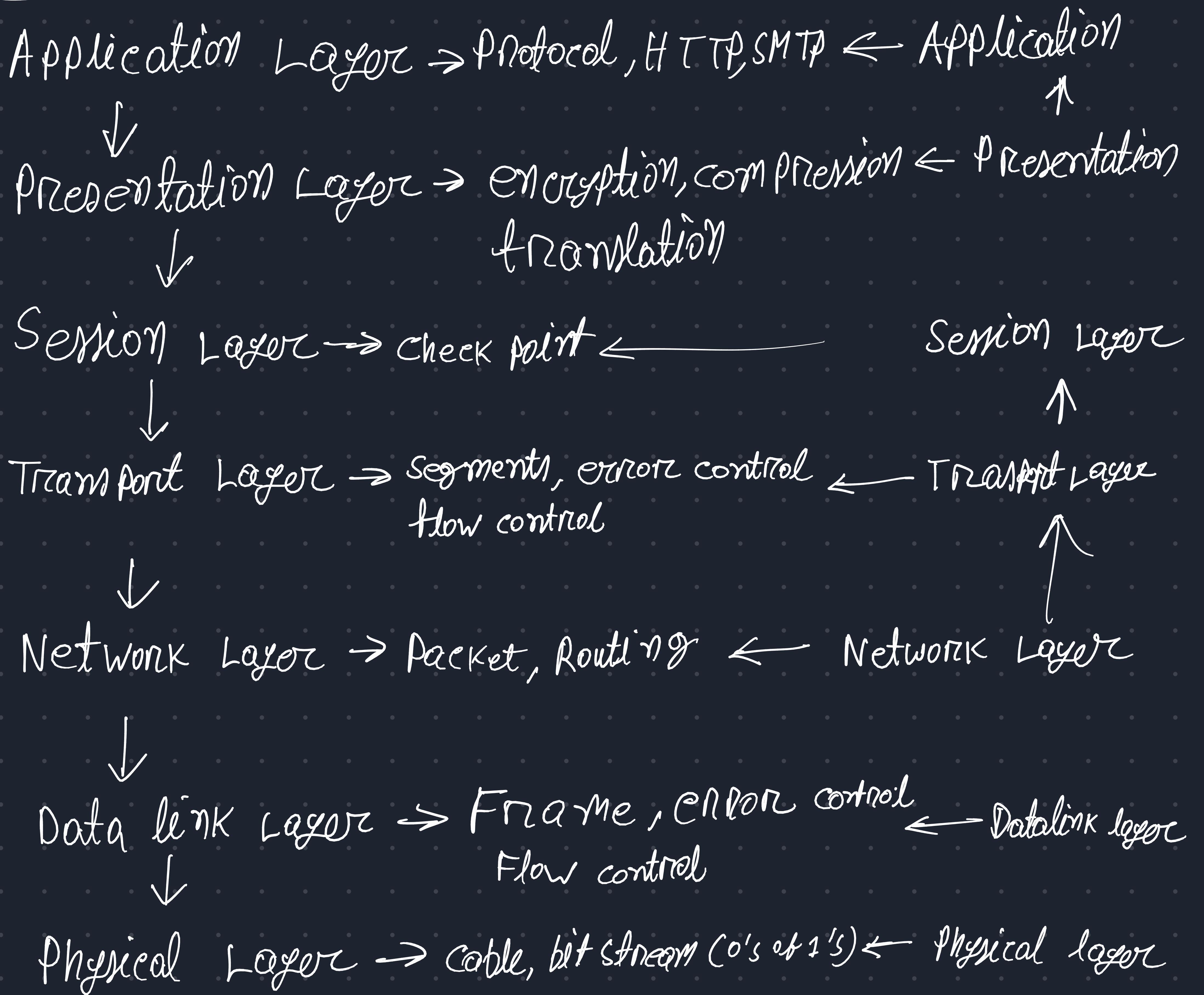


The OSI Model

- * OSI → Open System Interconnection,
ISO → International standards for organization

Sender

Receiver



5 layer

OSI (7 Layer)

4 layer

Application Layer	Application Layer Presentation Layer Session Layer	Application Layer
Transport Layer	Transport Layer	Transport Layer
Network layer	Network layer	Internet layer
Datalink layer	Data link layer	Network Access Layer
Physical layer	Physical Layer	

