny) — L = 3
Q (Quantennany) — L = 4

In 2B1Q $m = 2$, $n = 1$, $L = 4$

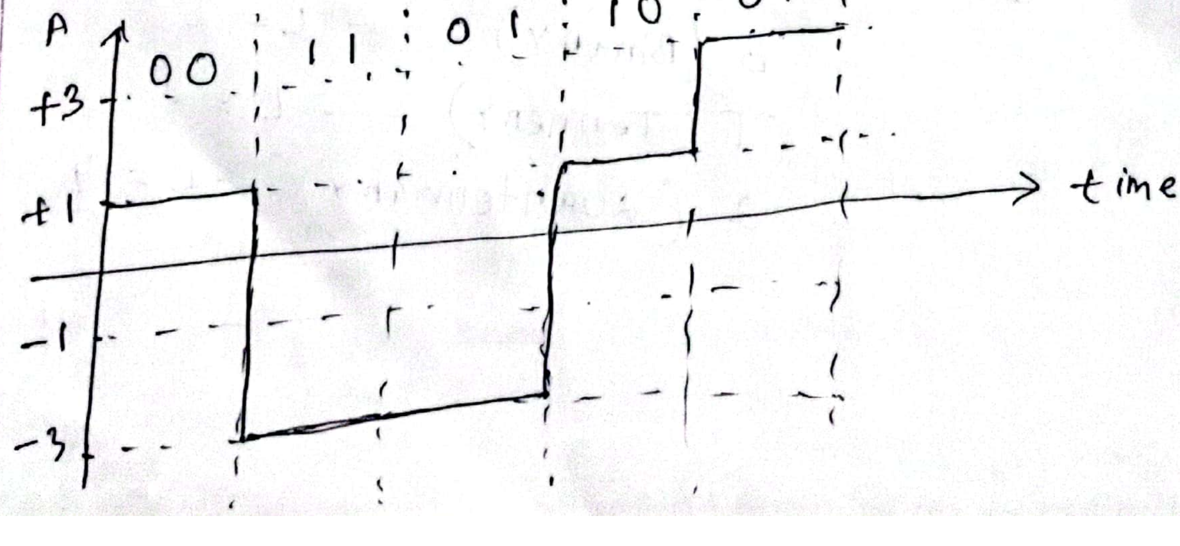
00/10/11/01 no. of ~~da~~ binary pat. $= 2^2 = 4$

$\pm 1, \pm 3$ ← no. of signal pat. $= 4^1 = 4$

Table given

2B1Q	Prev. Level Positive	Prev. Level Negative
Next Bit	Next Level	Next level
00	+1	−1
01	+3	−3
10	−1	+1
11	−3	+3

Dig. data: 00 11 01 10 01



$\nearrow + - 0$

8B6T: $m = 8,\ n = 6,\ L = 3$

no. of binary pat $= 2^8 = 256$ $\quad 2^m$

no. " signal " $= \cancel{6^3 = 216}$

$L^n \quad 3^6 = 729$

unused

Redundant signal $= 729 - 256 = 473$

- Synchronization
- error detection
- DC balance

Hexadecimal

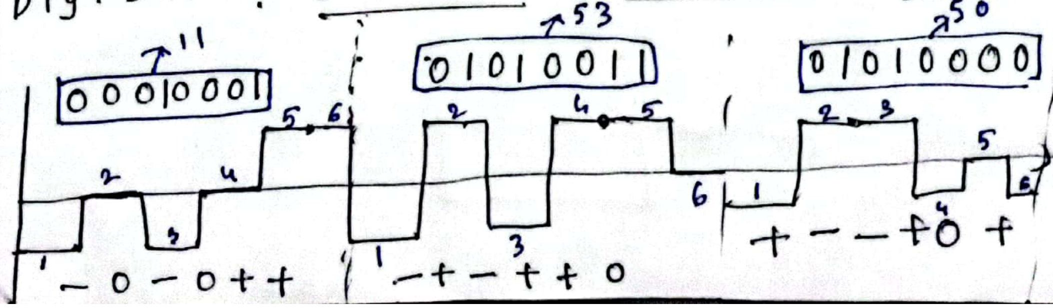
Data	Code
00	-+00-+
11	-0-0++
0A	0-++-0
8bit	6bit

