Department of Electronics & Telecommunication Engineering

Jnan Chandra Ghosh Polytechnic

Semester – 4

UNIT -6

DIGITAL COMMUNICATION

(PULSE CODE MODULATION)

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Pulse Code Modulation (Digital Communication)

Objective of this class is to study :

1. Idea of digital communication – Advantages of digital communication over analog communication
2. Basic Steps in PCM System: Filtering – Sampling – Quantizing – Encoding – Line coding (HDB3, AMI, CMI, NRZ, RZ)
3. Block schematic description of transmitter and receiver of PCM system
4. Principles of linear and non-linear quantization – Companding, Inter Symbol Interference

Idea of digital communication

Digital communication is the process of devices communicating information digitally

Digital communication is a mode of communication where the information or the thought is encoded digitally as discreet signals and electronically transferred to the recipients. Digital communication is one of the most commonly used mode of communication in the current scenario. Organizations generally rely on this mode for all their business communication

In digital communication information flows in a digital form and the source is generally the keyboard of the computer. A single individual is capable of digital communication and thus it also saves wastage of manpower and is one of the cheapest modes of communication. Digital communication is also a really quick way to communicate. The information can reach the recipient within a fraction of a second. An individual no longer has to wait to personally meet the other individual and share his information.

Digital communication system has indeed made our lives easier and is one of the quickest and most reliable modes of communication.

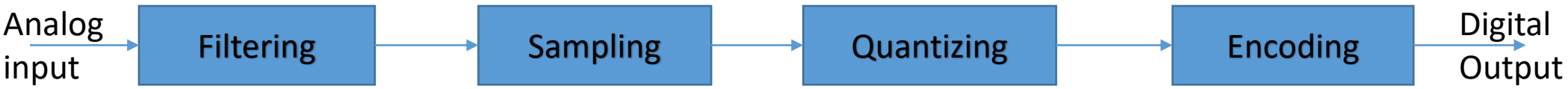
Examples of digital systems that we use every day include mobile phones, television, radio, and of course the Internet. CDs and MP3s are replacing records and tapes, and the number of **digital** cameras sold this year exceeded the number of analog cameras by a factor of three

PULSE CODE MODULATION (Basic Steps/Process)

Pulse Code Modulation (PCM) is used to convert analog signal to digital signal

There are Four steps / processes in PCM -

1. Filtering
2. Sampling
3. Quantizing
4. Encoding



Filtering : This **filter** eliminates the high frequency components present in the input analog signal which is greater than the highest frequency of the message signal, to avoid aliasing of the message signal