* TCP / IP Protocol suite or Internet protocol

* Developed by ARPANET

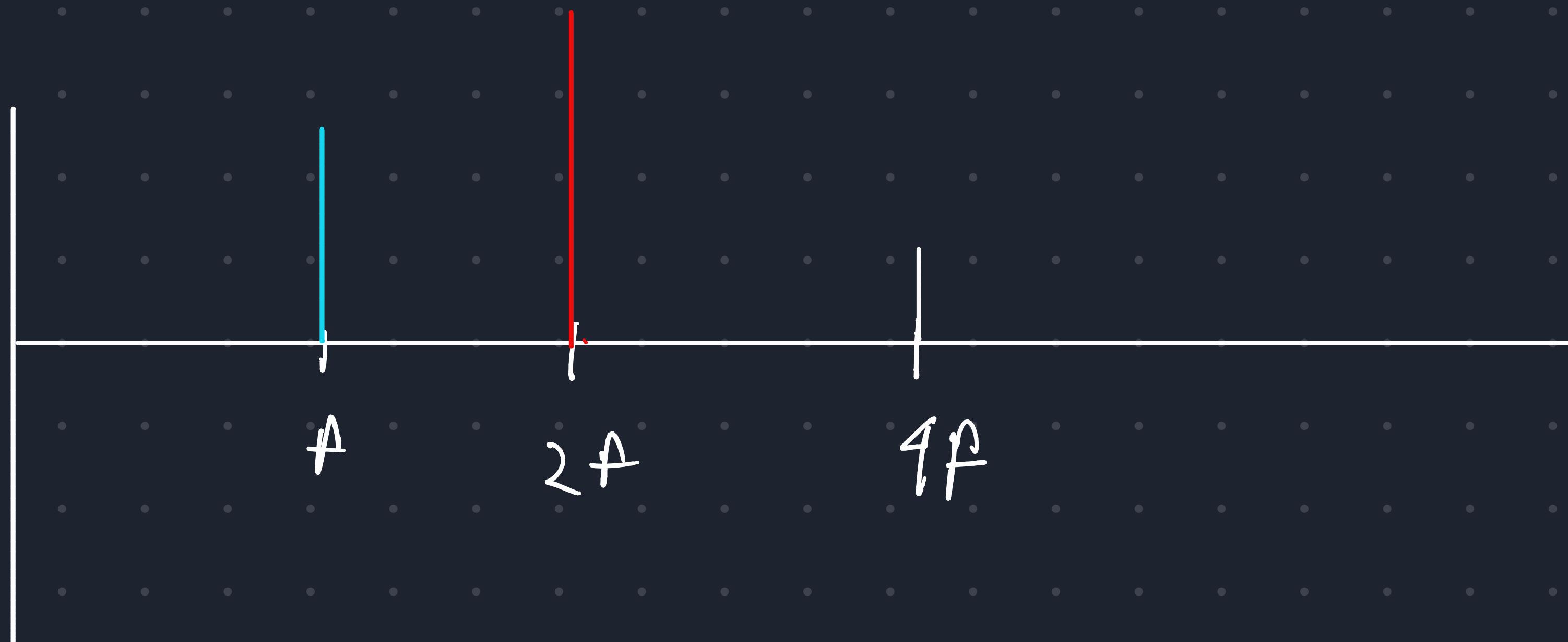
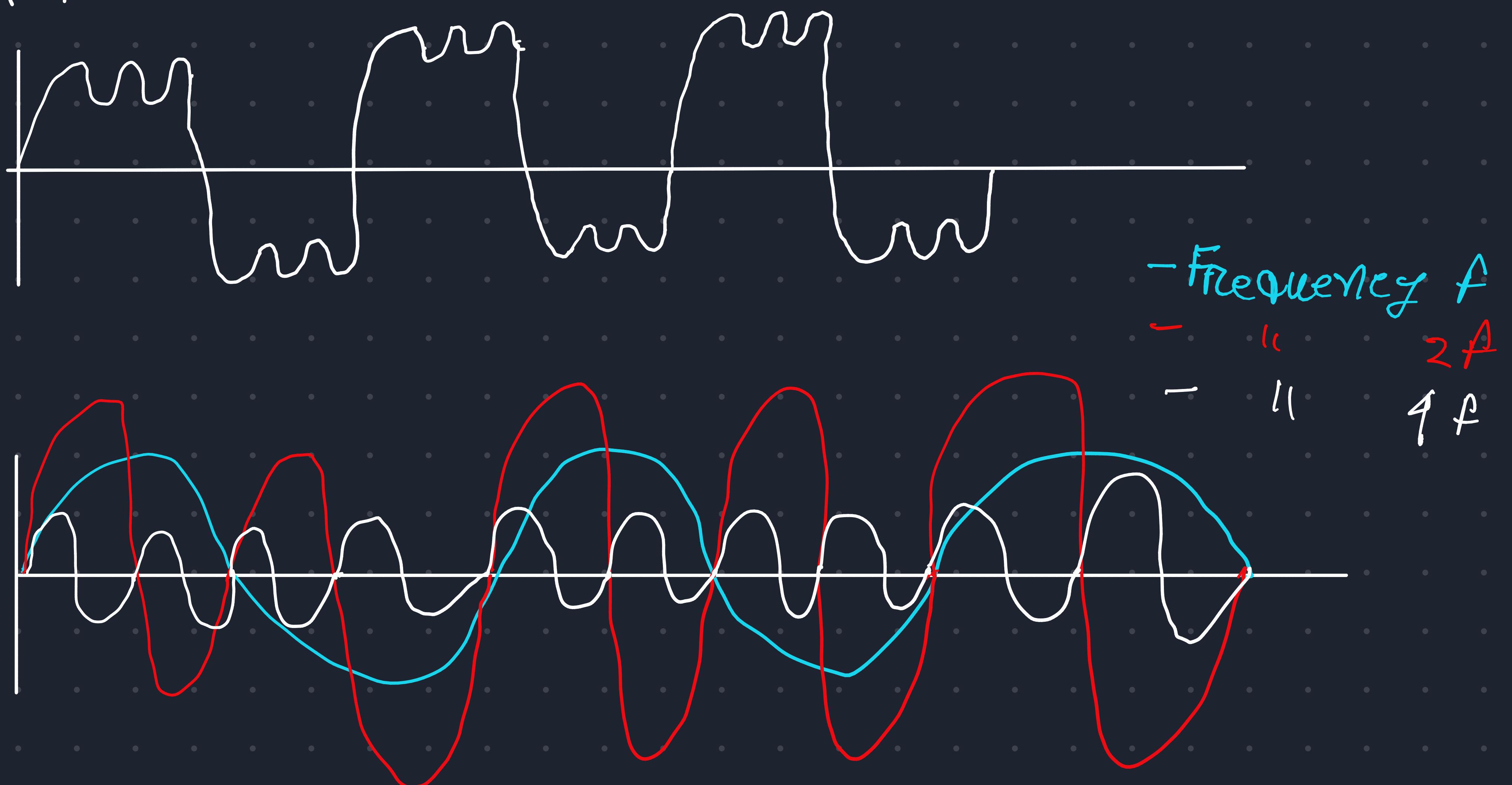
* TCP refers to Transmission control protocol.

* TCP is more reliable.

* TCP / IP is a practical model.

Composite signals

Amplitude



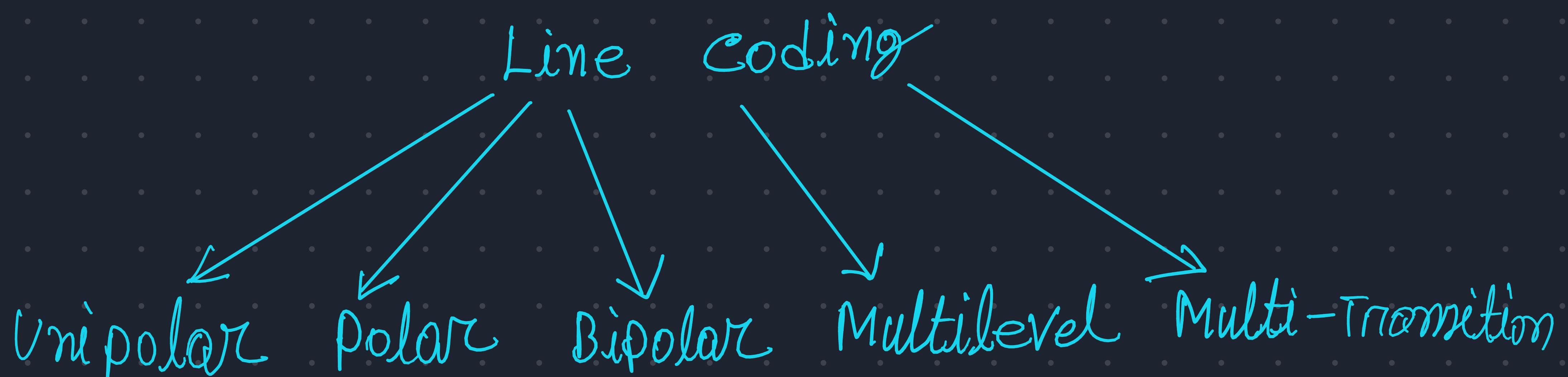
b) Frequency decomposition of periodic composition signals.

Digital transformation

Digital to digital

Line Coding
Block Coding

Analog to digital
Scrambling (PAM)
(pulse Amplitude modulation)
PCM (Pulse code modulation)



Unipolar scheme:

positive voltage $\rightarrow 1$

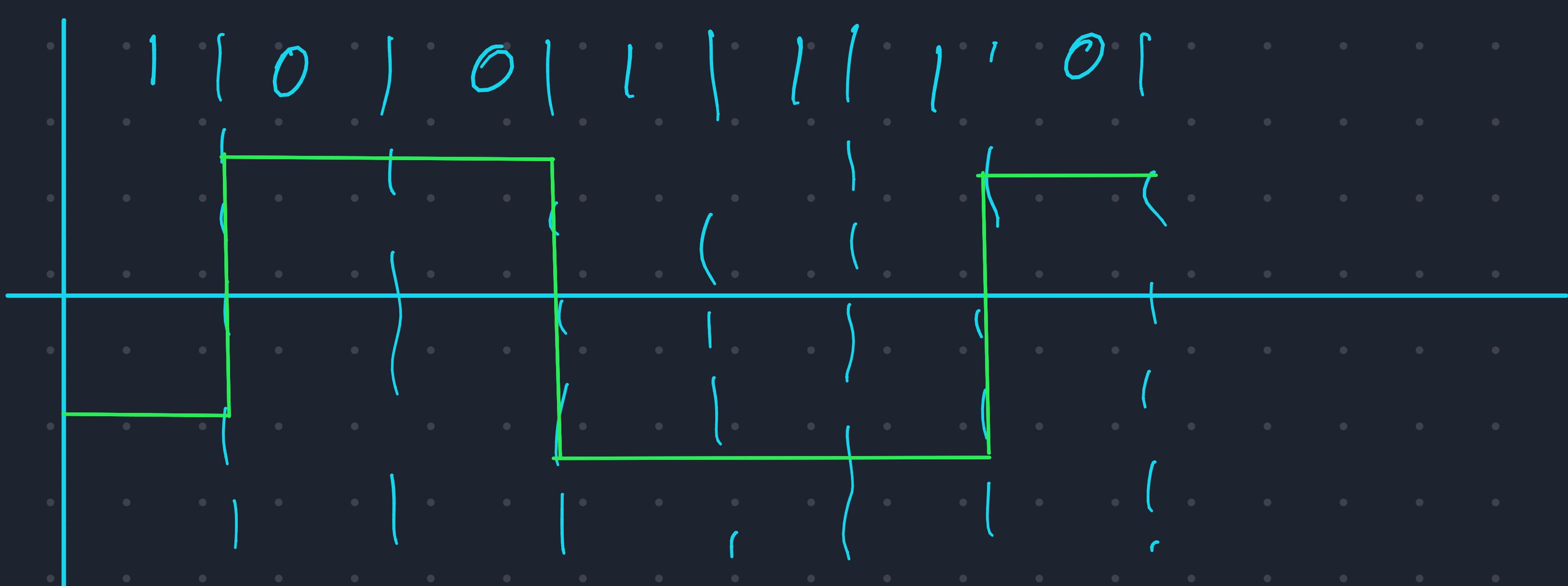
zero $\rightarrow 0$

$\rightarrow NRZ$
non return zero

NRZ-L:

1 \rightarrow negative ✓
0 \rightarrow positive ✓

1001110

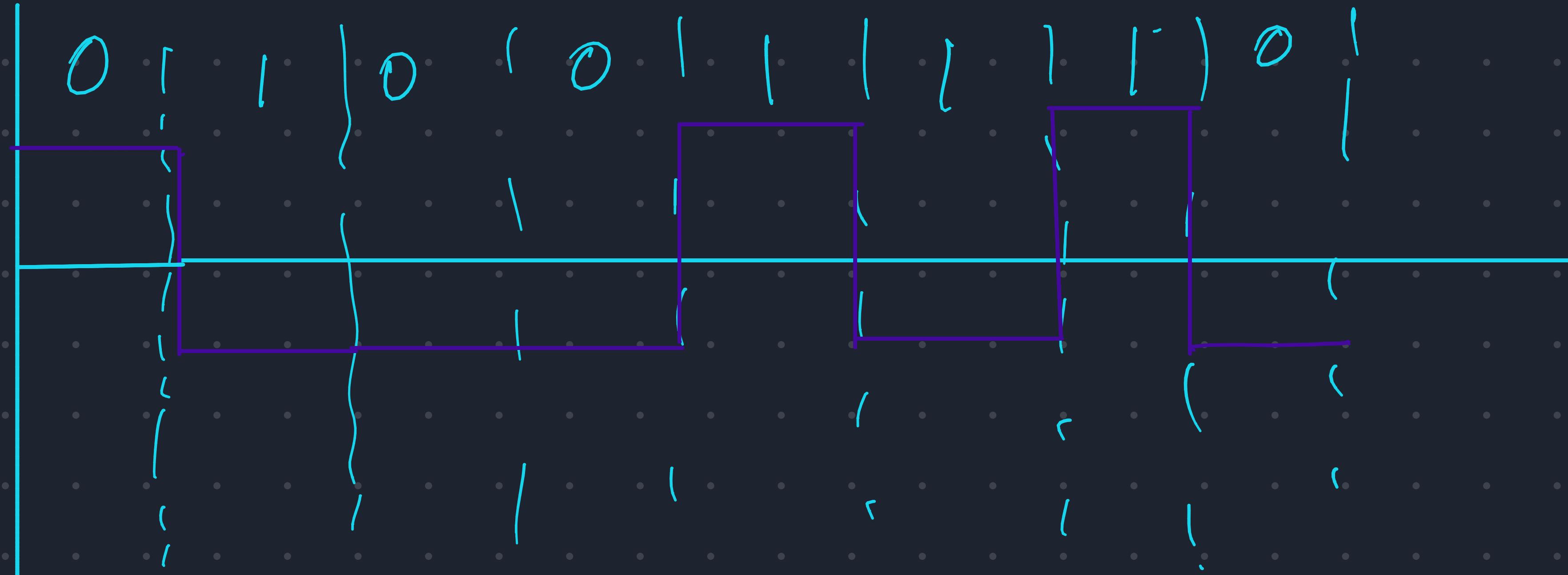


NRZ-I:

1 → transition

0 - no transition

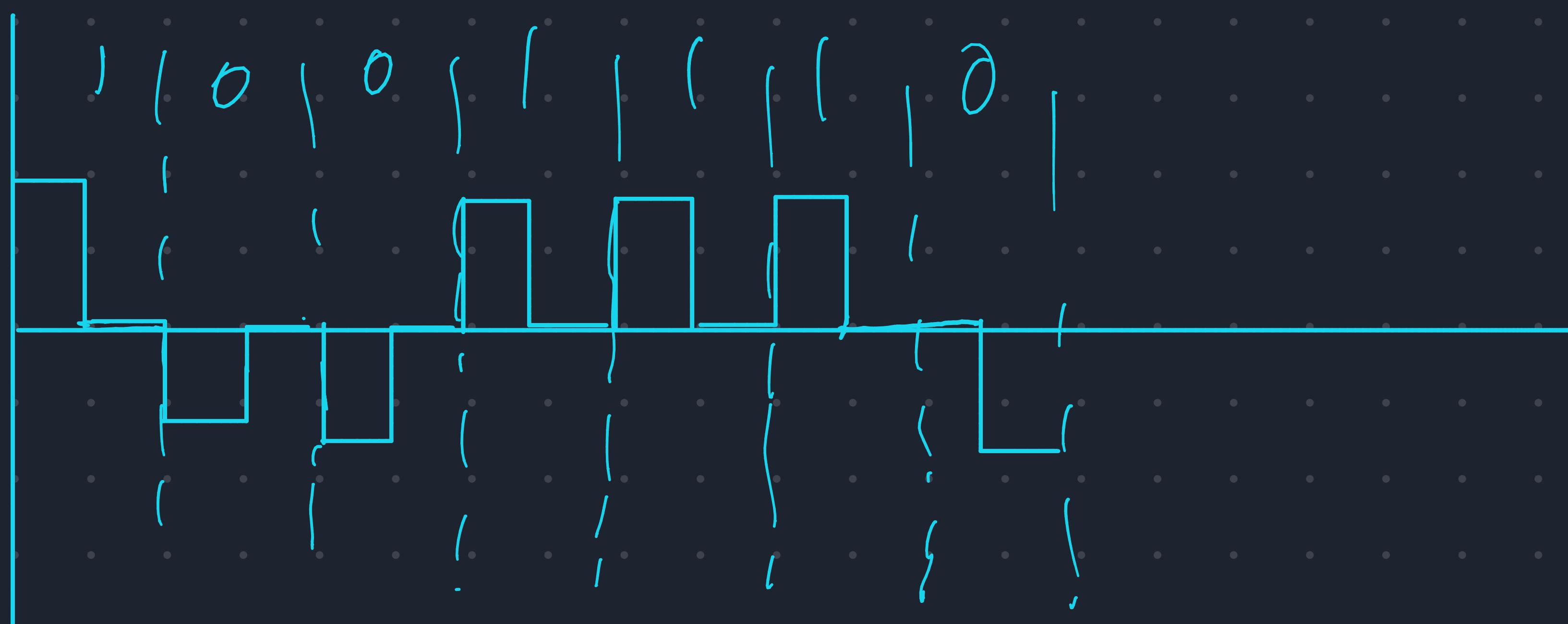
Note: এদি signal এর মুক্তি 1
মানে কোন একটি 0 মুক্তি
এতে বাবে নিয়।