Data	Code
2A	+0+-0-
50	+--+0+
53	-+-++0
8bit	6bit

DC balance: --++0+ : weight +1

-0-0++ : weight 0

Dig. Data : 00010001 01010011 01010000



Hex Bin

0001·0001 → 11 → $- 0 - 0 + +$

weight : 0

01010011 → 53 → $- + - + + 0$

wt : +1

[1st +1 → no change]

01010000 → 50 → $\boxed{+ - - + 0 +}$ $\boxed{\text{wt} : +1}$

2nd +1 ; invert

$- + + - 0 -$ [only for চিহ্ন

(graph এ main টাই আসবে)

$\boxed{\text{wt} : -1}$

reciever find negative

— যাকে দিয়ে invert করা হয়েছে

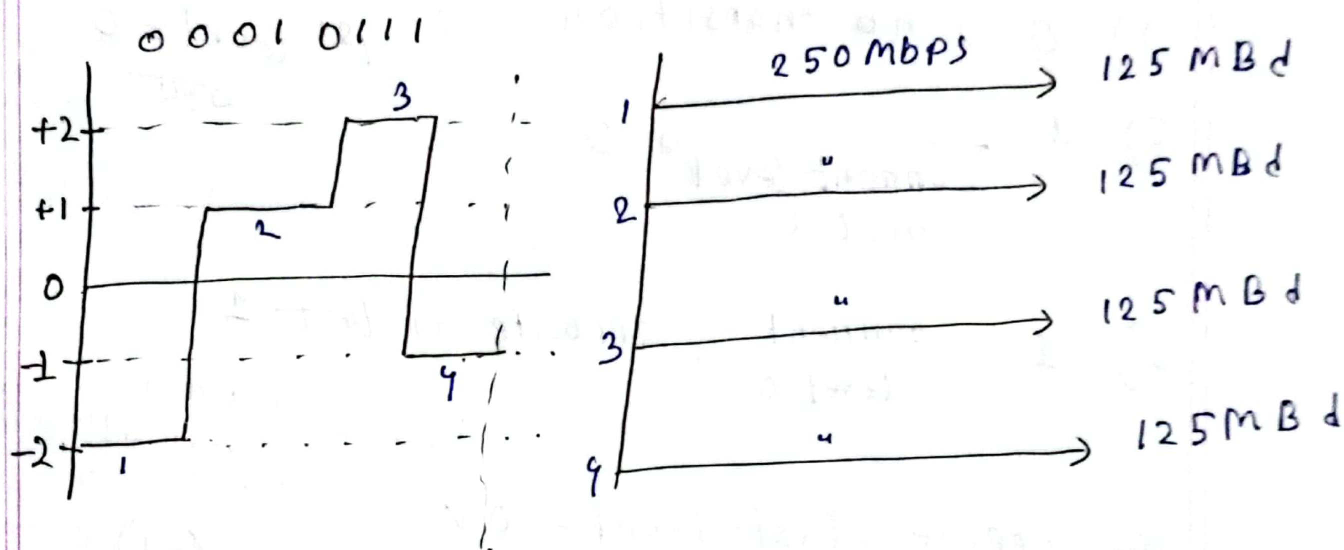
So, prev. graph total wt $= 0 + (+1) + (-1)$
$= 0$ (target)

$2^8 = 256$

$5^4 = 625$

Redundant → zero
$= 625 - 256 = 369$

4D - PAM5



Suppose, wire no. = 1

0 → redundant (অর্থাৎ)

this → 8B4Q

no. of binary pattern $= 2^8 = 256$

" " signal " $= 4^4 = 256$

Multi transition :

MLT-3

Rules:

