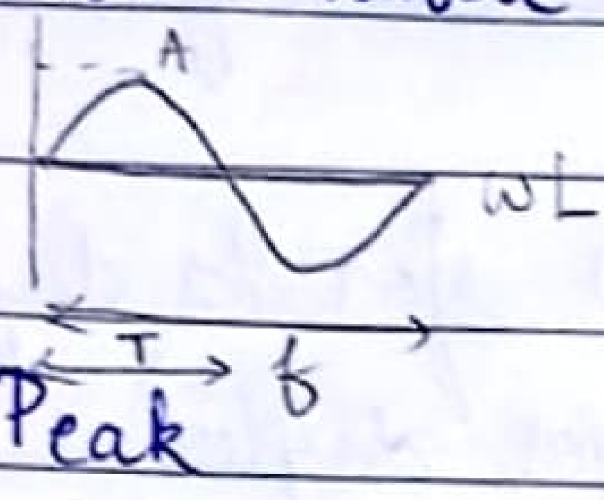
6.6.2023

# Unit - II

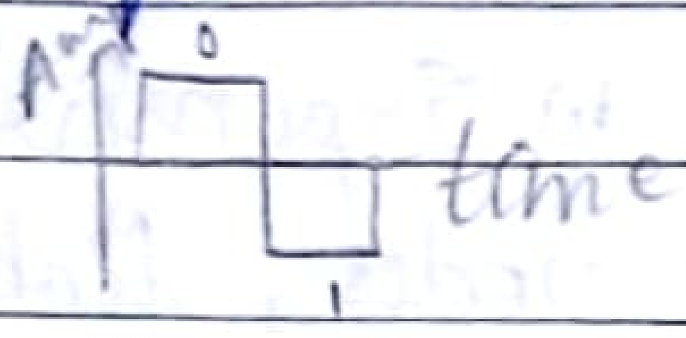
## * Data and Signals:

* Signals:-
  1) Analog - continuous pattern of data. Eg: weather forecasting
  2) Digital - discrete intervals of time → getting data

1) Analog (periodic)
* Sine wave




2) Digital (non-periodic)
* Square wave




* Peak
  Amplitude

* Frequency - No. of cycles completed in 1 s

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

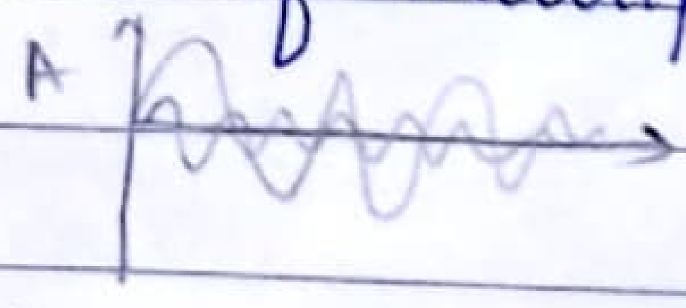
* Phase - degree in which the wave starts
  ↳ position of sine wave relative to 0.

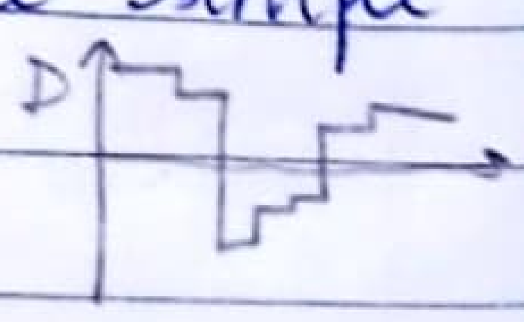
* Wave length - Distance traveled by sine wave in 1 period.

  Wavelength = Progogation Speed x Period

* Bandwidth - Amt of data that can be transfered in 1 s

* Simple signals - smallest unit of signals - 1T, 1F, 1WL
  Composite signal - composed of multiple simple signals. ⇒ $\boxed{f_h - f_{low}}$




* Bit length = Progogation Speed * Bit duration

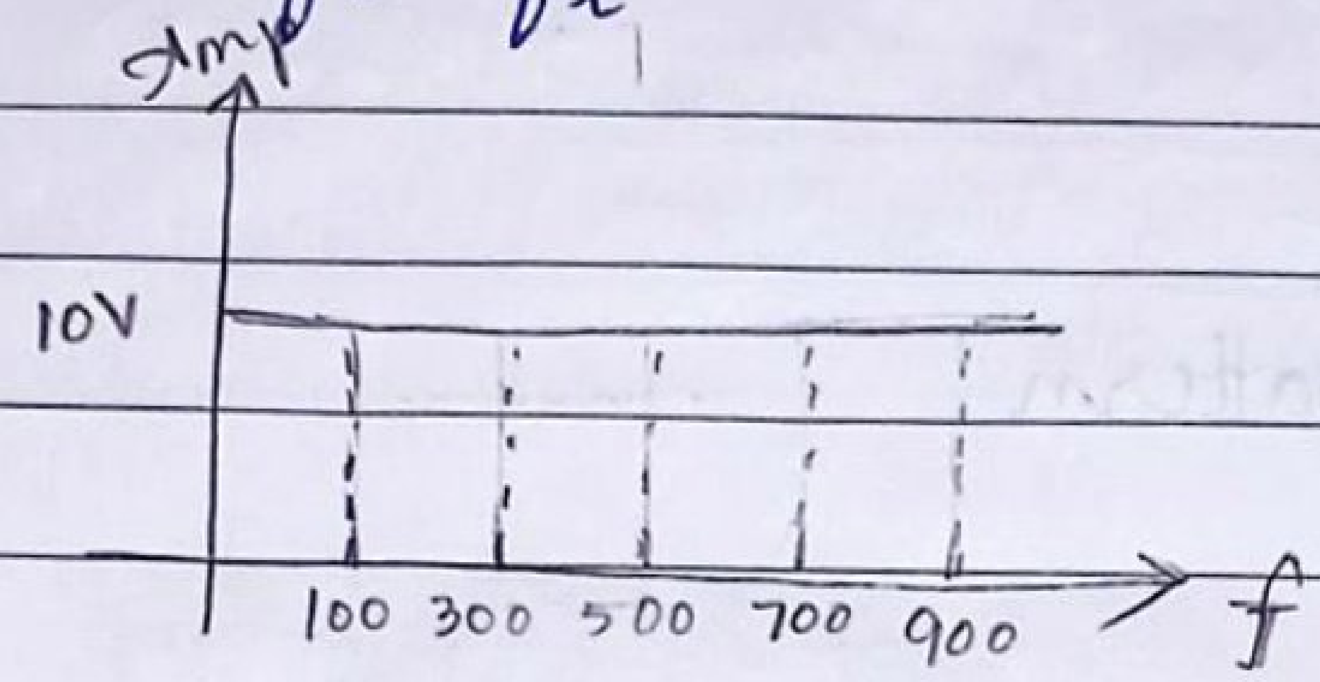
* Problems:

1) The power we use at home is $f = 60\,Hz$. Calculate time period

$$T = \frac{1}{f} = \frac{1}{60}\ s$$

2) If periodic signal is composed of 5 sine waves of freq: 100, 300, 500, 700, 900 Hz. Calculate Bandwidth
Peak Amp → Voltage = 10 V