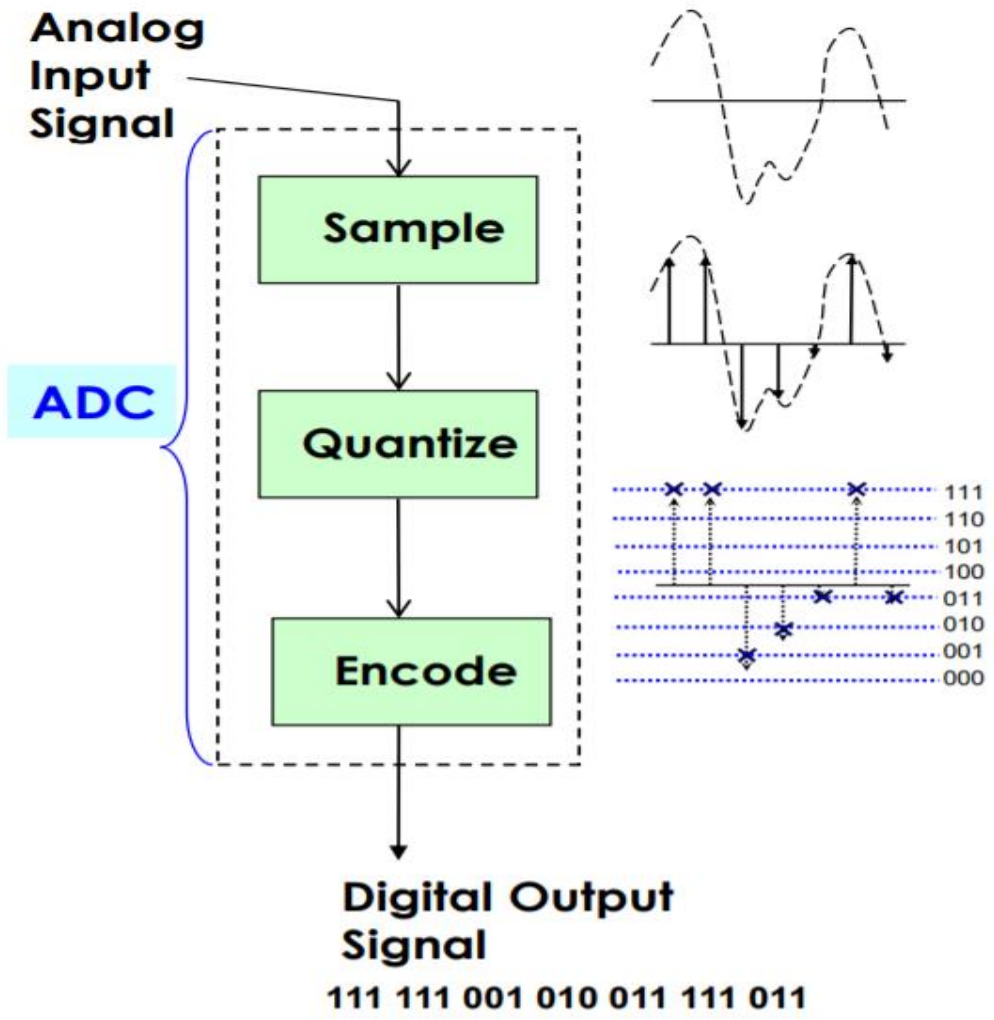
PCM PROCESS

- **Sampling :** Sampling is a process of measuring the amplitude of a continuous-time signal at discrete instants, converts the continuous signal into a discrete signal.
- For example, conversion of a sound wave to a sequence of samples. The Sample is a value or set of values at a point in time or it can be spaced.
- Sampler extract samples of a continuous signal, it is a subsystem ideal sampler produces samples that are equivalent to the instantaneous value of the continuous signal at the specified various points.
- The Sampling process generates flat- top Pulse Amplitude Modulated (PAM) signal.

- **Quantization** : In quantization an analog sample with an amplitude that converted into a digital sample with an amplitude that takes one of a specifically defined set of quantization values.
- Quantization is done by dividing the range of possible values of the analog samples into some different levels and assigning the center value of each level to any sample in the quantization interval.
- Quantization approximates the analog sample values with the nearest quantization values. So almost all the quantized samples will differ from the original samples by a small amount. That amount is called quantization error.
- The result of this quantization error is we will hear a hissing noise when playing a random signal.

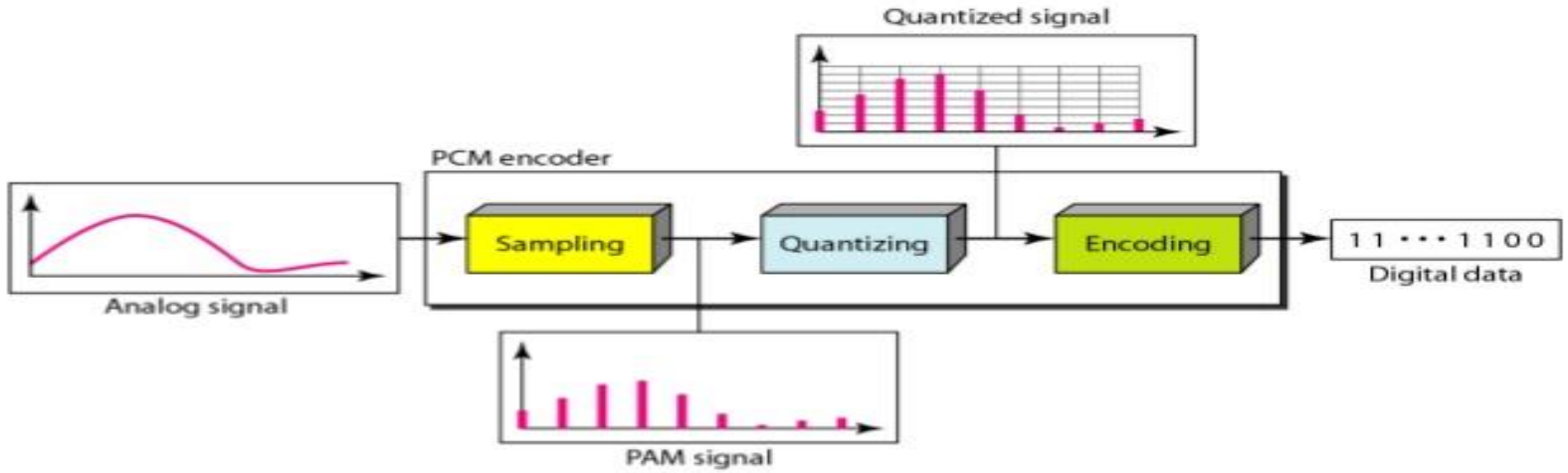
- **Encoding** : Converting analog samples into binary numbers that are 0 and 1. Maps the quantized values to digital words.