$+ \ 0 \ -$

1st level = 0 হবে

1) $0 \rightarrow$ no transition

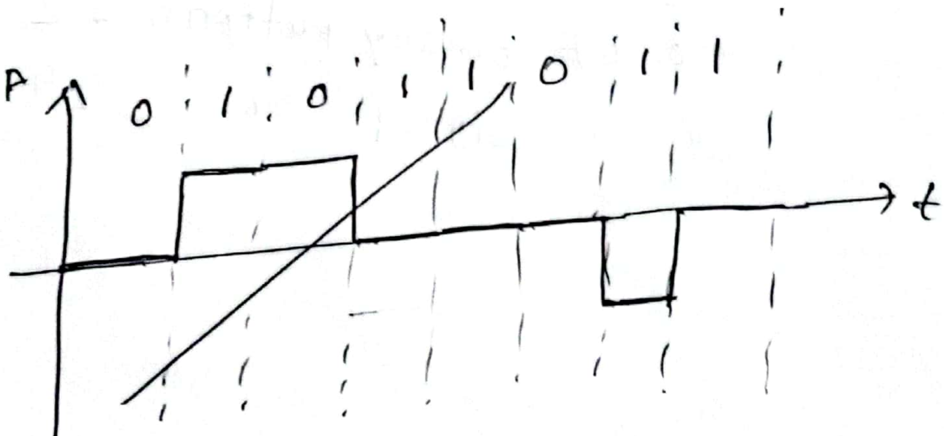
2) $1 \xrightarrow[\text{not } 0]{\text{current level}} 0$

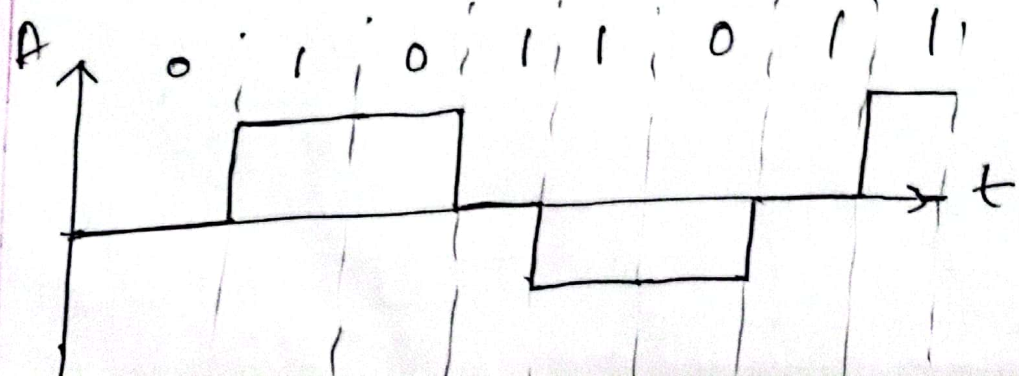
3) $1 \xrightarrow[\text{level } 0]{\text{current}}$ opposite of last 1

If ques এ দেয়া থাকে না

* suppose, last level = 0 V
last non-zero = neg (−1)