Return to zero (RZ):

0 → negative to zero ↘

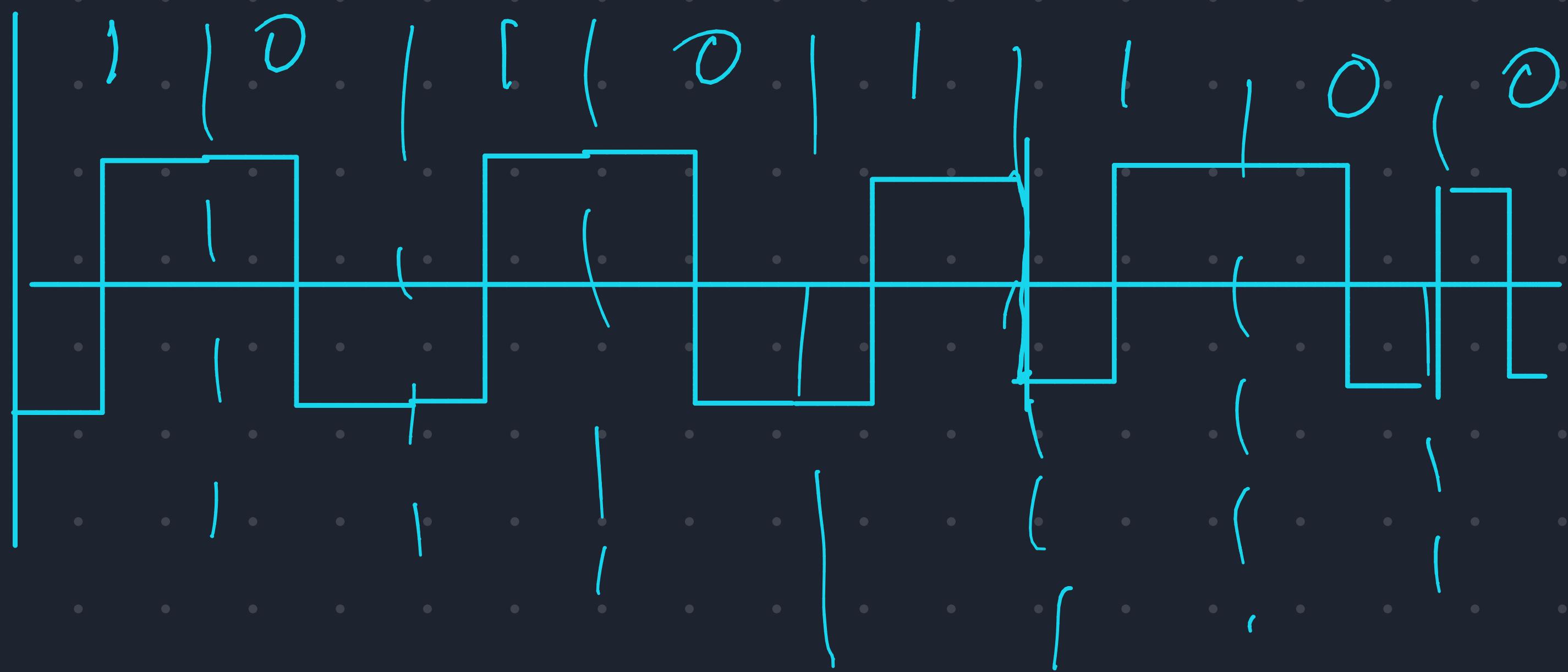
1 → Positive to zero ↗



Manchester (IEEE)

$1 \rightarrow$ negative to positive \sqcap

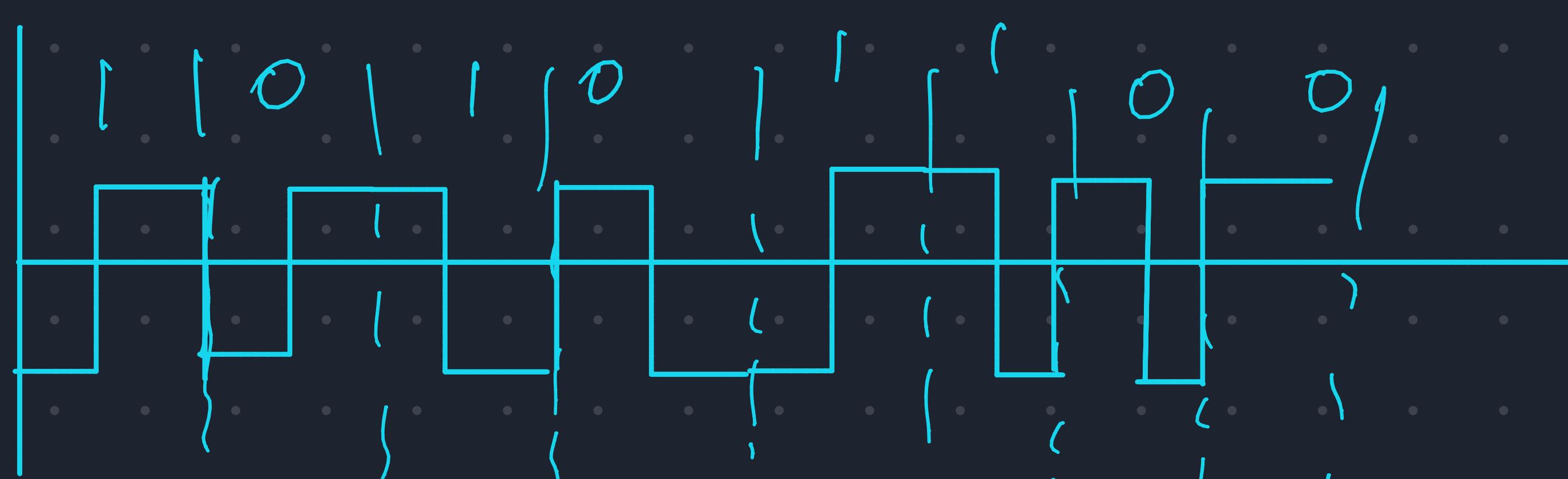
$0 \rightarrow$ positive to negative \sqcup



Differential Manchester:

$0 \rightarrow \sqcap, \sqcup$ (transition)

$1 \rightarrow \sqcup/\sqcap$ (no transition)



Bipolar Schemes:

$\sqcap \rightarrow$ AMI

$\sqcup \rightarrow$ Pseudoternary

Alternate Mark Inversion (AMI)