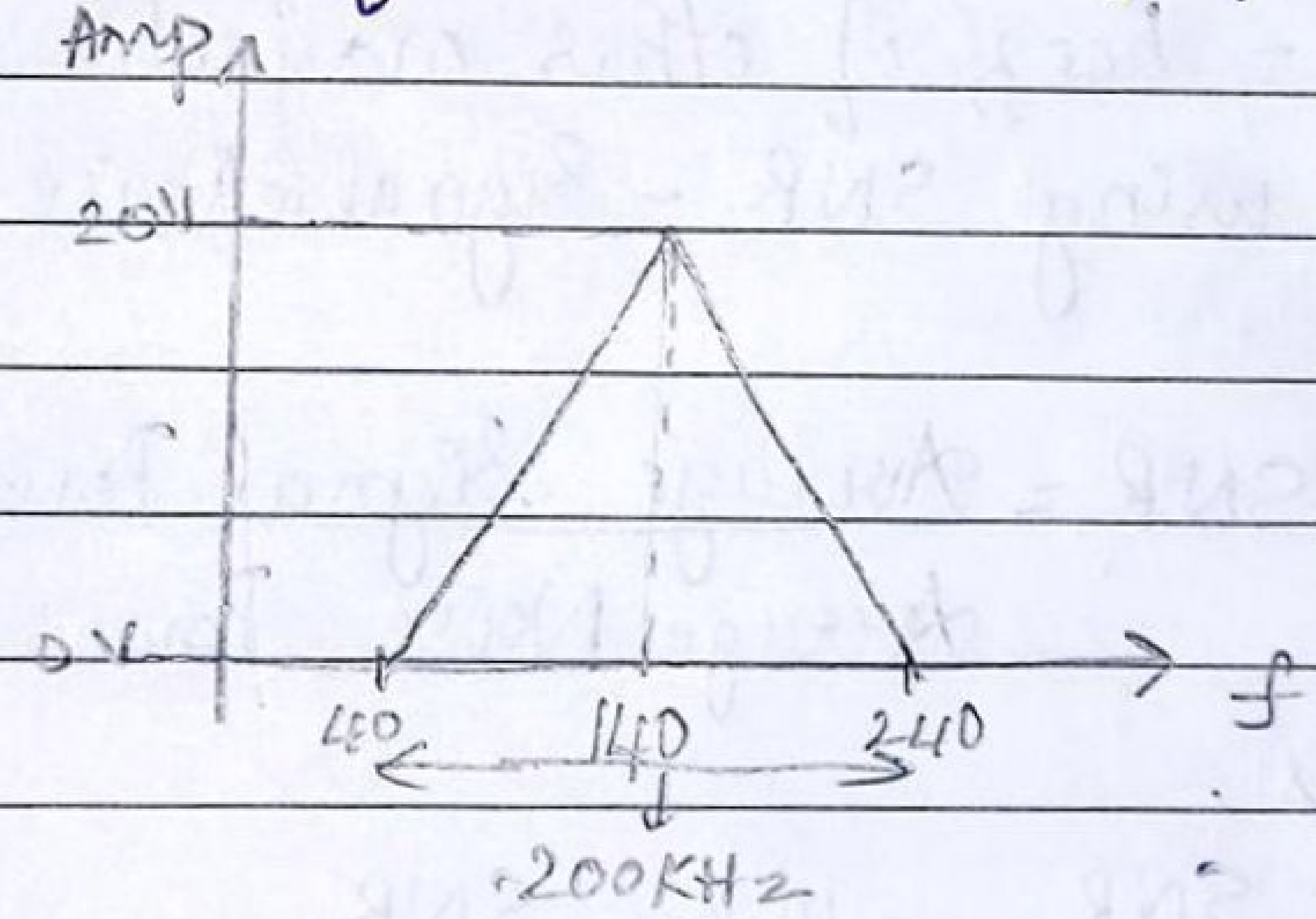
$$B/W = f_h - f_l = 900 - 100 = 800\ Hz$$




3) ~~Lowest freq~~ In a non-periodic composite signal, B/W is 200 KHz with middle freq of 140 KHz & peak Amp of 20 V.

$$B/W = f_h - f_l = 200\ KHz$$

2 Extreme freq. of Amp 0 V. Draw freq-Domain plot of this signal.

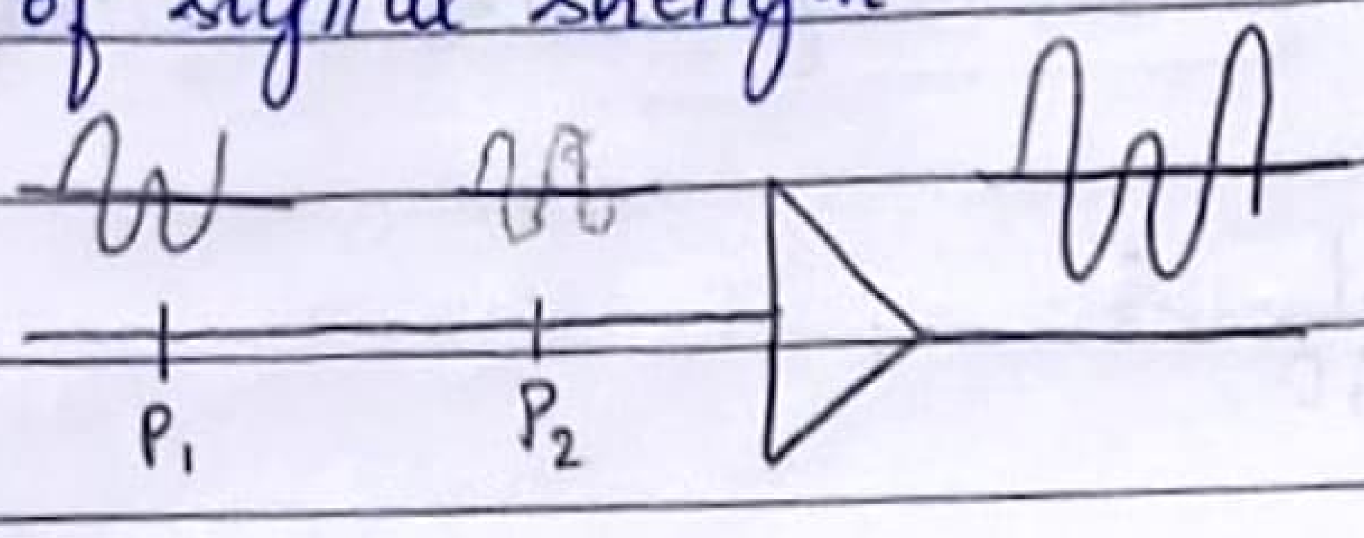



## * Transmission Impairment (TI)

Causes:

* Attenuation
* Distortion
* Noise

* Attenuation
- Loss of signal strength



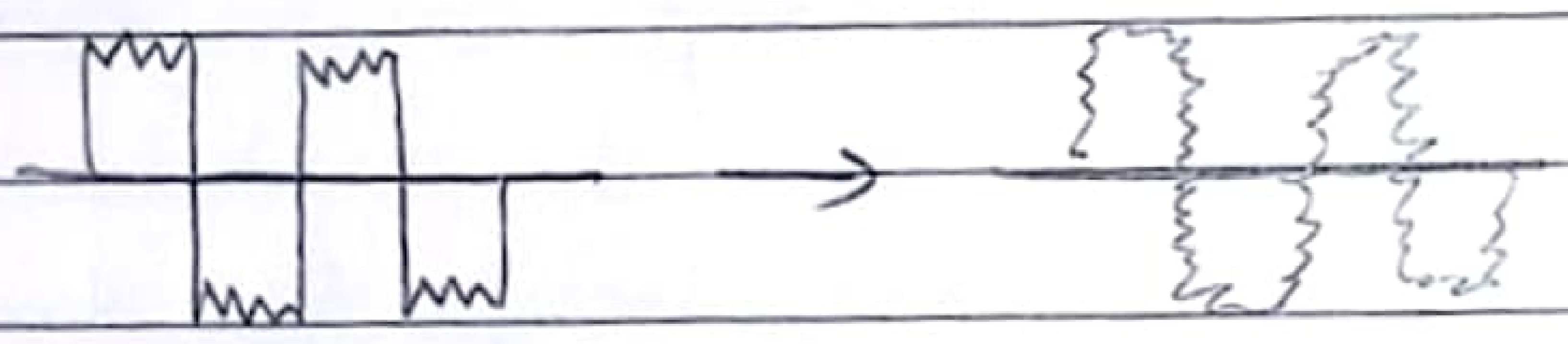

$$\underset{\text{decibels}}{dB} = 10 \log_{10} \left( \frac{P_2}{P_1} \right)$$

$P_2$ → Power of signal at point 2

$P_1$ → Power of signal at point 1

* One of reasons for TI.