PCM PROCESS



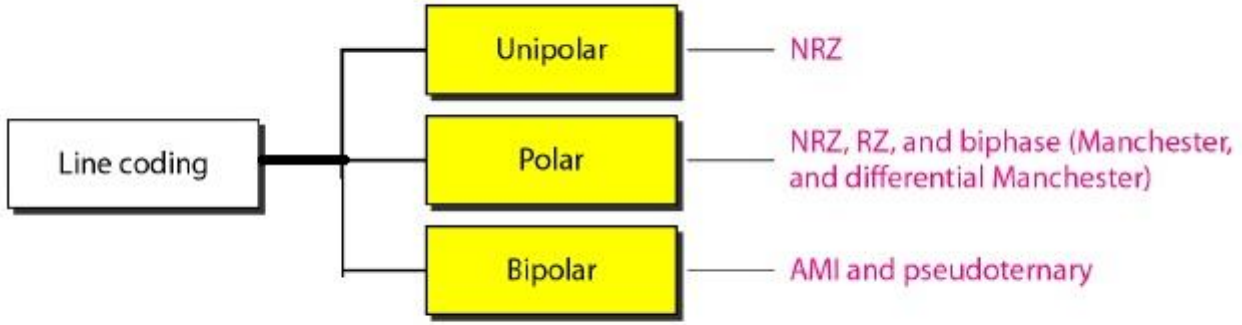
- **Sampling**
  - Makes the signal discrete in time.
  - If the analog input has a bandwidth of *B* Hz, then the ***minimum sample frequency*** such that the signal can be reconstructed without distortion, fs >= 2B
- **Quantization**
  - Makes the signal discrete in amplitude.
  - Round off to one of *q* discrete levels.
- **Encode**
  - Maps the quantized values to digital words that are *n* bits long.

PCM Block Diagram
with signalling process in different steps



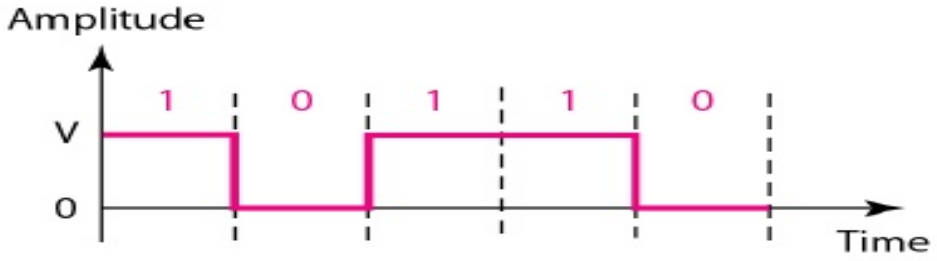
Line coding (HDB3, AMI,CMI, NRZ, RZ)

Different type Line Coding Schemes



Different type Line Coding Schemes

Unipolar NRZ Systems: **Unipolar** encoding is a line code. A positive voltage represents a binary 1, and zero volts indicates a binary 0. ... It is called **NRZ** because the signal does not return to zero at the middle of the bit, as instead happens in other line coding schemes, such as Manchester code.



$$\frac{1}{2}V^2 + \frac{1}{2}(0)^2 = \frac{1}{2}V^2$$

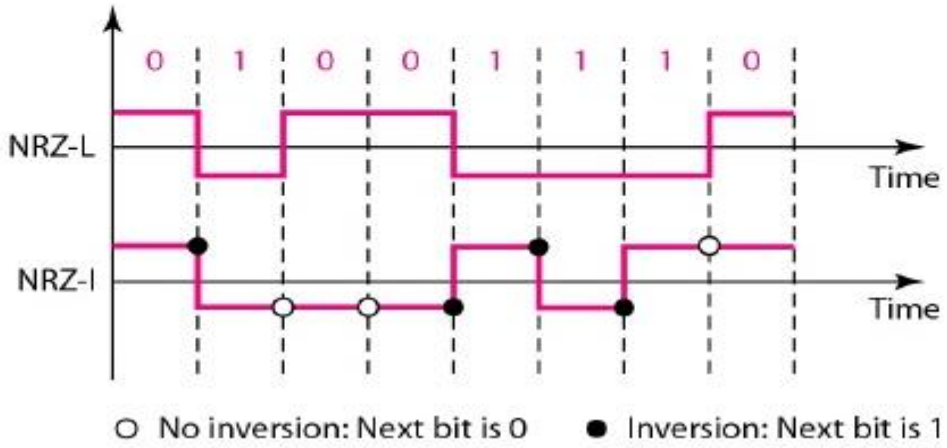
Normalized power

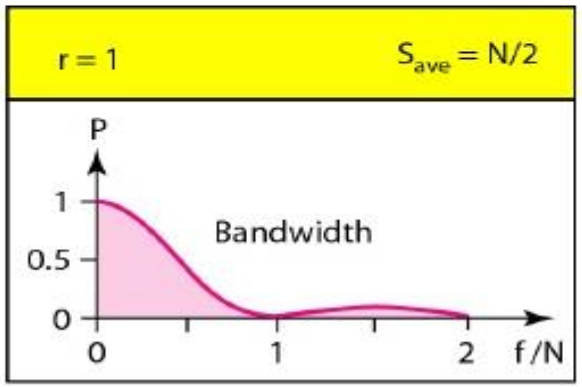
Different type Line Coding Schemes

Polar NRZ. In this type of **Polar** signaling, a High in data is represented by a positive pulse, while a Low in data is represented by a negative pulse.

