UNIT I

DIGITAL TRANSMISSION

- Data or information can be stored in two ways, analog and digital.
- For a computer to use the data, it must be in discrete digital form.
- Similar to data, signals can also be in analog and digital form. To transmit data digitally, it needs to be first converted to digital form.
- Data can be represented either in analog or digital form.
- The computers used the digital form to store the information.
- Therefore, the data needs to be converted in digital form so that it can be used by a computer.

Encoding and Modulation

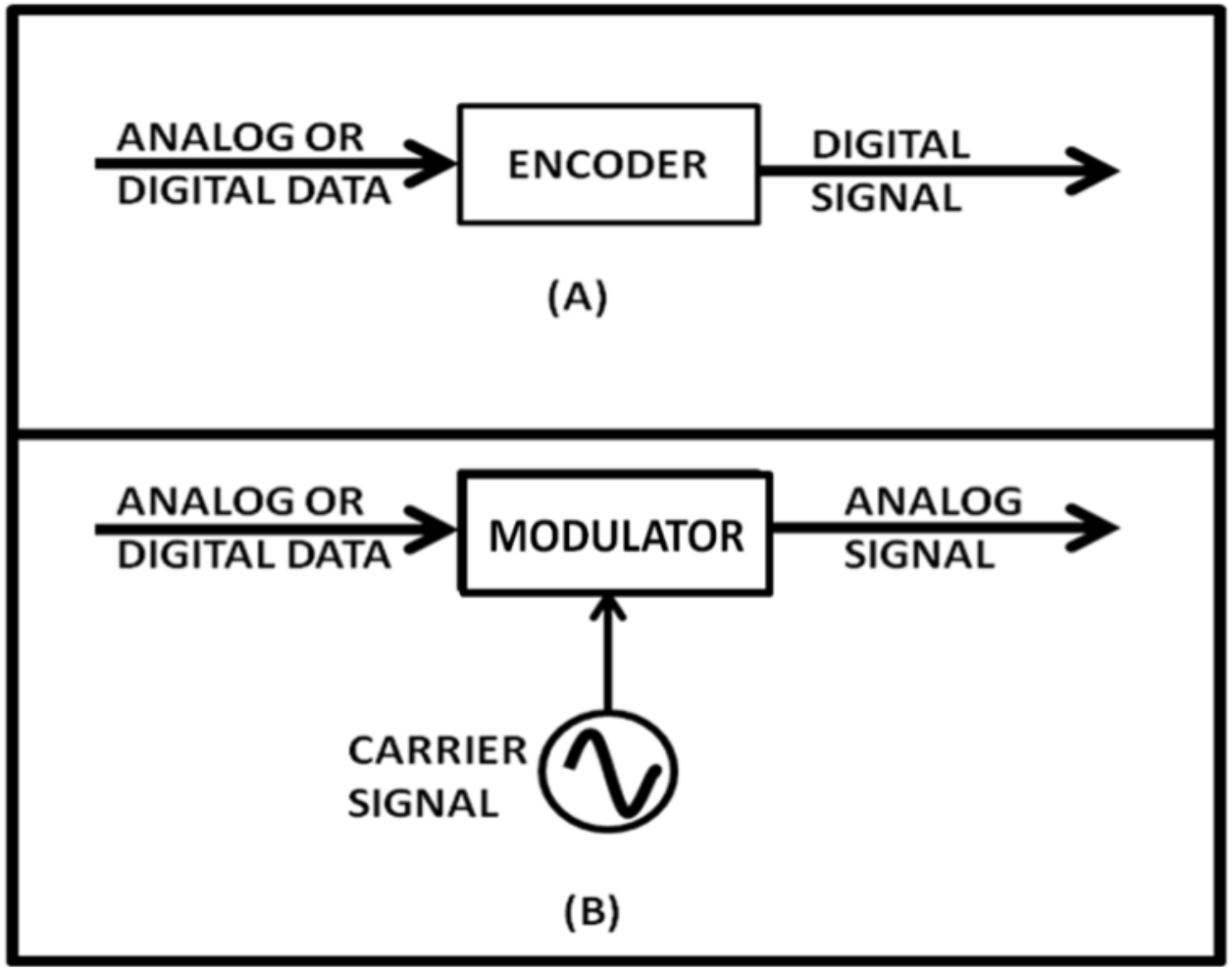

Figure: Signal Encoding

Encoding

- **Encoding** is the process of converting the data or a given sequence of characters, symbols, alphabets etc., into a specified format, for the secured transmission of data.

- **Decoding** is the reverse process of encoding which is to extract the information from the converted format.

Data Encoding

- Encoding is the process of using various patterns of voltage or current levels to represent **1s** and **0s** of the digital signals on the transmission link.

- The common types of line encoding are Unipolar, Polar, Bipolar, and Manchester.

Digital Modulation

- Digital-to-Analog signals is the next conversion we will discuss in this chapter. These techniques are also called as **Digital Modulation techniques**.

- **Digital Modulation** provides more information capacity, high data security, quicker system availability with great quality communication.

- Hence, digital modulation techniques have a greater demand, for their capacity to convey larger amounts of data than analog modulation techniques.

- There are many types of digital modulation techniques and also their combinations, depending upon the need.

- Types of digital modulation techniques: **ASK, FSK, PSK**

Line Coding

- A **line code** is the code used for data transmission of a digital signal over a transmission line. This process of coding is chosen so as to avoid overlap and distortion of signal such as inter-symbol interference.

Following are the properties of line coding −

- As the coding is done to make more bits transmit on a single signal, the bandwidth used is much reduced.
- For a given bandwidth, the power is efficiently used.
- The probability of error is much reduced.
- Error detection is done and the bipolar too has a correction capability.
- Power density is much favorable.
- The timing content is adequate.
- Long strings of **1s** and **0s** is avoided to maintain transparency.

Types of Line Coding

There are 3 types of Line Coding

- Unipolar
- Polar
- Bi-polar

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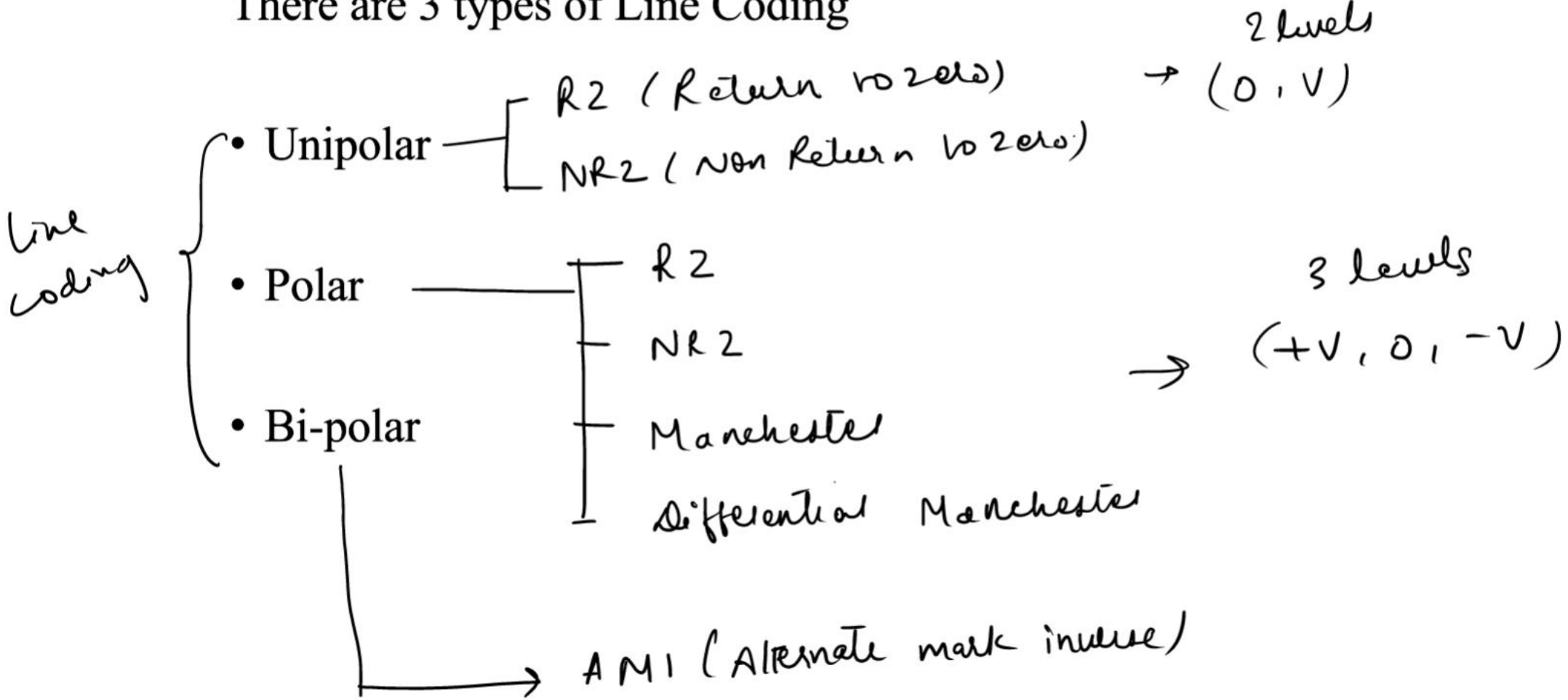