* Distortion
Change of signal pattern



* Noise

Types:-
1) Thermal - cable gets heated up
2) Crosstalk - If 2 cable overlay on each other
3) Impulse - bcoz of other magnetic interference

* Measured using SNR - Signal to Noise Ratio

$$SNR = \frac{\text{Average Signal Power}}{\text{Average Noise Power}}$$

In decibels,

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

* Problems:
1) A signal travels through an Amplifier & its power is ↑ 10 times. What is attenuation.

$$P_2 = 10 P_1$$

$$dB = 10 \log_{10} \left( \frac{10 P_1}{P_1} \right) = 10 \text{ decibels.}$$

2) The Power of a signal is 10 mW & Power of noise is 1 μW. $SNR = ?$ $SNR_{dB} = ?$

$$SNR = \frac{10 \times 10^{-3}}{10 \times 10^{-6}} = \boxed{10^4}$$

$$SNR_{dB} = 10 \log_{10} 10^4 = 4 \times 10 = \boxed{40 \text{ decibels}}$$

3) Calculate SNR & $SNR_{dB}$ for a noiseless ~~fan~~ channel.

$$SNR = \frac{\text{Avg SP}}{0} = \infty$$

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

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* Data Rate limits: - Restrictions you have on Data Rate
1) Bandwidth availability
2) Levels in signal - More levels, amt of data that can be transfered high
3) Noise - Amt of data transfer ↓

* Algorithms:
1) Noiseless Channel [Non-ideal channel]
   * Nyquist bitrate - scientist - proposes a formula
     $Bitrate = 2 * B/W * \log_2 L$  L - No. of levels in signals (1V level)
     B/W - Bandwidth

2) Noisy Channel
   * Channel exposed to noise
   * Shannon Capacity $= B/W * \log_2 (1 + SNR)$

* Problems:
1) We need to send 265 Kbps over noiseless ch. with B/W = 20 KHz. How many signal levels is req?

$$265 \times 10^3 \text{ bps} = 2 \times 20 \times 10^3 \times \log_2 L$$

$$\log_2 L = 6.625$$
$$\boxed{L = 98.701}$$

2) $SNR_{dB} = 36$ & $B/W = 20MHz$. Calulte capacity.

$$10 \log_{10} SNR = SNR_{dB}$$
$$SNR = 10^{\frac{36}{10}}$$
$$SNR = 3981.07$$

$$Capacity = B/W * \log_2(1+SNR)$$
$$= 20 \times 10^6 \times \log_2(3982.07)$$
$$= \boxed{239.186 \text{ Mbps}}$$

* **Latency**
* Time taken by entire packet to move from source to destination machines.
* It depends on:-

1) * **Propogation time (PT)**
Time taken by single bit to move from S to D machine
PT = Distance / Propogation speed

2) * **Tramission time (TT)**
Time take by entire message to move from S to D.
TT = Msg Size / B/W

3) * **Queuing Time (QT)**
Time spent by message in sender's queue & receiver's queue.

4) * **Processing Delay (PD)**
When msg is received by intermediate node, it has to be processed (msg)

Latency = PT + TT + QT + PD

* Data Transmission

× 1) Analog Transmission
* Channel which supports only analog signals
* Analog data ⇒ Analog signal - A-A Conversion
  Digital data ↗ - D-A Conversion
* Modulation - Conversion of Data to signal (sender)
* Demodulation - Signal to Data (Receiver)
* Modem supports both modulation & demodulation

✓ 2) Digital Transmission
* Supports only Digital Signals
* Analog data → Digital signal - A-D Conversion
  Digital data ↗ D-D Conversion

* Digital to Digital Conversion

1) * Line Coding

1. Unipolar - NRZ
One side of graph
2. Polar - NRZ, RZ, Biphase
Both sides of graph
3. Bipolar - AMI
Both sides of graph

} Single level

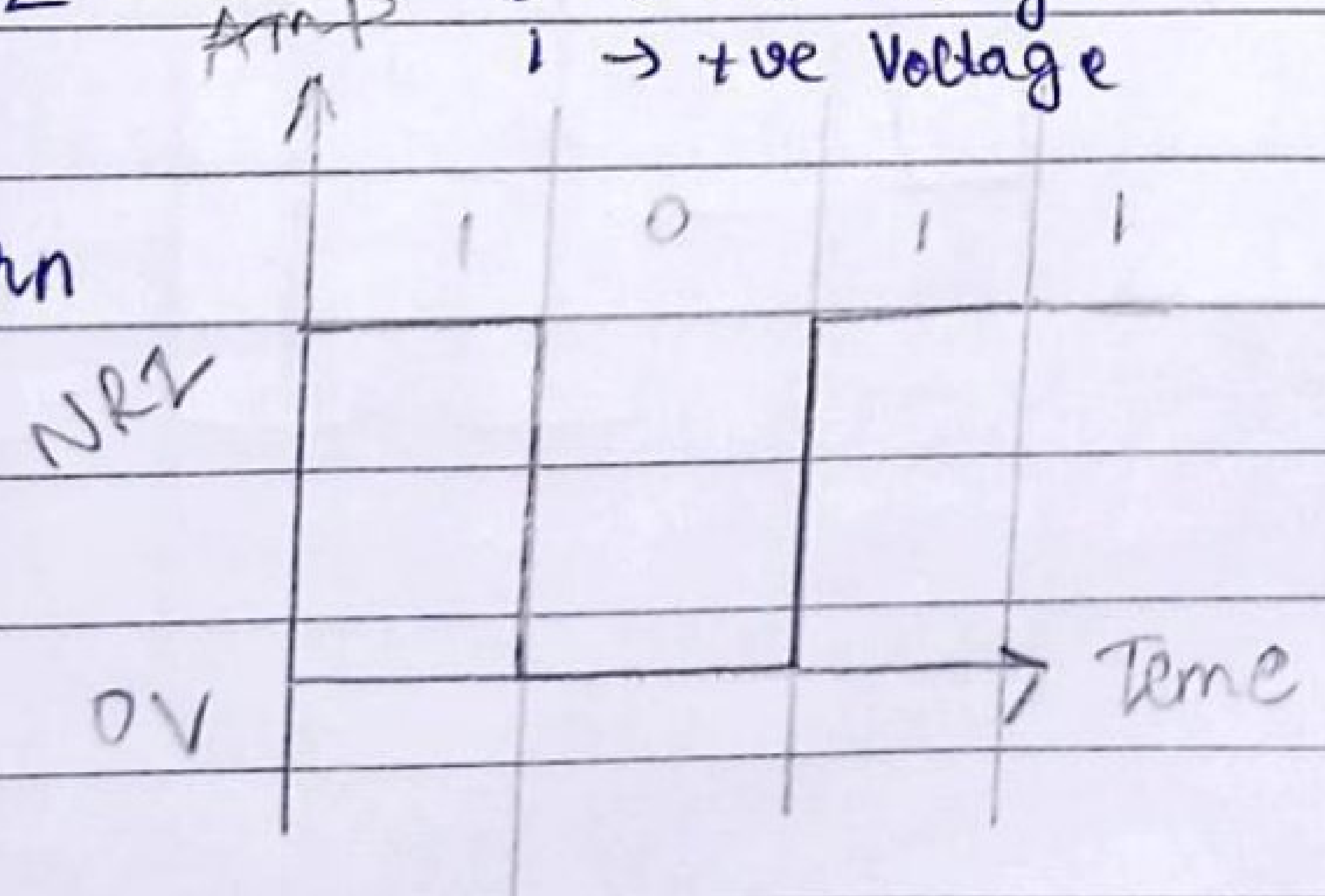
× 4. Multilevel
× 5. Multitransition

} Multi level

1. Unipolar - NRZ

*NRZ (Not Return to zero)