$0 \rightarrow$ zero voltage level

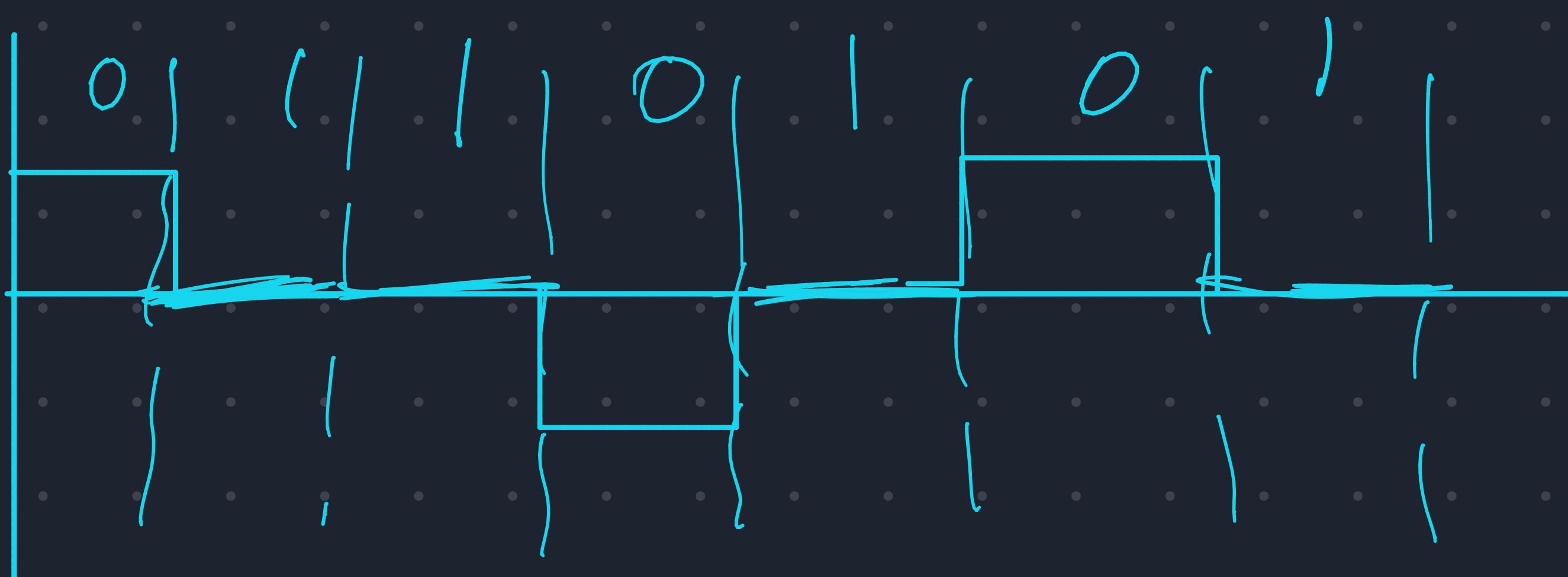
$1 \rightarrow$ Alternate voltage level



Pseudoternary:

1 → zero voltage level

0 → alternate



Multilevel Encoding (2B1Q)

length of the binary pattern

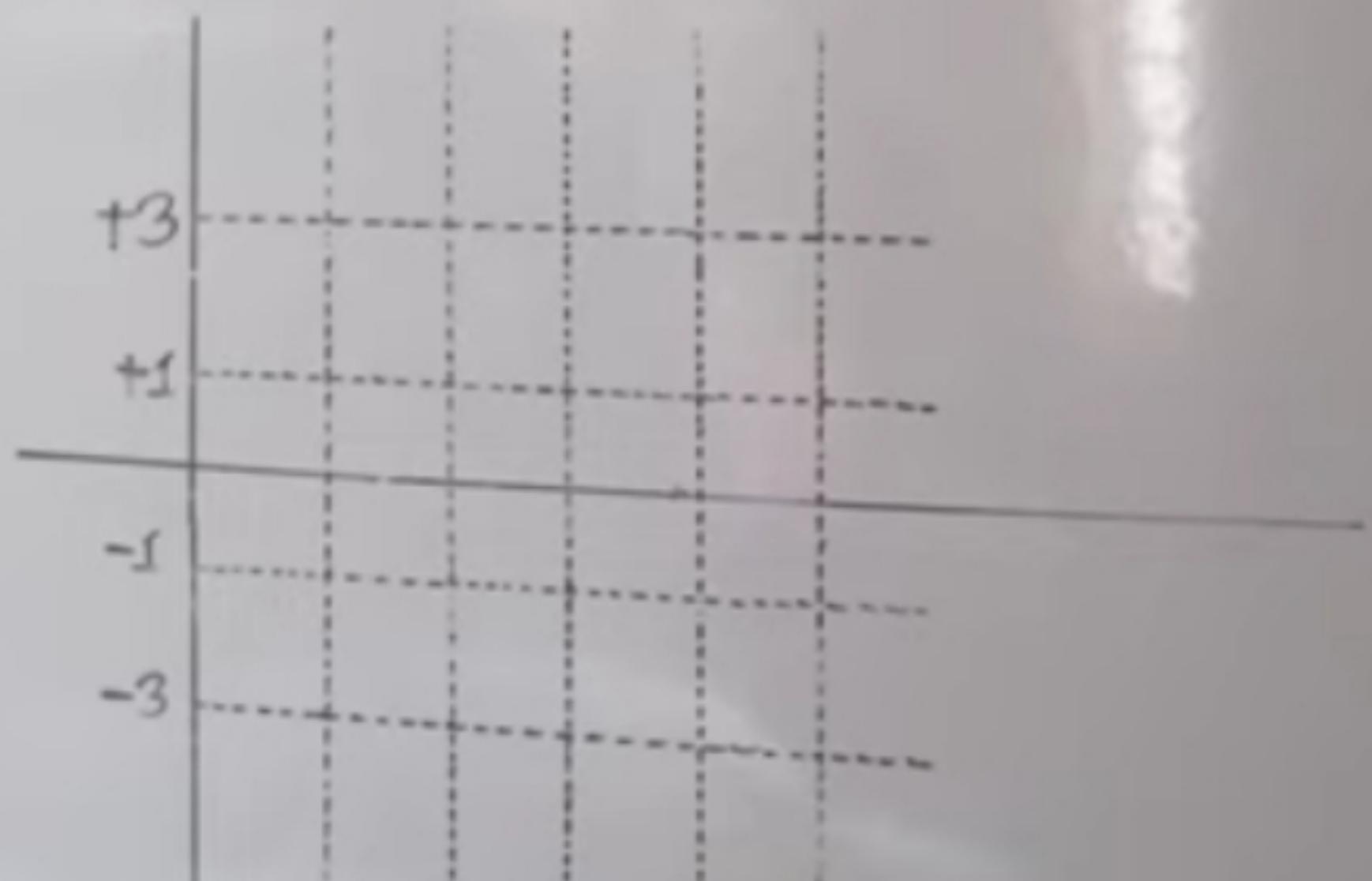
$m B$ $n L$ length of the signal pattern