Unipolar Signaling

Unipolar signaling is also called as **On-Off Keying** or simply.

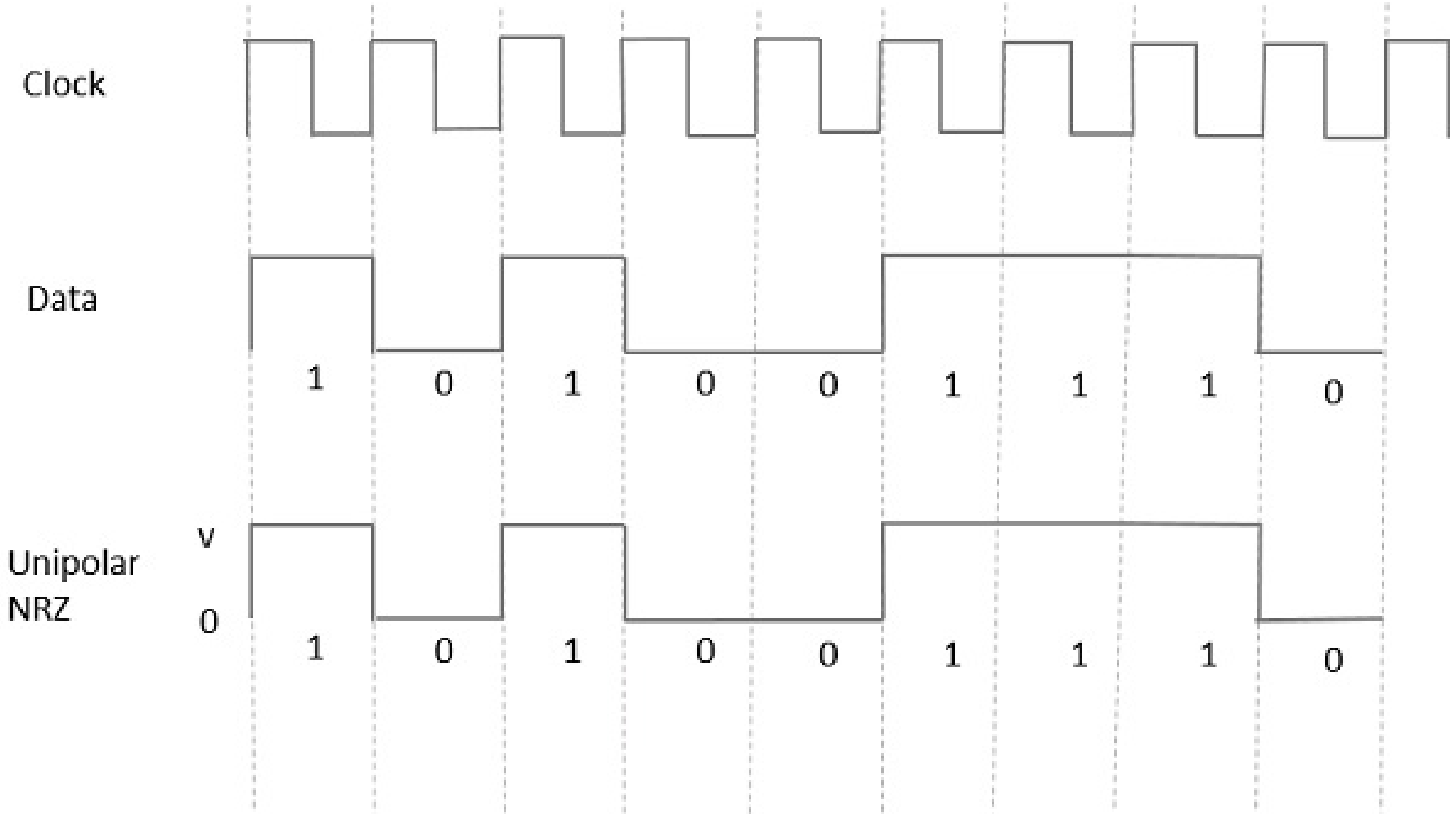
The presence of pulse represents a **1** and the absence of pulse represents a **0**.

There are two variations in Unipolar signaling −

- Non Return to Zero NRZNRZ
- Return to Zero RZRZ

Unipolar Non-Return to Zero NRZ

- In this type of unipolar signaling, a High in data is represented by a positive pulse called as **Mark**, which has a duration $\mathbf{T_0}$ equal to the symbol bit duration.
- A Low in data input has no pulse.


Clock
Data
1
0
1
0
0
1
1
1
0
Unipolar
NRZ
V
0
1
0
1
0
0
1
1
1
0

Advantages

The advantages of Unipolar NRZ are −

- It is simple.
- A lesser bandwidth is required.