0 → No Voltage
1 → +ve Voltage

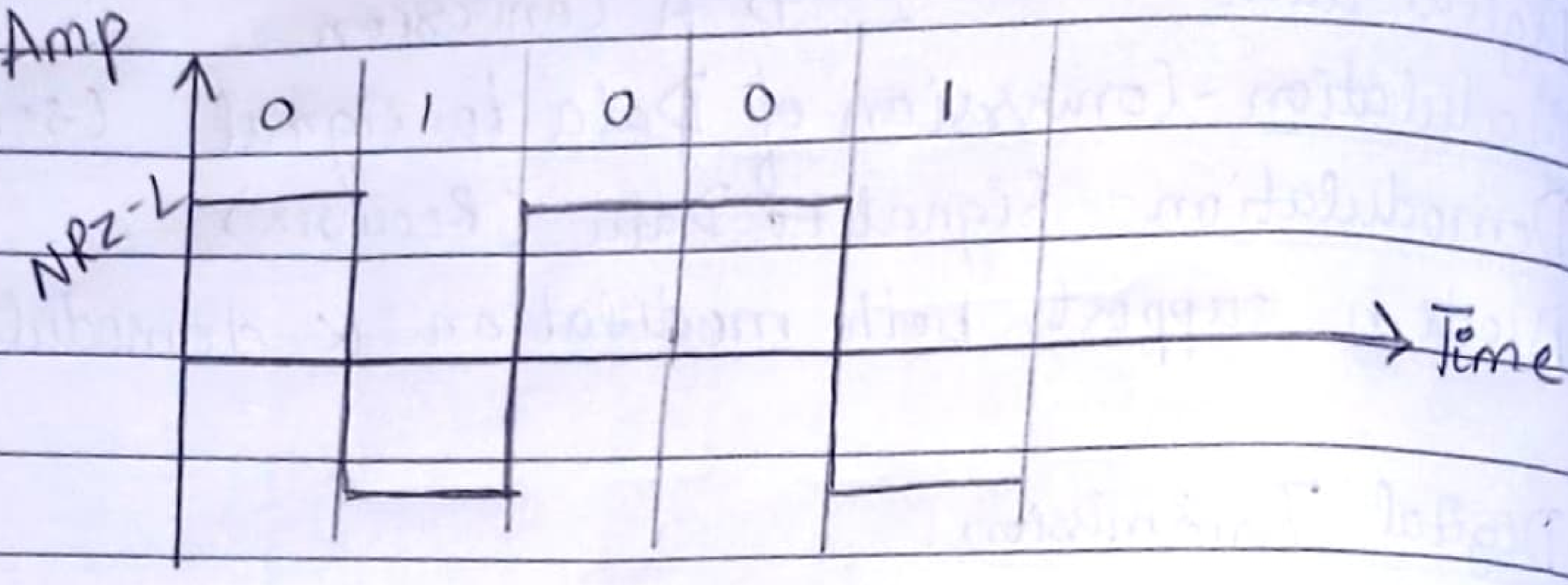



* Consecutive 0's & 1's are not differentiated → NRZ fails

2. Polar - NRZ

i) NRZ - L (level)