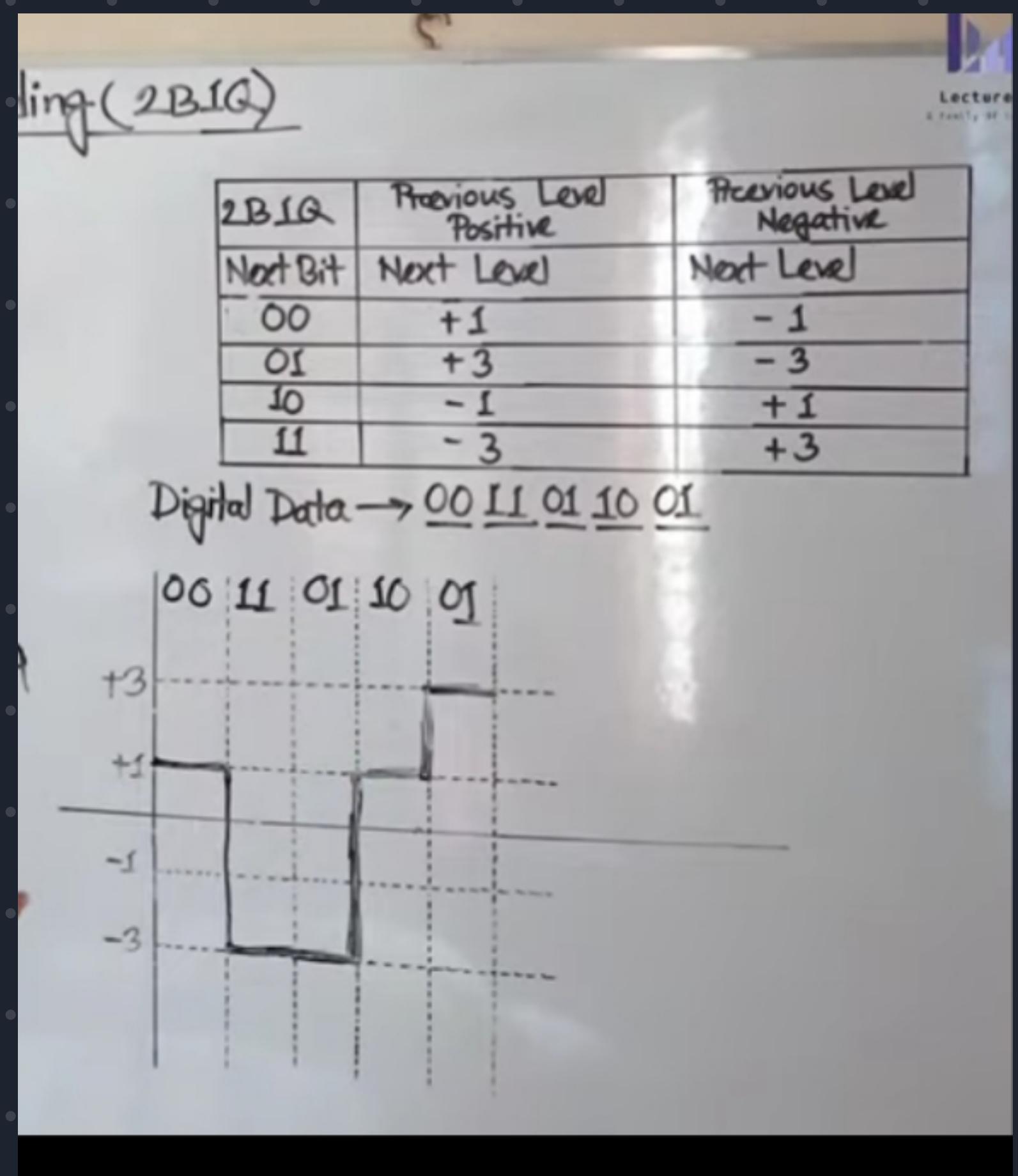
$$\begin{aligned} \text{no. of data pattern} &= 2^m \\ &= 2^L \\ &= 4 \end{aligned}$$

Number of levels in signaling
 B (binary), $L=2$
 T (ternary), $L=3$
 Q (quaternary), $L=4$

2B1Q	Previous Level Positive	Previous Level Negative
Next Bit	Next Level	Next Level
00	+1	-1
01	+3	-3
10	-1	+1
11	-3	+3

Digital Data → 00 11 01 10 01





1. What is Nyquist theorem?

Ans: The Nyquist theorem states that can be fully reconstructed if it is sampled at a rate at twice its highest frequency

(Nyquist rate: $f_s \geq 2f_{\text{max}}$). This prevents aliasing and ensures accurate signal reproduction in digital systems.

2. What is bit stuffing and byte stuffing? Explain with example.

1. Bit Stuffing

Definition:

Bit stuffing is a process where extra bits are inserted into the data to prevent accidental detection of control sequences (e.g., frame delimiters).

Bit Stuffing vs. Byte Stuffing

Bit Stuffing

- Extra **bits** (0s) are inserted after every **five consecutive 1s** in data to prevent confusion with control signals.
- Used in **bit-oriented protocols** (e.g., HDLC).

Example:

Original: 011111010111110111

After bit stuffing: 0111110101111100111 (0 added after five 1s)

Byte Stuffing

- Extra **bytes** (like escape characters) are added before special control characters to differentiate them from actual data.
- Used in **byte-oriented protocols** (e.g., PPP).

Example:

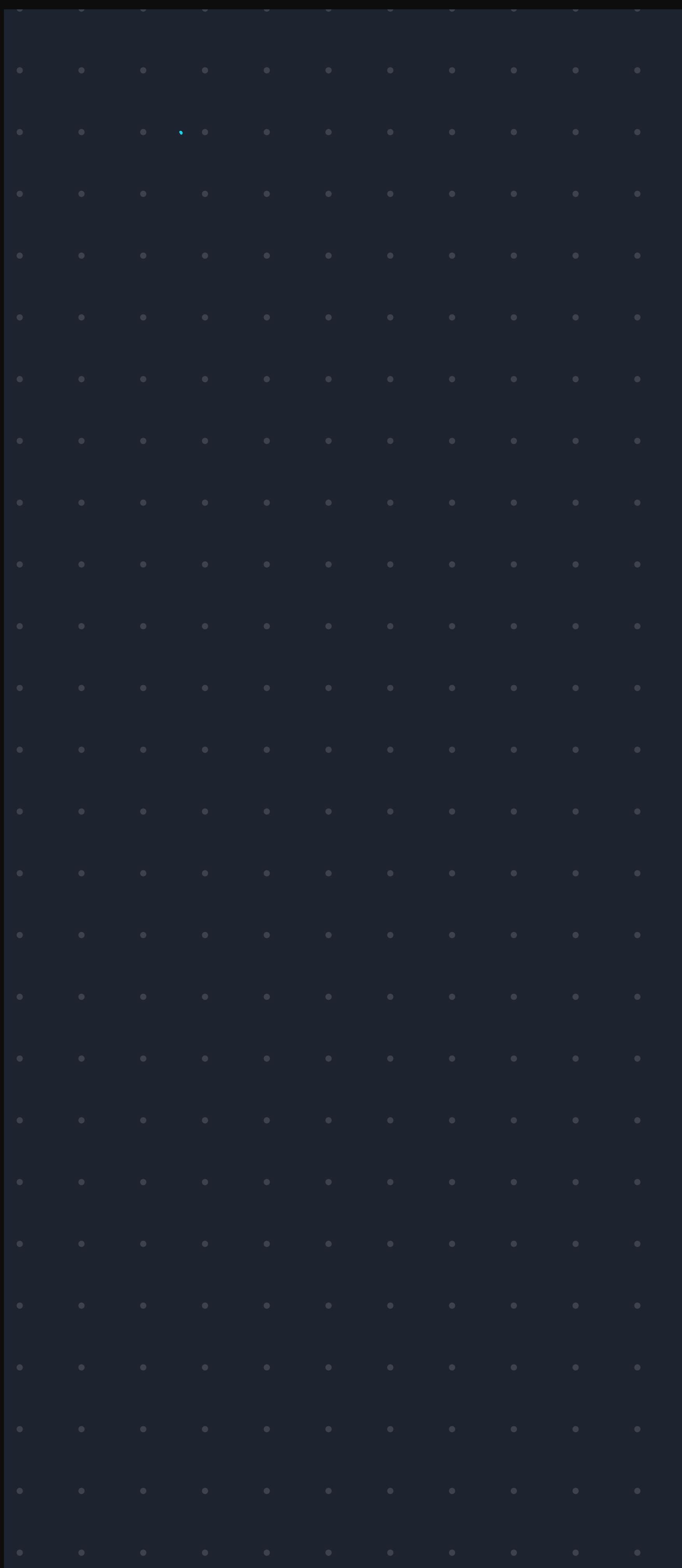
Original: DATA FLAG MOREDATA

After byte stuffing: DATA ESC FLAG MOREDATA (ESC added before FLAG)