Disadvantages

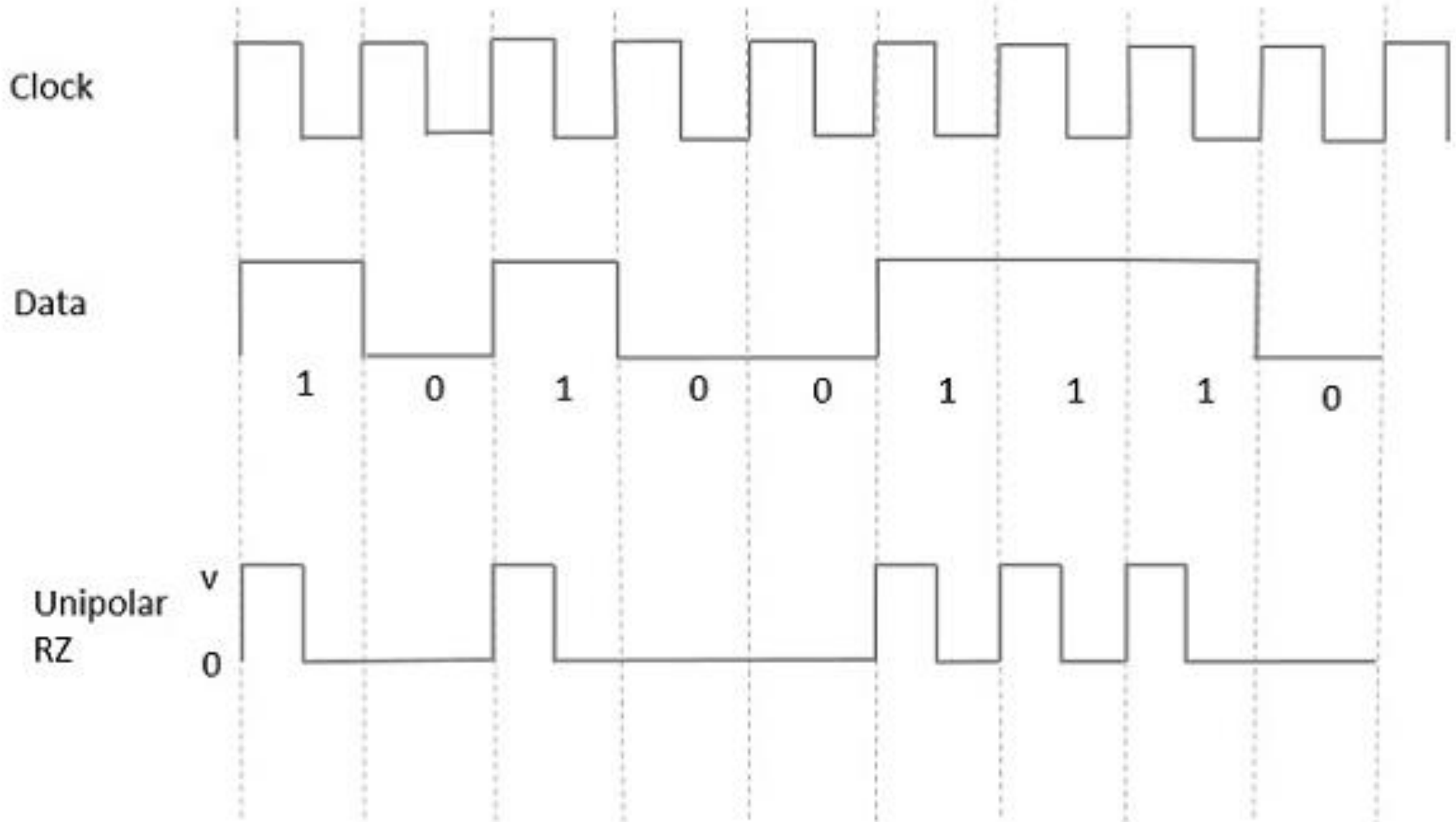
The disadvantages of Unipolar NRZ are −

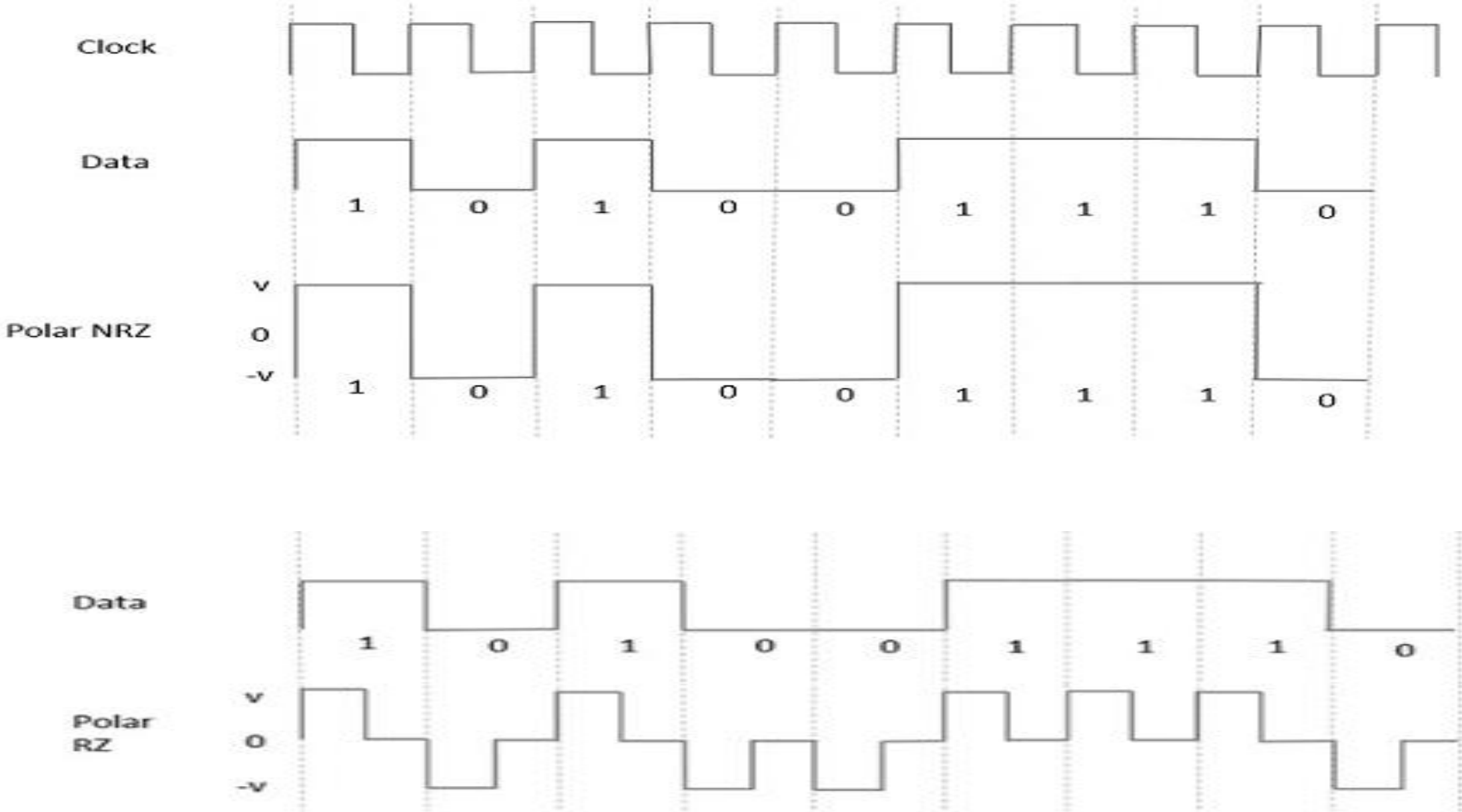
- No error correction done.
- Presence of low frequency components may cause the signal droop.
- No clock is present.
- Loss of synchronization is likely to occur (especially for long strings of **1s** and **0s**).

Unipolar Return to Zero RZ

- In this type of unipolar signaling, a High in data, though represented by a **Mark pulse**, its duration $\mathbf{T_0}$ is less than the symbol bit duration.
- Half of the bit duration remains high but it immediately returns to zero and shows the absence of pulse during the remaining half of the bit duration.

- **Advantages**
- The advantages of Unipolar RZ are −
- It is simple.
- The spectral line present at the symbol rate can be used as a clock.
- **Disadvantages**
- The disadvantages of Unipolar RZ are −
- No error correction.
- Occupies twice the bandwidth as unipolar NRZ.
- The signal droop is caused at the places where signal is non-zero at 0 Hz.