0 → +ve Voltage
1 → -ve Voltage

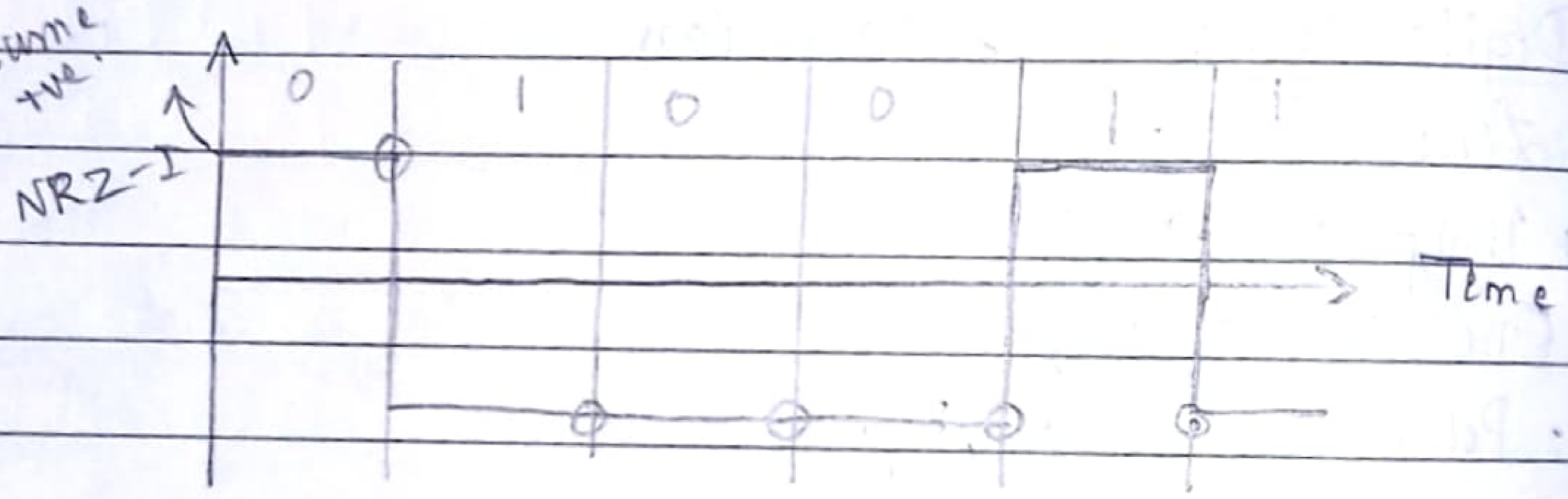



ii) NRZ - I Inversion ~~(Index)~~

Next bit 0 - No inversion
Next bit 1 - Inversion

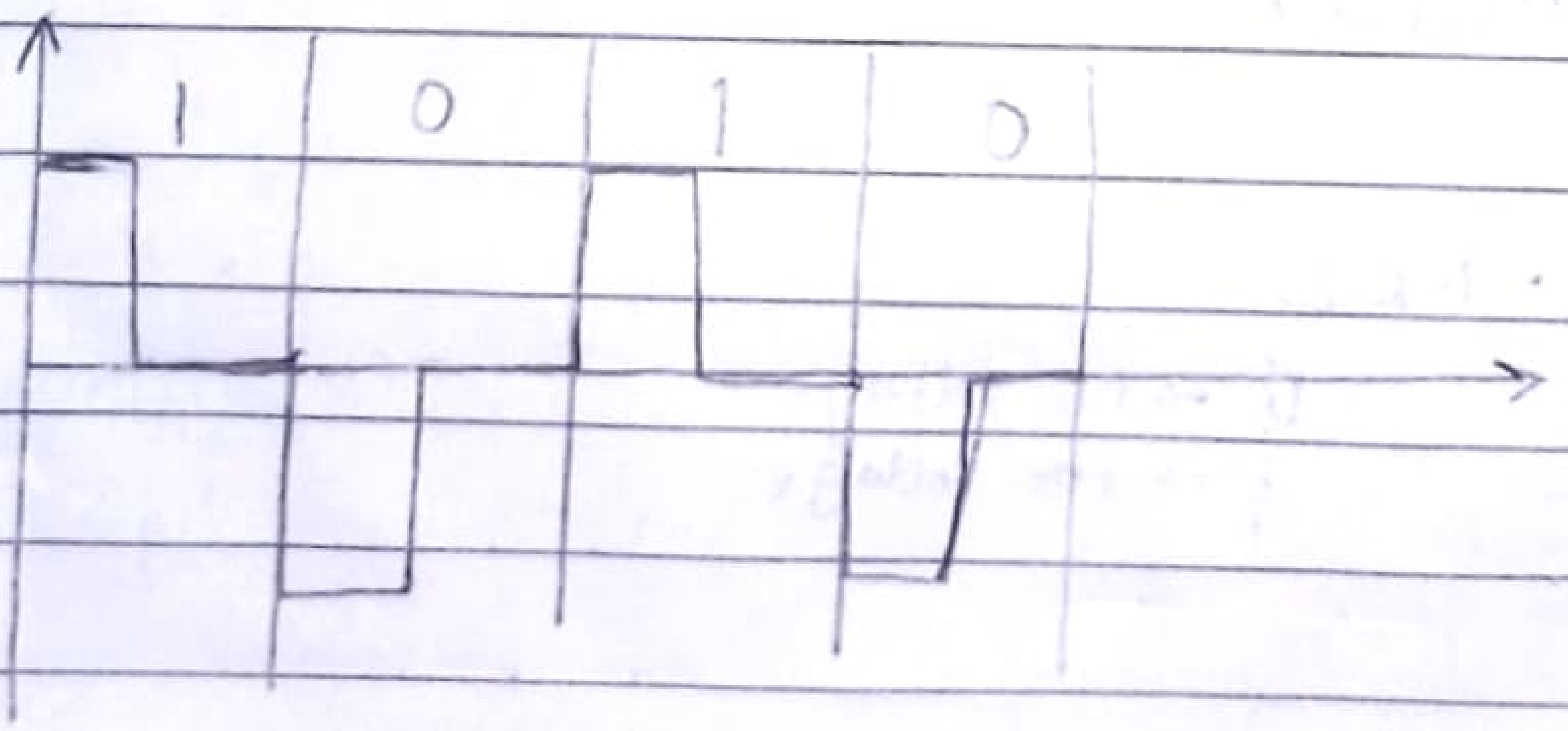
* Assume +ve

If no




iii) RZ (Return to Zero)