Dig. data 01011011





bitno → increase
Line coding → improve

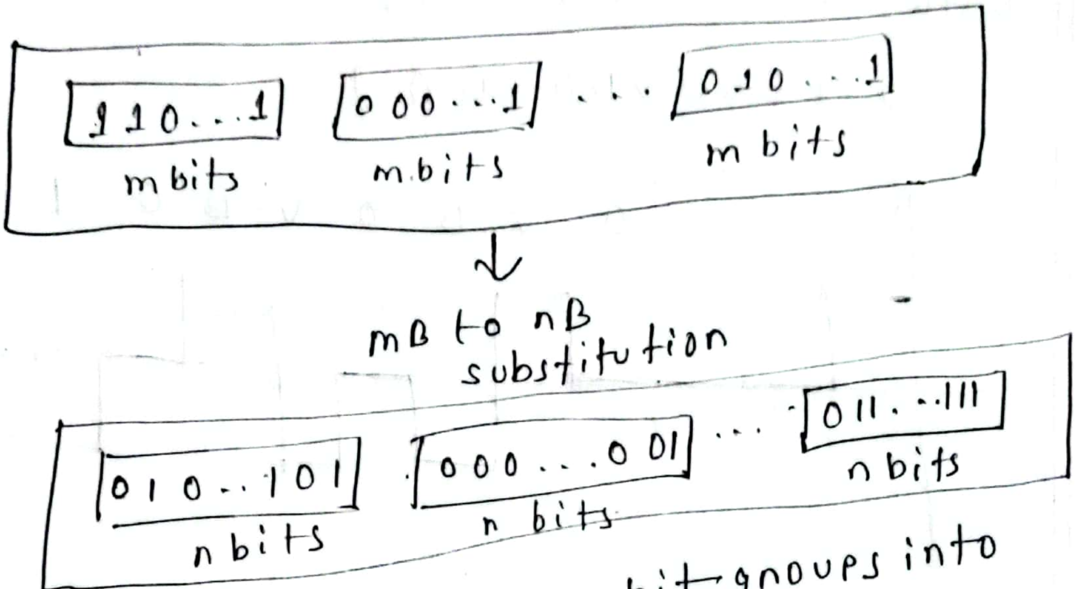
Block Coding

— to gain redundancy → 4B/5B

mB/nB

n > m

Division of a stream into m-bit groups



Combining n-bit groups into a streams

Step : Division → substitution → combination

Scrambling

→ AMI (improve)

B8ZS → Bipolar with 8 zero substitution

8 zero → 000VB0VB

V(violation) — same as last non-zero level

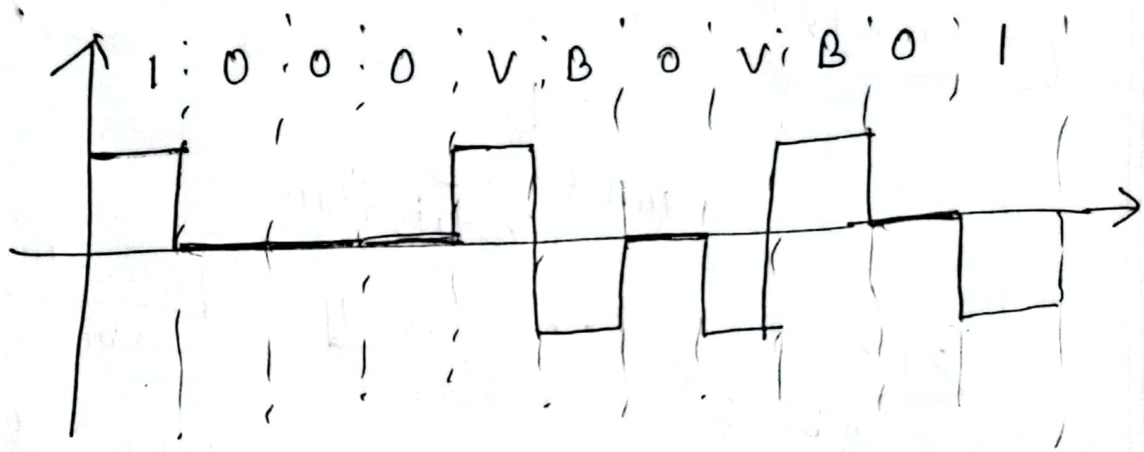
B (Bipolar) — opposite to last non-zero level

0 → zero level
1 → opposite to last non-zero level

Assume, last non-zero (−1)

Data: 1 0 0 0 0 0 0 0 0 0 1

→ 1 0 0 0 V B 0 V B 0 1



(HDB3) High Density Bipolar 3 zero

4 zeroes → 0 0 0 V or B 0 0 V

আগের মোট non-zero সংখ্যা
- odd − 0 0 0 V
- even → B 0 0 V

V → same as last non-zero level

B − opposite to last non-zero level

assume, last non-zero negative

Dig. Data: 1 0 0 0 1 1 0 0 0 0 0