Clock
Data
1
0
1
0
0
1
1
1
0
Unipolar
RZ
v
0

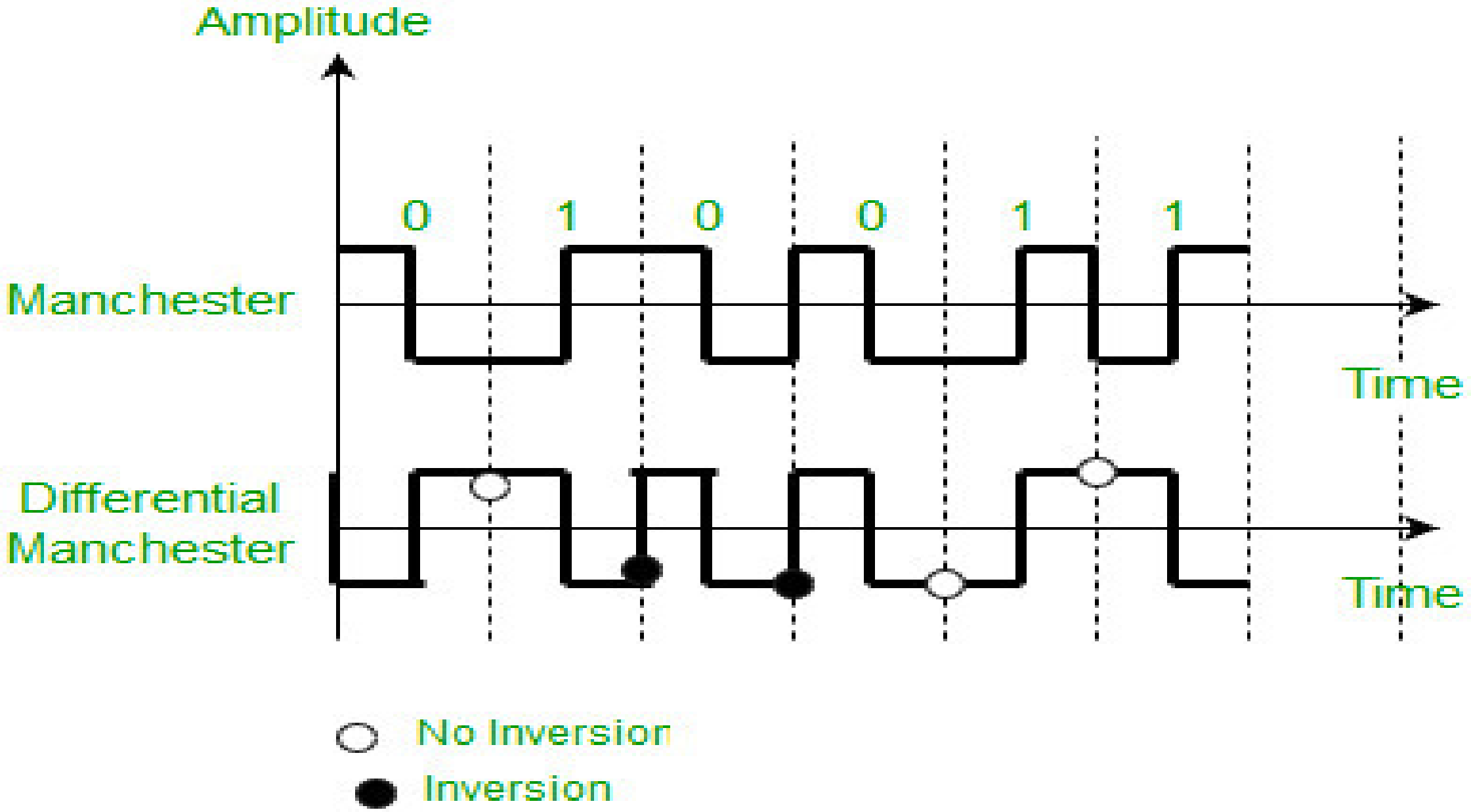

Clock
Data
1 0 1 0 0 1 1 1 0
Polar NRZ
v
0
-v
1 0 1 0 0 1 1 1 0
Data
1 0 1 0 0 1 1 1 0
Polar RZ
v
0
-v

Biphase (Manchester and Differential Manchester)

- Manchester encoding is somewhat combination of the RZ (transition at the middle of the bit) and NRZ- schemes.

- The duration of the bit is divided into two halves. The voltage remains at one level during the first half and moves to the other level in the second half. The transition at the middle of the bit provides synchronization.

- There is always a transition at the middle of the bit but the bit values are determined at the beginning of the bit. If the next bit is 0, there is a transition, if the next bit is 1, there is no transition.


Amplitude
0
1
0
0
1
1
Manchester
Time
Differential
Manchester
Time
No Inversion
Inversion

Bipolar Signaling

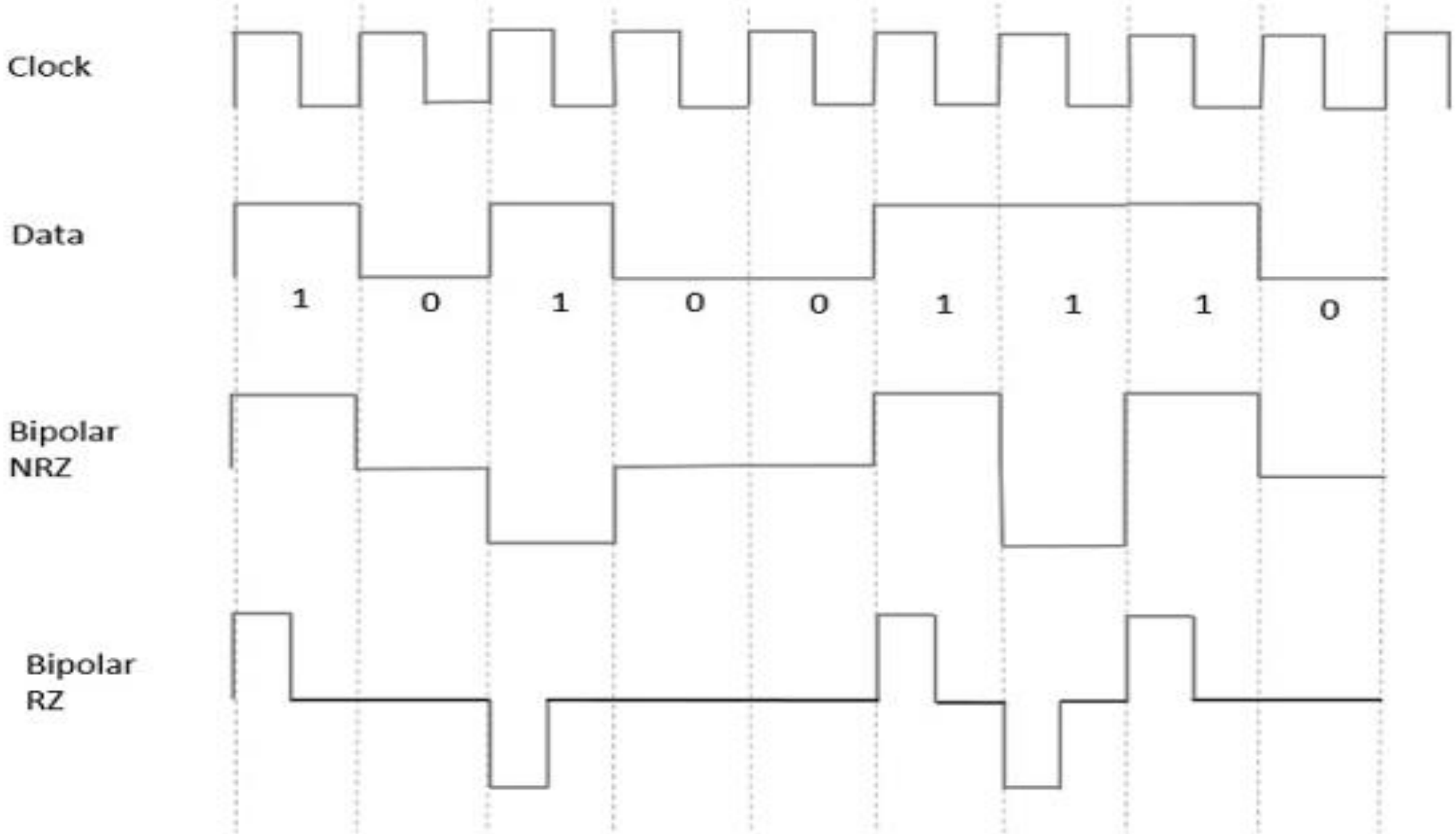
- This is an encoding technique which has three voltage levels namely **+, -** and **0**. Such a signal is called as **duo-binary signal**.

- An example of this type is **Alternate Mark Inversion** AMI**.**

- For a 1, the voltage level gets a transition from + to – or from – to +, having alternate 1s to be of equal polarity. A 0 will have a zero voltage level.

Even in this method, we have two types.