0 → -ve V to 0V
1 → +ve V to 0V

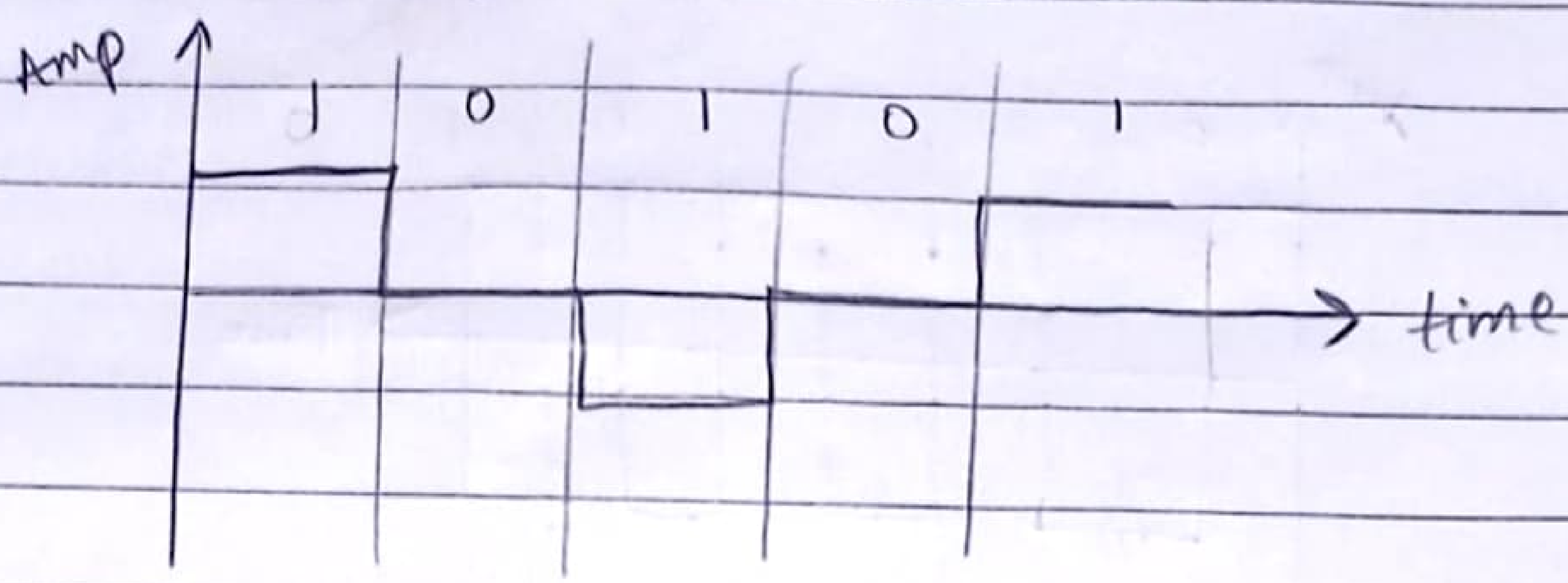


3. Bipolar

i) AMI - Alternate Marking ~~Index~~ Inversion

0 → 0V always

1 → +ve, -ve, +ve - alternate

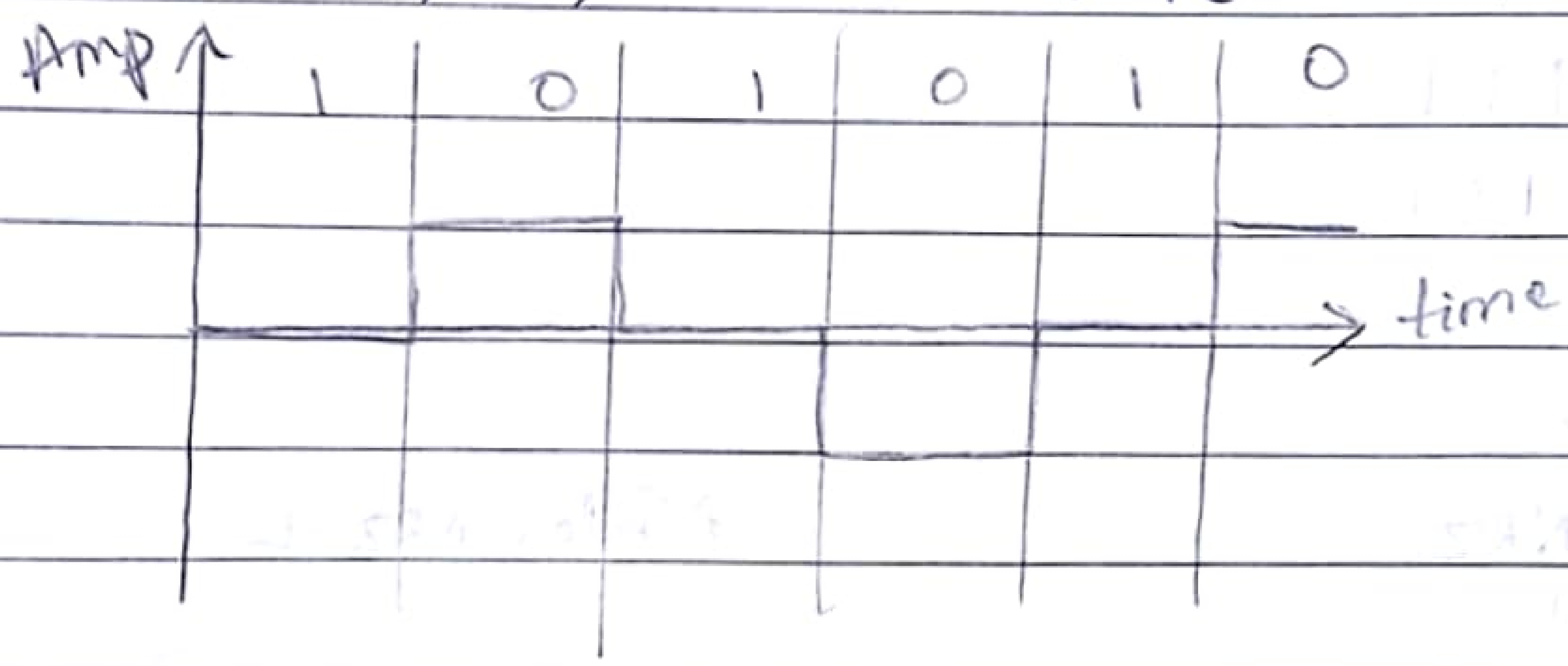



ii) Pseudoternary

Oppo to AMI

1 → 0V always

0 → +ve, -ve, +ve - alternate

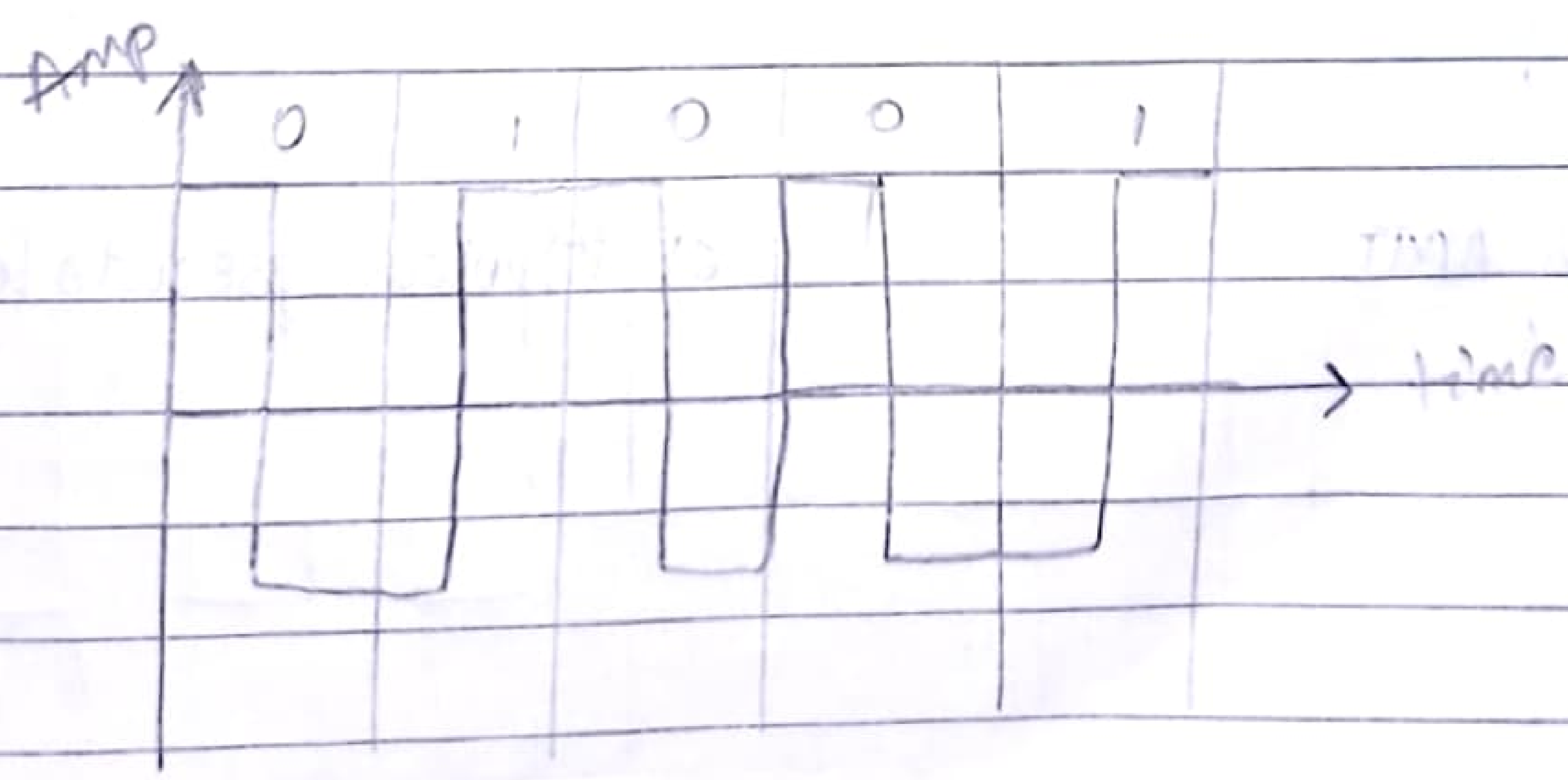



iv)* Biphase (Polar)

a) Manchester

0 → +ve to -ve

1 → -ve to +ve

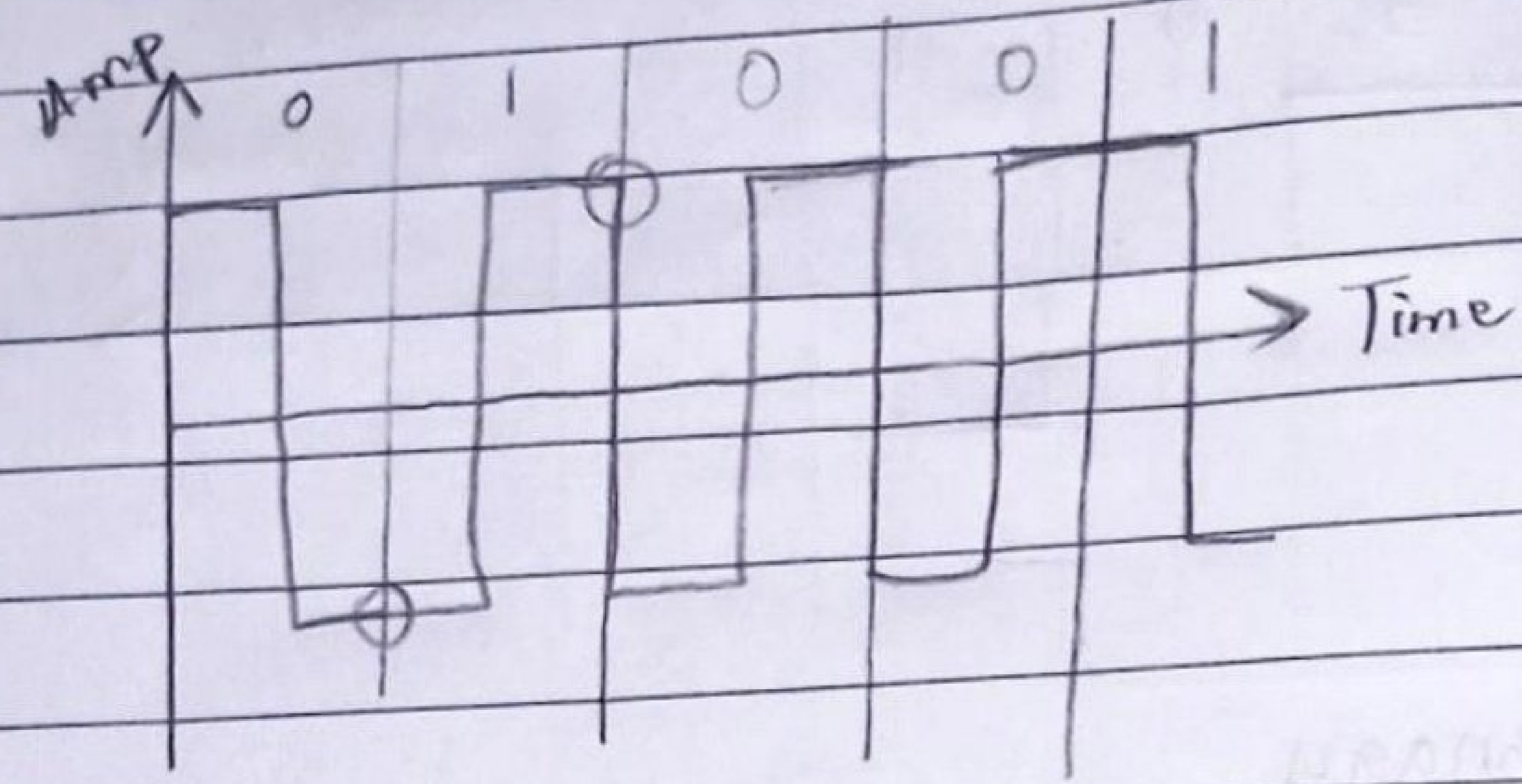


b) Differential Manchester

Oppo to NRZ-I

Next bit 1 → No Inversion

Next bit 0 → Inversion




* Problems:

1) Convert foll. data strings

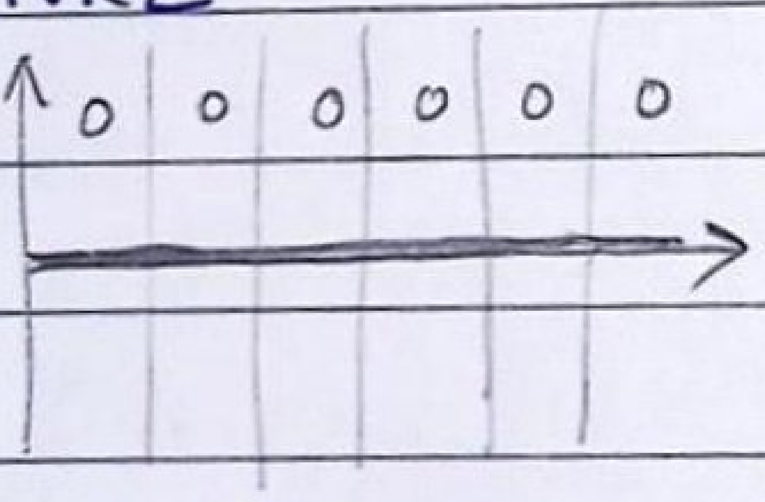
1. 000000
2. 111111
3. 010101

1. 000 000

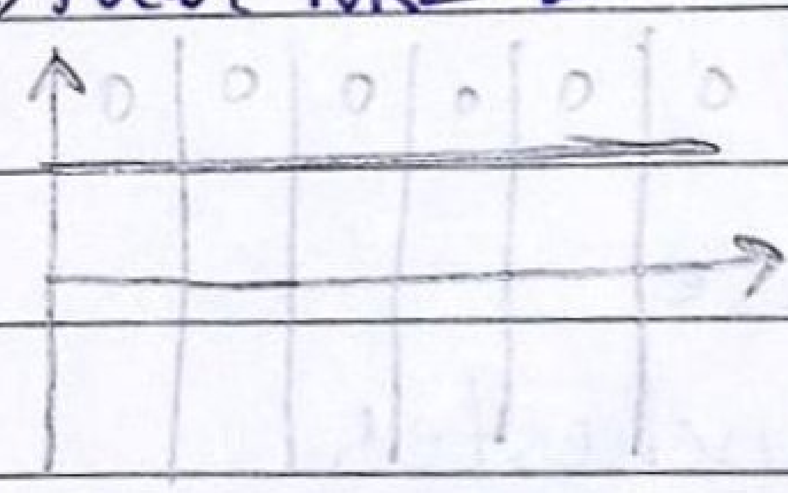
1) Polar NRZ

0 → 0V

1 → +ve V




2) Polar NRZ-L



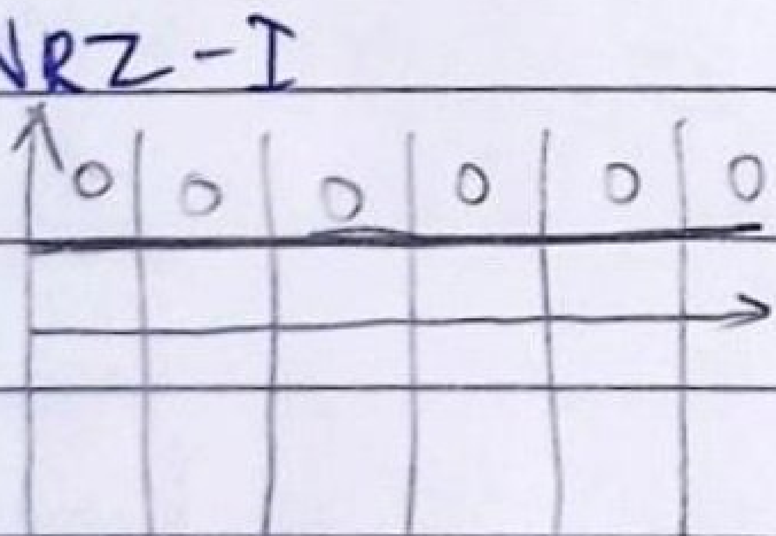

0 → +ve V

1 → -ve V

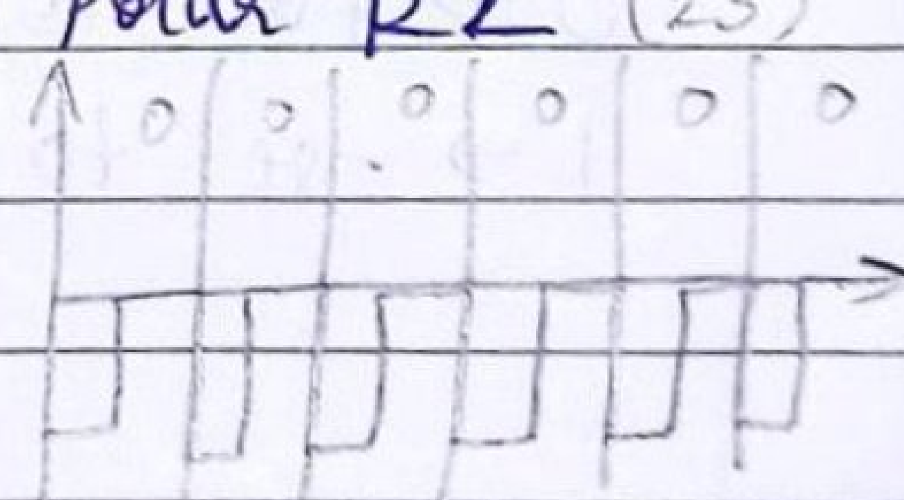
3) Polar NRZ-I

0 → No I

1 → I




4) Polar RZ (2S)