2. Byte Stuffing

Definition:

Byte stuffing is used in character-oriented protocols where special characters (like frame delimiters) in the data are **preceded by an escape character** to distinguish them from actual control characters.



3 In how many ways error can be controlled in a noisy channel? Explain one of them with a suitable example.

Ans

4. what's the difference between circuit switching and Diagram network.

It seems like you meant **Circuit Switching Network** and **Packet Switching Network (Diagram Network)**. Here's the difference:

Feature	Circuit Switching Network	Packet Switching Network
Connection Type	Dedicated physical path established before communication.	Data is divided into packets and sent independently.
Example	Traditional telephone networks.	Internet, VoIP, emails.
Resource Allocation	Fixed bandwidth reserved for the entire session.	No fixed path; packets take different routes.
Efficiency	Less efficient (even if no data is sent, resources stay reserved).	More efficient (bandwidth shared dynamically).
Delay	Lower delay once the circuit is established.	Higher initial delay due to packet routing.
Reliability	More reliable (fixed path ensures steady quality).	Less reliable (packets may arrive out of order).

Example of Circuit Switching:

1. A phone call is made.
2. A dedicated line is established.
3. The call continues using that line until the session ends.

Example of Packet Switching:

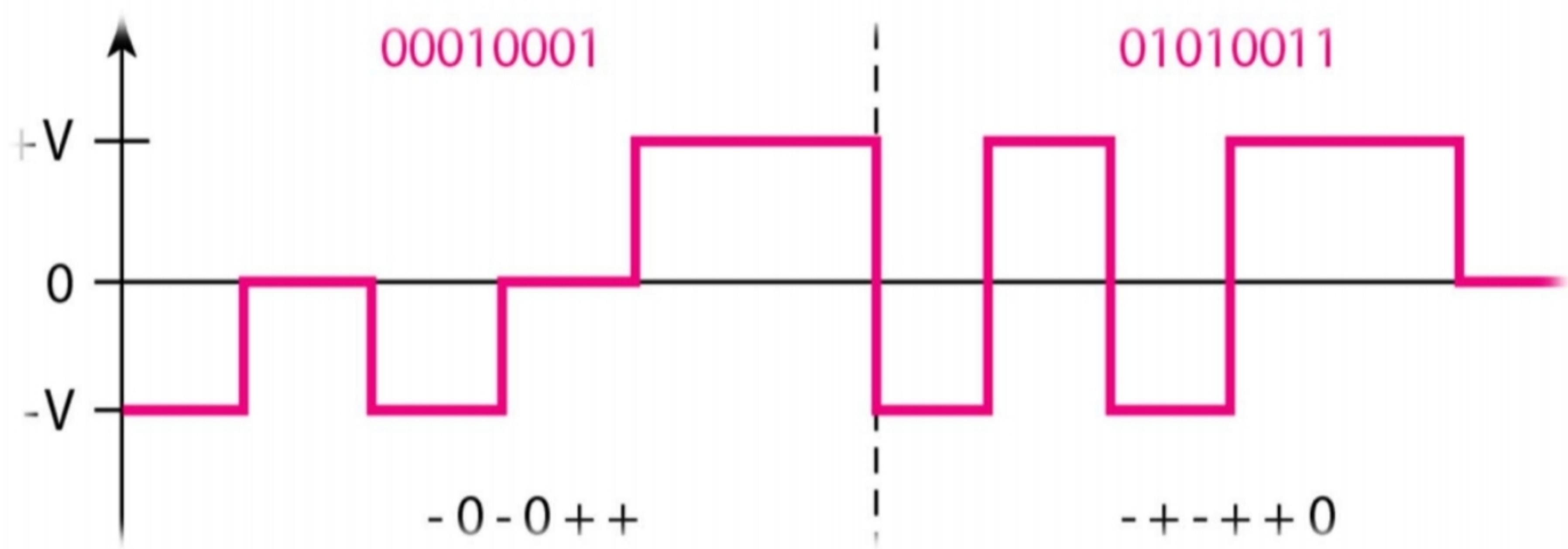
1. An email is sent.
2. It is broken into packets.
3. Each packet takes different routes and reassembles at the destination.

5.

MULTILEVEL 8B6T SCHEME

- Used in 100Base-4T cable.
- Encode 8 bits as a pattern of 6 signals, where the signal has three levels (ternary).
- $2^8 = 256$ different data pattern.
- $3^6 = 478$ different signal pattern.
- $478 - 256 = 222$ redundant signal elements to provide
 - Synchronization
 - Error detection.
 - DC balance.