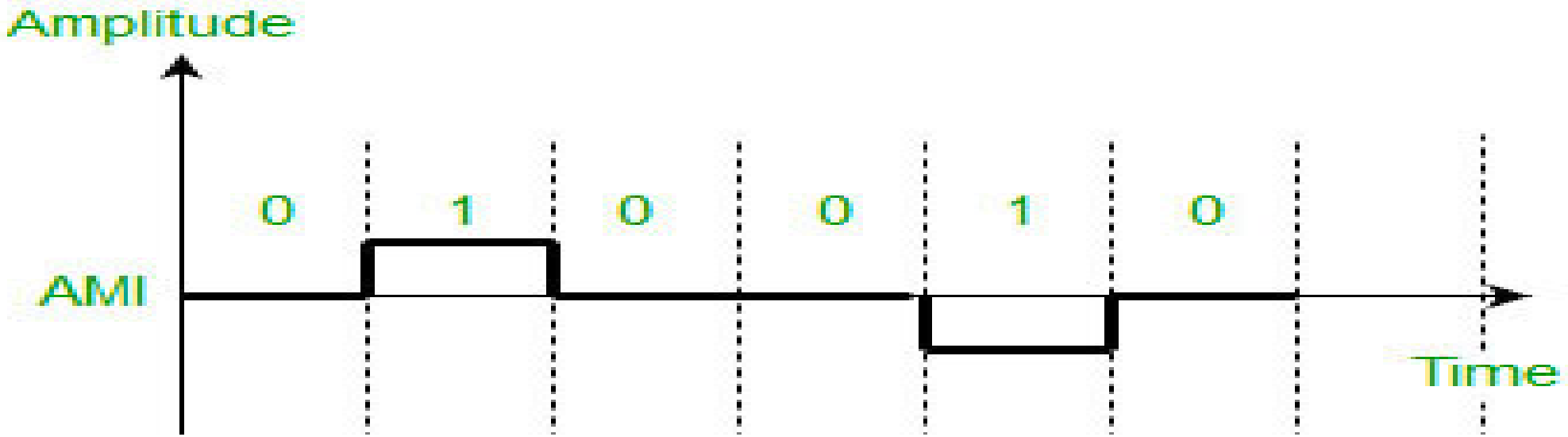
- Bipolar NRZ
- Bipolar RZ

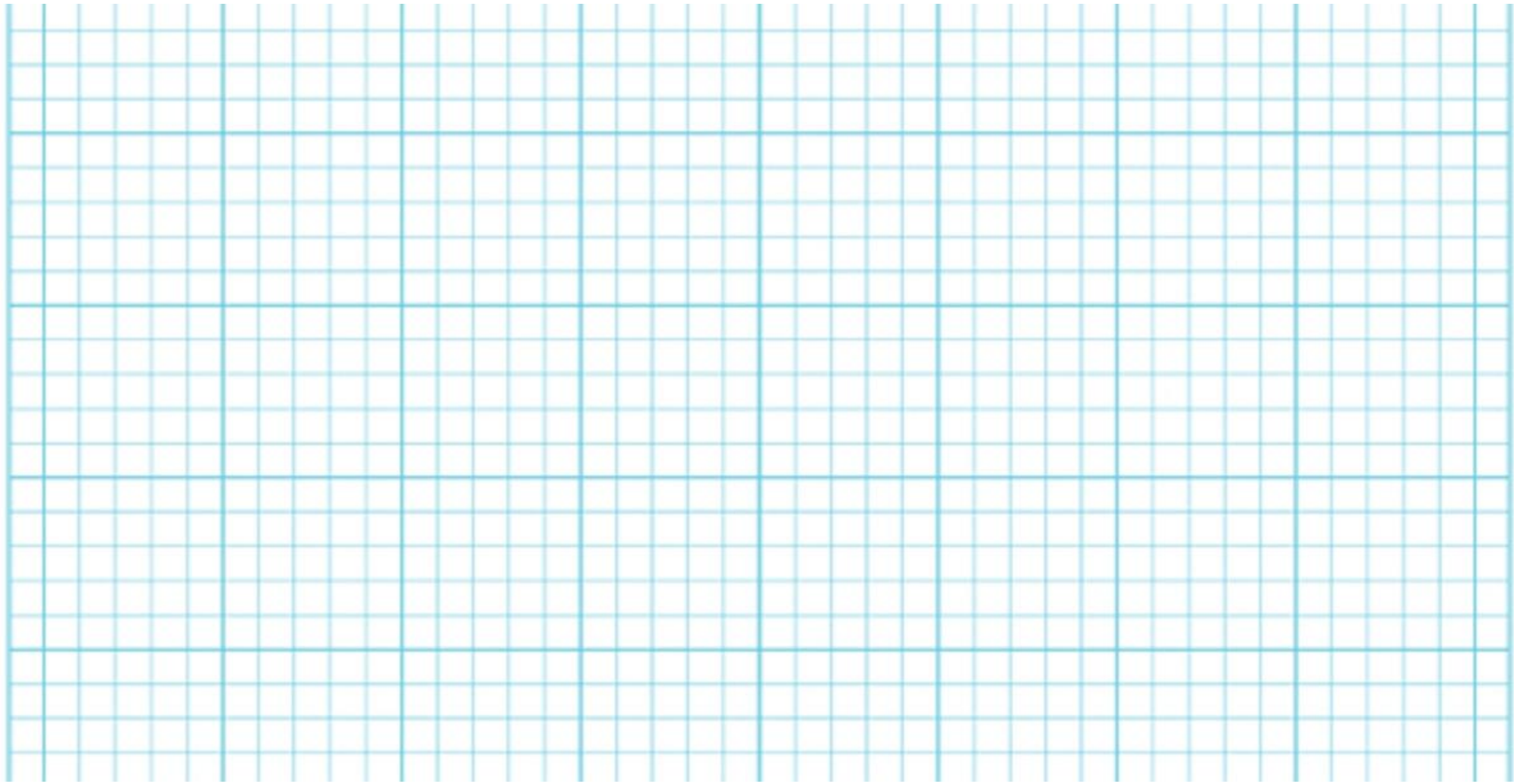

Clock
Data
1
0
1
0
0
1
1
1
0
Bipolar
NRZ
Bipolar
RZ

Bipolar schemes –

- In this scheme there are three voltage levels positive, negative, and zero. The voltage level for one data element is at zero, while the voltage level for the other element alternates between positive and negative.

- Alternate Mark Inversion (AMI) – A neutral zero voltage represents binary 0. Binary 1's are represented by alternating positive and negative voltages.





Block Coding

- To ensure accuracy of the received data frame redundant bits are used. For example, in even-parity, one parity bit is added to make the count of 1s in the frame even. This way the original number of bits is increased. It is called Block Coding.

- Block coding is represented by slash notation, mB/nB. Means, m-bit block is substituted with n-bit block where n > m. Block coding involves three steps:

- Division,
- Substitution
- Combination.

- After block coding is done, it is line coded for transmission.

- It normally involves three steps: division, substitution, and combination.
- In the division step, a sequence of bits is divided into groups of m-bits.
- In the substitution step, we substitute an m-bit group for an n-bit group.
- Finally, the n-bit groups are combined together to form a stream which has more bits than the original bits.

Block coding

Block code → Set of words
↳ fixed no. of bits

0101 → 01011
codeword.

"Info" bit → k
Parity bits → r

$n = k + r$
n: actual bit
r: Parity bit.
k: codeword bits

$n = k + r$ bits

k ("Info" bit	r (Parity bits)

for (n, k) block code

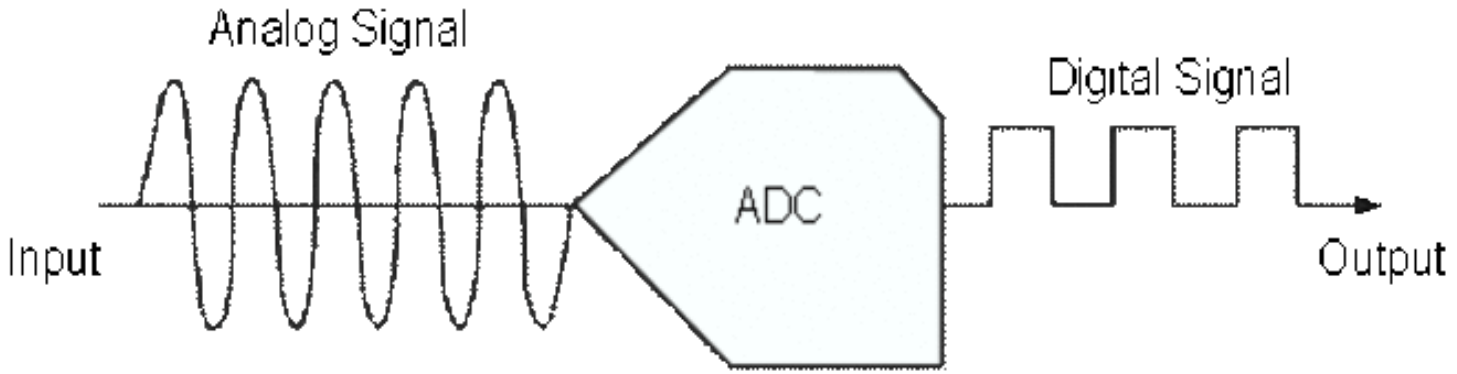
i) 2^k codewords have req. structure
ii) $2^n - 2^k$ redundant words.
iii) code rate. $R = \frac{k}{n}$ $0 \le R \le 1$

(4, 3) Even parity
n k block code

n = 4
k = 3
r = n − k = 1

Analog to Digital Conversion

- Analog-to-Digital converters (ADC) translate analog signals, real world signals like temperature, pressure, voltage, current, distance, or light intensity, into a digital representation of that signal. This digital representation can then be processed, manipulated, computed, transmitted or stored.