0 → -ve to

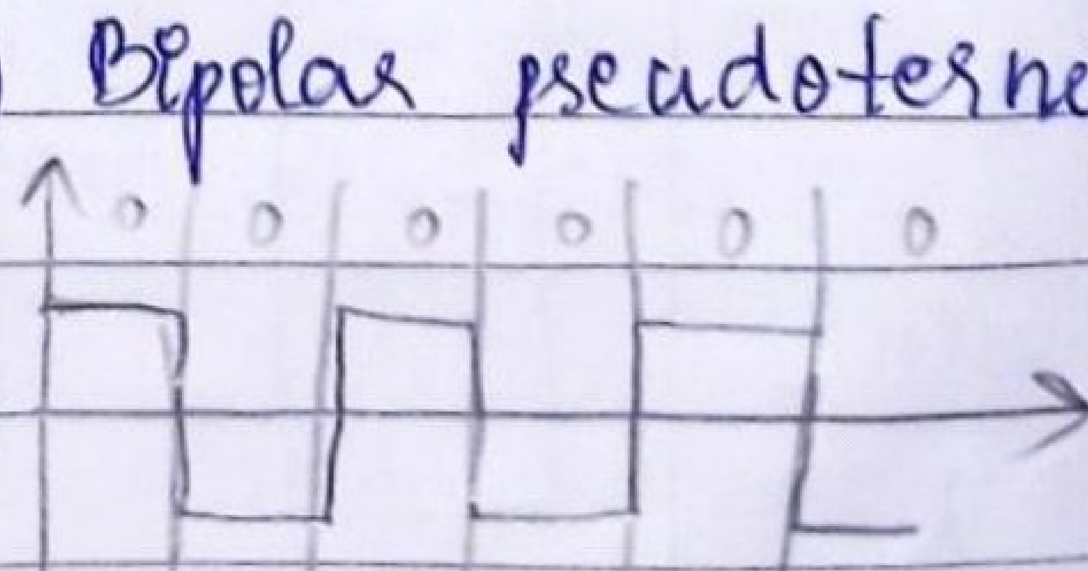
1 → +ve to

5) Bipolar AMI

0 → 0V

1 → Alt


6) Bipolar pseudoternary

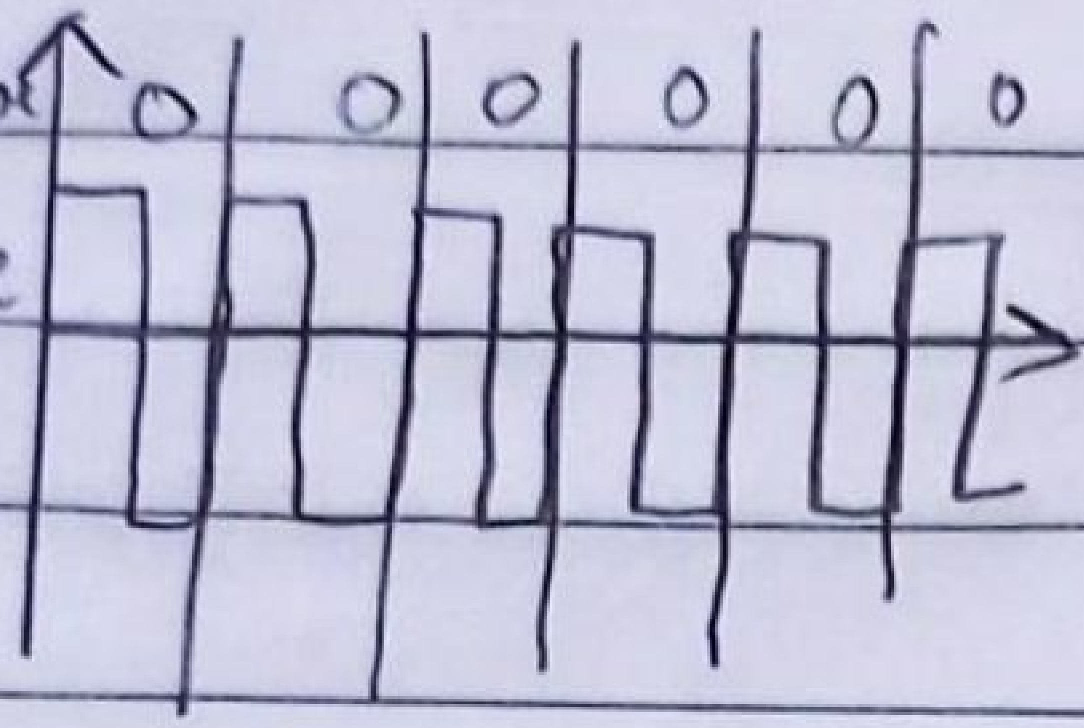



0 → Alt

1 → 0V

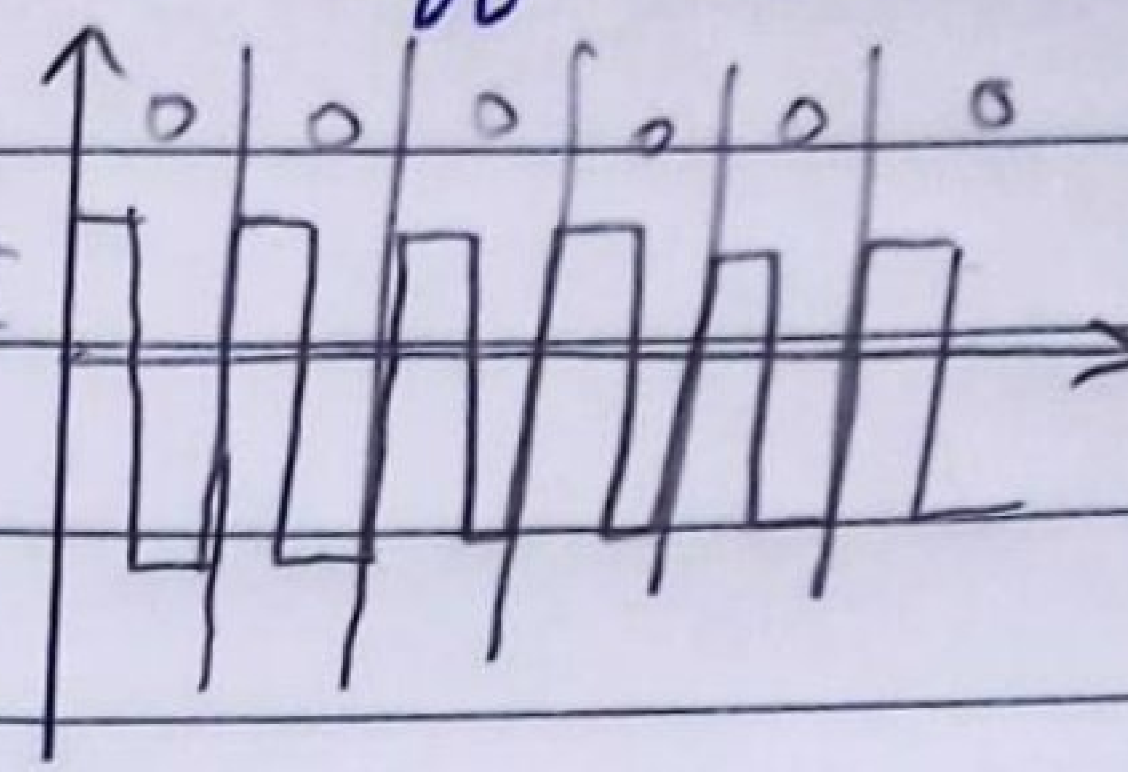
7) Polar Manchester (2S)

0 → +ve to -ve
1 → -ve to +ve




8) Polar Diff. Manchester (2S)

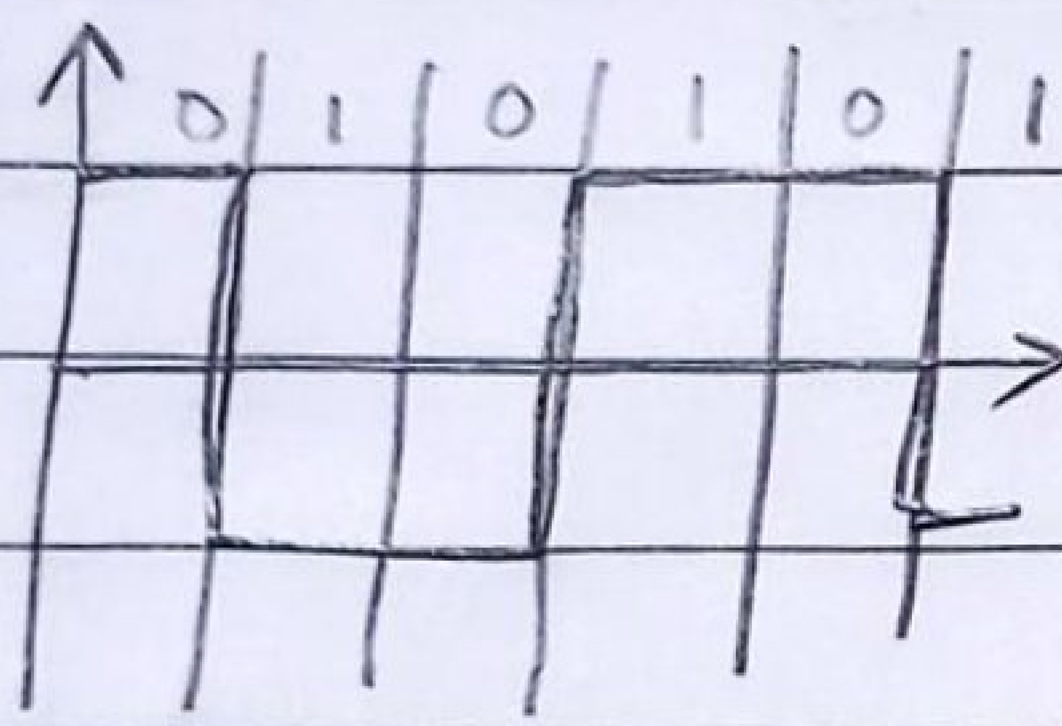
0 → I
1 → No I




3. 010101

1) NRZ - I

0 → No I
1 → I




2) Polar Diff M

0 → I
1 → No I