MULTILEVEL 8B6T SCHEME



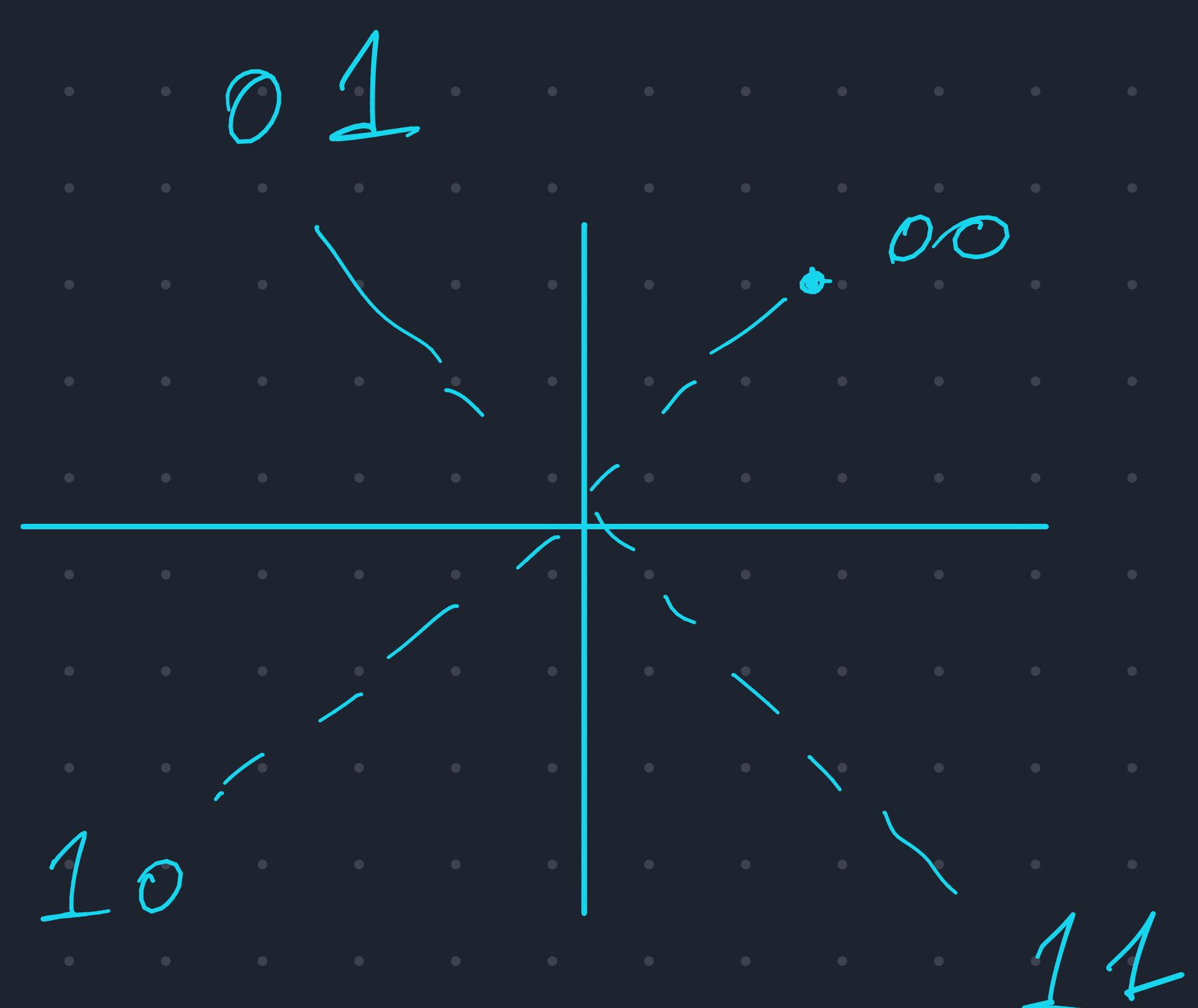
6. QAM

• QAM is combined of ASK and PSK

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- The minimum bandwidth requirement for QAM is same as that for ASK and PSK

4-QAM



1 amplitude 4-QAM

- I (In-Phase): The amplitude of first carrier wave
- Q (Quadrature): The amplitude of second carrier wave

In 4-QAM, there are 4 unique combination

1. Symbol 1: $I = +1, Q = +1$

(a) What is composite signal? How can we decompose it into its components? Explain it briefly.

(b) What are the main causes of transmission impairments? Explain it briefly.

(c) What is the way to measure attenuation?
The loss in a cable is usually defined in decibels per kilometer (dB/km). If the signal at the beginning of a cable with -0.3 dB/km has a power of 2 mW, what is the power of the signal at 10 km?

(d) What is SNR? If the peak voltage value of a signal is 20 times the peak voltage value of the noise, what is the SNR? What is the SNR_{dB} ?

Composite Signal:

A composite signal is a complex waveform formed by combining multiple simpler signals, such as different frequency components or modulated signals, into a single transmission. This combination allows for efficient use of the transmission medium and can carry more information simultaneously.

Decomposing a Composite Signal:

To analyze or process the individual components of a composite signal, various signal decomposition techniques are employed:

1. Fourier Transform: This method transforms the composite signal from the time domain to the frequency domain, enabling the identification of its frequency components.
2. Wavelet Transform: This technique analyzes the signal at different scales, providing both time and frequency information, which is useful for non-stationary signals.
3. Empirical Mode Decomposition (EMD): EMD decomposes a signal into intrinsic mode functions, each representing simple oscillatory modes, effectively handling non-linear and non-stationary signals.
4. Independent Component Analysis (ICA): ICA separates a multivariate signal into additive, independent components, often used in blind source separation problems.

Causes of Transmission Impairments:

Transmission impairments are factors that degrade the quality of a signal as it travels through a transmission medium. The main causes include:

1. Attenuation: The gradual loss of signal strength over distance due to the resistance and imperfections in the transmission medium.
2. Noise: Unwanted random signals that interfere with the desired signal, originating from various sources like thermal fluctuations, electromagnetic interference, or crosstalk between channels.
3. Distortion: Alterations in the signal waveform caused by non-linearities in the transmission medium, leading to changes in the signal's amplitude, frequency, or phase.

Understanding these causes is crucial for designing robust communication systems that can mitigate these impairments effectively.

How does an analog signal convert into digital signal? Briefly explain all the steps associated with it.

Converting an analog signal into a digital signal involves two primary steps: **sampling** and **quantization**. Here's a brief overview of each step:

1. **Sampling:** This process involves measuring the amplitude of the continuous analog signal at regular intervals, known as the sampling rate. According to the Nyquist-Shannon sampling theorem, to accurately reconstruct the original signal, the sampling rate must be at least twice the highest frequency present in the analog signal. (en.wikipedia.org)
2. **Quantization:** After sampling, each measured amplitude is approximated to the nearest value within a finite set of discrete levels. This step introduces quantization error, which is the difference between the actual analog value and its quantized digital representation. (en.wikipedia.org)

These steps are typically performed by an **Analog-to-Digital Converter (ADC)**, which processes the analog signal to produce a corresponding digital signal. (en.wikipedia.org)



c) Briefly explain different types of analog-to-analog conversion techniques including [04] advantages, disadvantages and real application scenarios.

Analog-to-analog conversion involves modifying an analog signal to encode information, enabling its transmission over various media. The primary techniques include:

1. Amplitude Modulation (AM):

In AM, the amplitude of a carrier signal is varied in proportion to the instantaneous amplitude of the message signal.

- **Advantages:**

- Simple to implement and cost-effective.
- Efficient use of bandwidth.

- **Disadvantages:**

- Susceptible to noise interference, leading to signal degradation.
- Inefficient use of power, as the carrier consumes significant power even without information.

- **Applications:**

- AM radio broadcasting.
- Aircraft communication systems.

2. Frequency Modulation (FM):

FM involves varying the frequency of the carrier signal in accordance with the message signal's amplitude.

- **Advantages:**

- Improved noise immunity compared to AM.
- Better sound quality in audio applications.

- **Disadvantages:**

- More complex circuitry and higher power consumption.
- Requires a wider bandwidth, leading to less efficient use of the frequency spectrum.

- **Applications:**

- FM radio broadcasting.
- Television sound transmission.

3. Phase Modulation (PM):

PM entails varying the phase of the carrier signal in response to the message signal's amplitude.

- **Advantages:**

- Offers noise resistance similar to FM.
- Efficient use of bandwidth compared to FM.

- **Disadvantages:**

- More complex to implement than AM.
- Phase ambiguity can complicate demodulation.

- **Applications:**

- Satellite communication systems.
- Digital communication systems using phase-shift keying.

Analog to Digital

Step of Quantization

Steps of Quantization

- Step 1: Assuming that the original analog signal has instantaneous amplitudes between V_{min} and V_{max} , the range (between V_{min} and V_{max}) is divided into L zones, each of height Δ (delta)

$$\Delta = \frac{V_{max} - V_{min}}{L}$$

- Step 2: The midpoint of each zone is assigned a value from 0 to L-1 (resulting in L values)
- Step 3: Each sample falling in a zone is then approximated to the value of the midpoint.

Normalized PAM value = $\frac{\text{actual amplitude}}{\Delta}$

Quantize value = $\frac{\text{Quantization value}}{\Delta}$

Normalized error = Normalized quantize value
- PAM value