PULSE CODE MODULATION

- The most common technique to change an analog signal to digital data is called pulse code modulation (PCM).

- A PCM encoder has the following three processes:

✓Sampling

✓Quantization

✓Encoding

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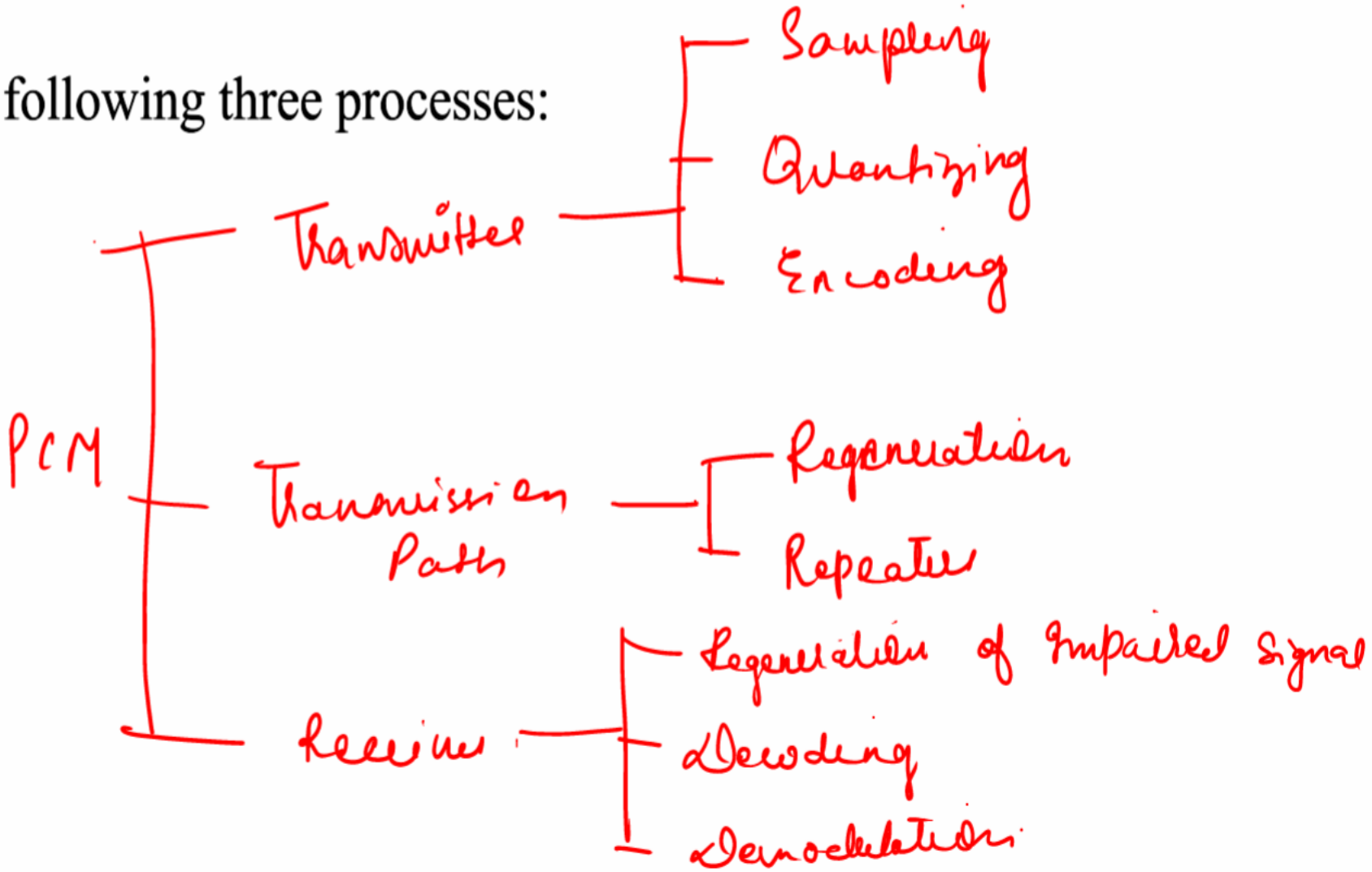


- Low pass filter :

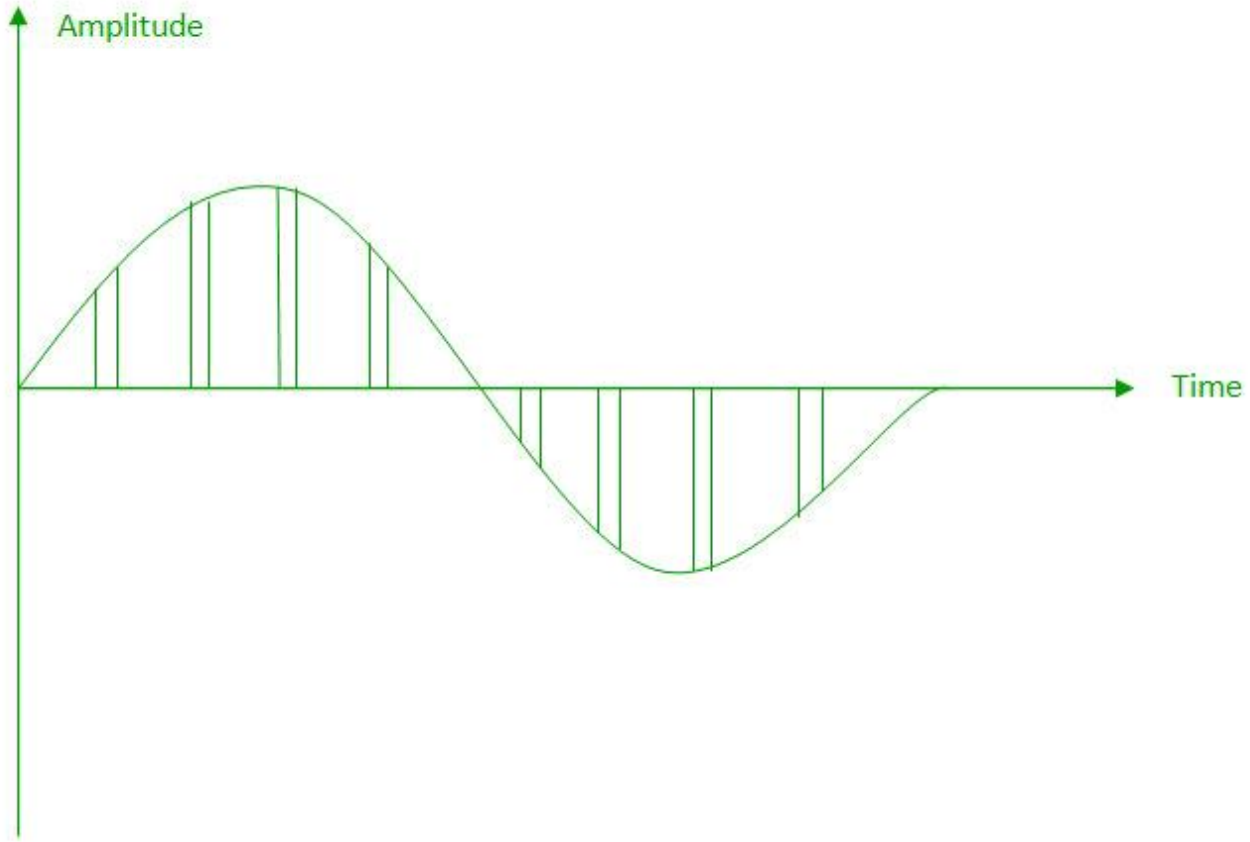
The low pass filter eliminates the high frequency components present in the input analog signal to ensure that the input signal to sampler is free from the unwanted frequency components. This is done to avoid aliasing of the message signal.

1. **Sampling –** The first step in PCM is sampling. Sampling is a process of measuring the amplitude of a continuous-time signal at discrete instants, converting the continuous signal into a discrete signal. There are three sampling methods:

- **Ideal Sampling:** In ideal Sampling also known as Instantaneous sampling pulses from the analog signal are sampled. This is an ideal sampling method and cannot be easily implemented.

➢Natural Sampling:

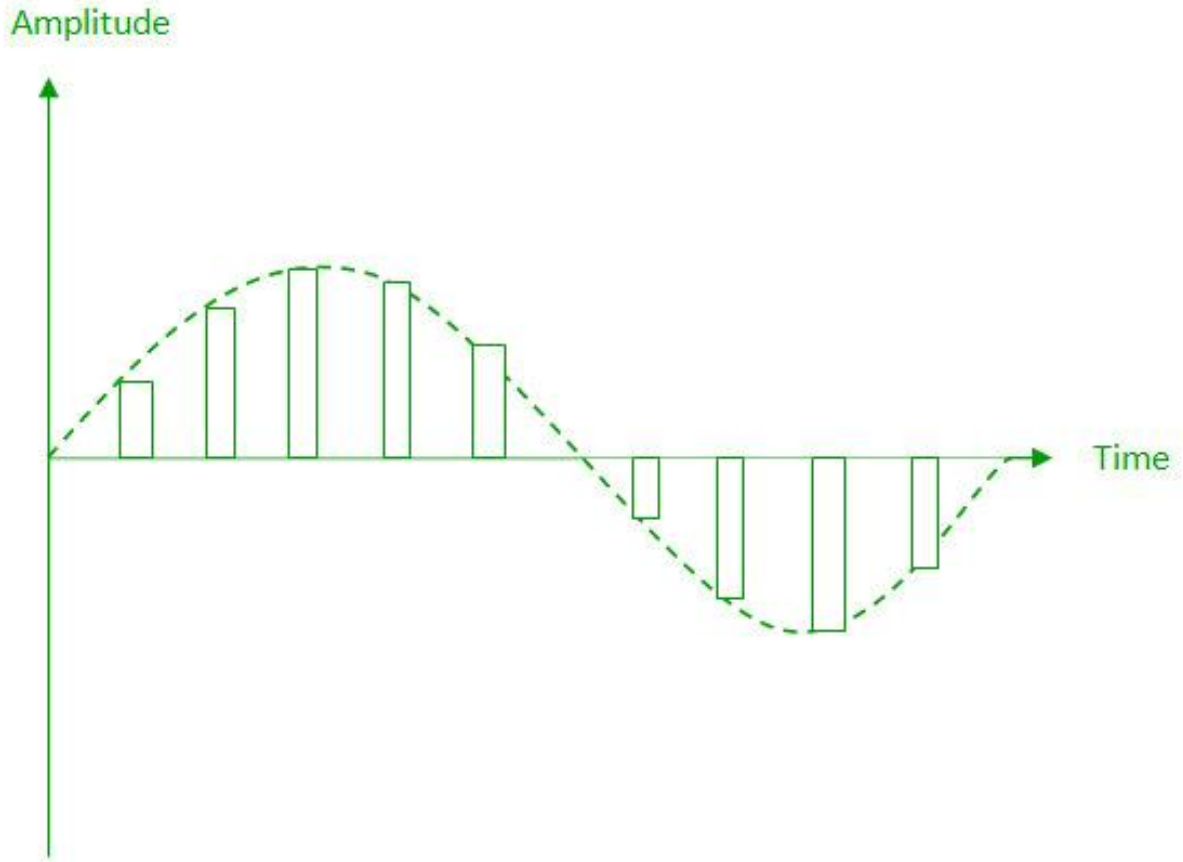
- Natural Sampling is a practical method of sampling in which pulse have finite width equal to T. The result is a sequence of samples that retain the shape of the analog signal.



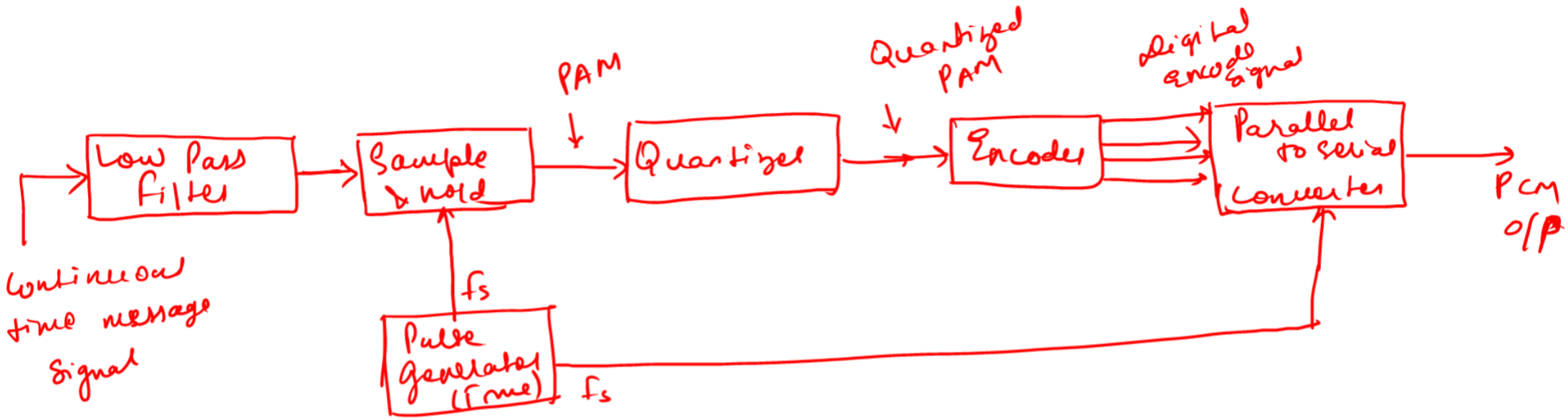
➢Flat top sampling:

- In comparison to natural sampling flat top sampling can be easily obtained.

- In this sampling technique, the top of the samples remains constant by using a circuit. This is the most common sampling method used.

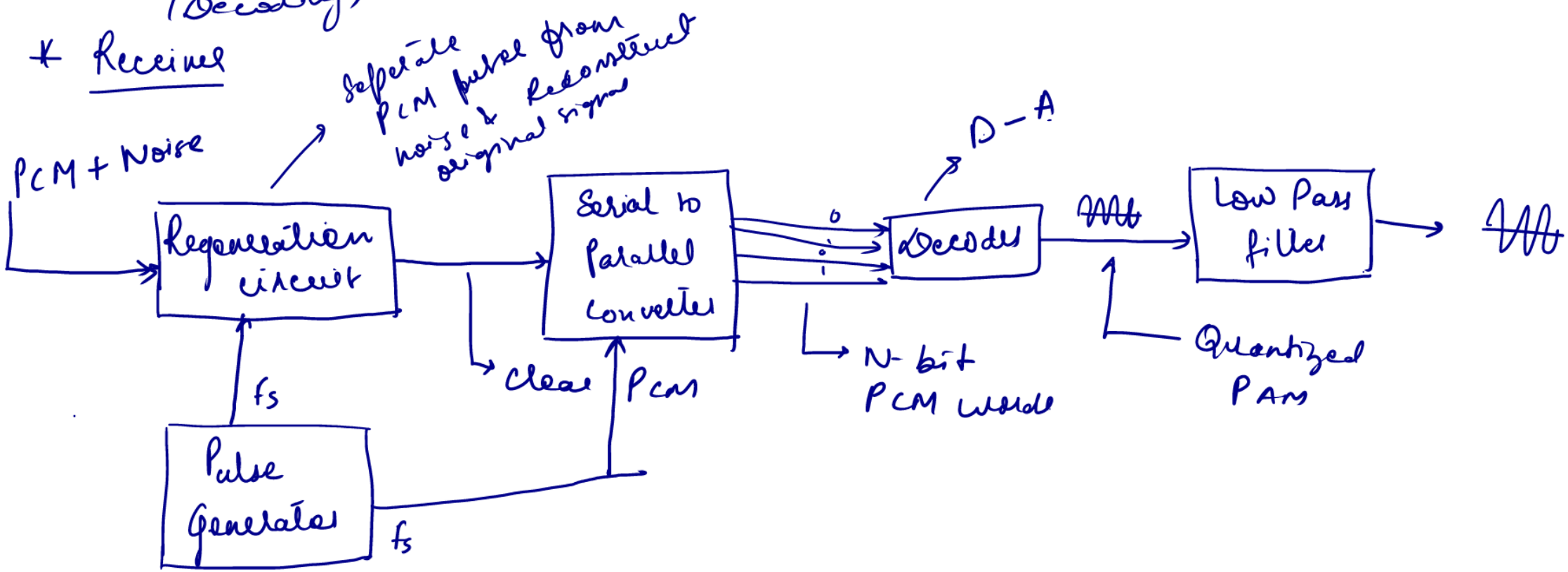


PCM (Transmitter) (encoder)



(Decoding)

* Receiver



Transmission Modes

- The transmission mode decides how data is transmitted between two computers.The binary data in the form of 1s and 0s can be sent in two different modes: Parallel and Serial.

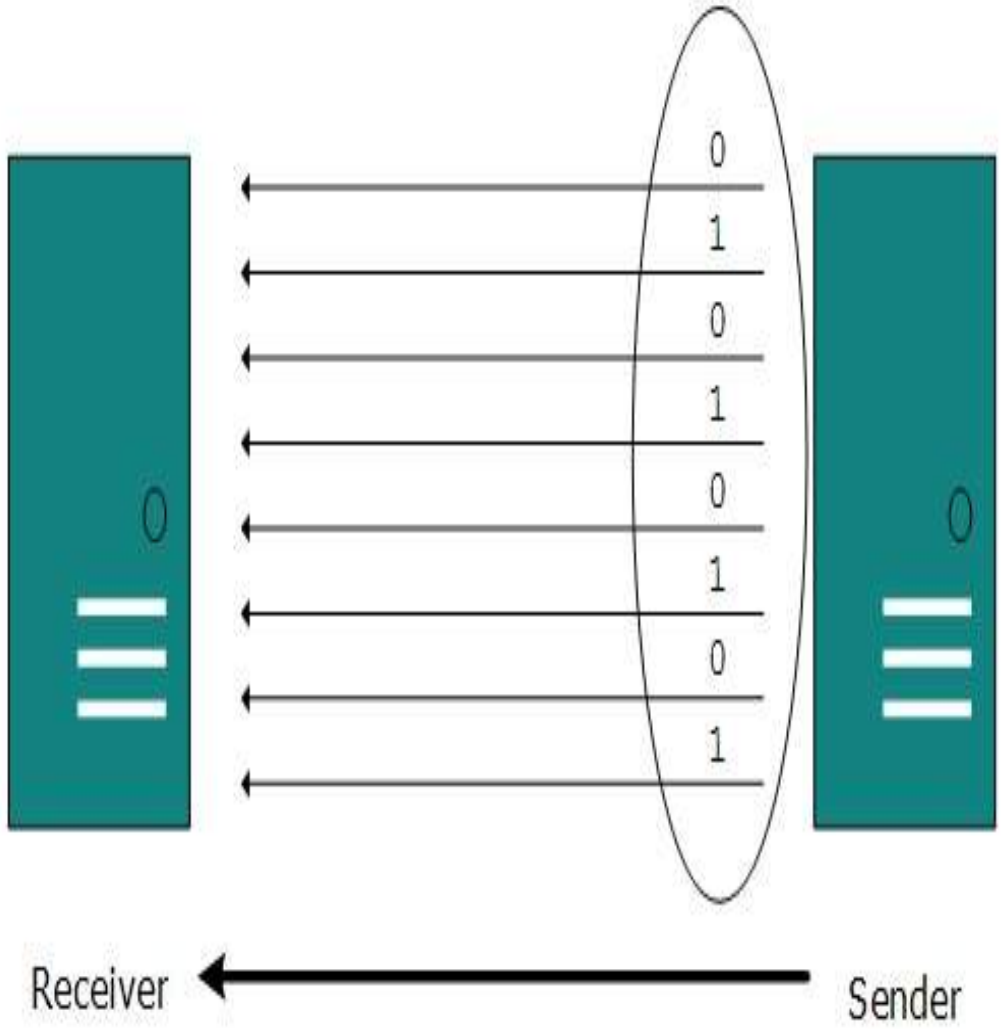
Parallel Transmission

- The binary bits are organized in-to groups of fixed length. Both sender and receiver are connected in parallel with the equal number of data lines.

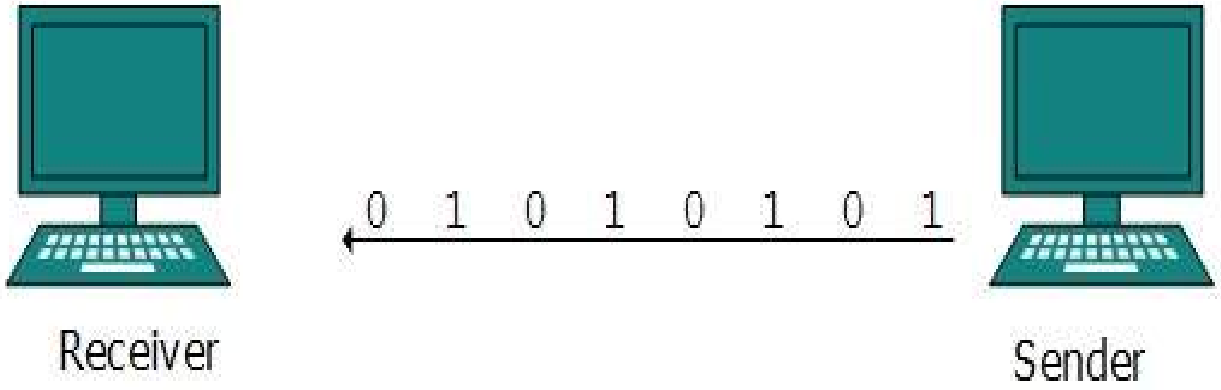
- Both computers distinguish between high order and low order data lines. The sender sends all the bits at once on all lines.

- Because the data lines are equal to the number of bits in a group or data frame, a complete group of bits (data frame) is sent in one go.

- Advantage of Parallel transmission is high speed and disadvantage is the cost of wires, as it is equal to the number of bits sent in parallel.



Parallel Transmision



Serial Transmision

Serial Transmission

- In serial transmission, bits are sent one after another in a queue manner. Serial transmission requires only one communication channel.

- Serial transmission can be either asynchronous or synchronous.

Asynchronous Serial Transmission

- It is named so because there is no importance of timing.
- Data-bits have specific pattern and they help receiver recognize the start and end data bits.
- For example, a 0 is prefixed on every data byte and one or more 1s are added at the end.
- Two continuous data-frames (bytes) may have a gap between them.

Synchronous Serial Transmission

- Timing in synchronous transmission has importance as there is no mechanism followed to recognize start and end data bits.

- There is no pattern or prefix/suffix method. Data bits are sent in burst mode without maintaining gap between bytes (8-bits).

- Single burst of data bits may contain a number of bytes. Therefore, timing becomes very important.

- It is up to the receiver to recognize and separate bits into bytes.

- The advantage of synchronous transmission is high speed, and it has no overhead of extra header and footer bits as in asynchronous transmission.