Polar NRZ-L & Polar NRZ-I Schemes

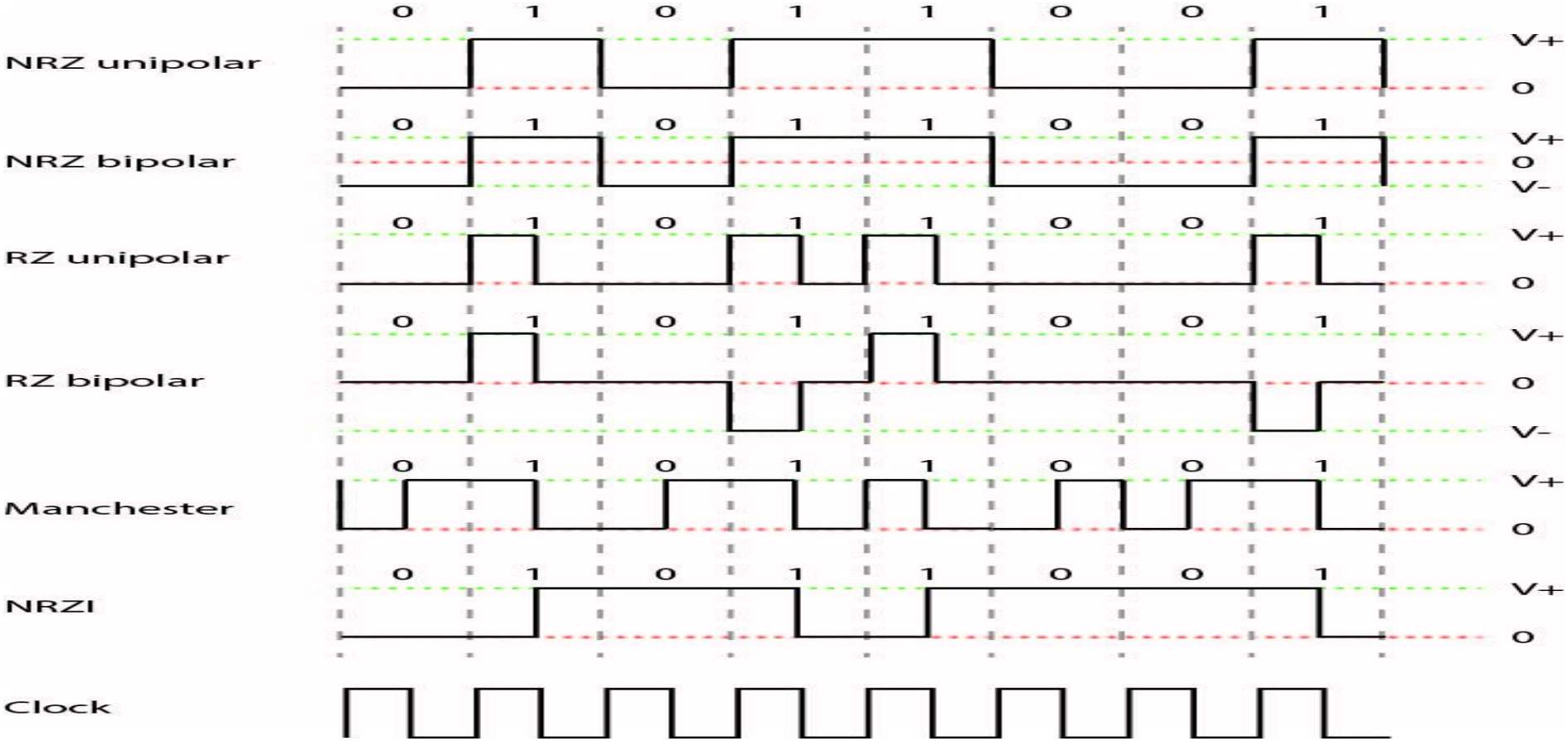
- In NRZ-L, the level of the voltage determines the value of the bit. RS232.
- In NRZ-I, the inversion or the lack of inversion determines the value of the bit. USB, Compact CD, and Fast-Ethernet.
- NRZ-L and NRZ-I both have an average signal rate of N/2 Bd.
- NRZ-L and NRZ-I both have a DC component problem.





Different type Line Coding Schemes

RZ Scheme: **RZ** (return-to-zero) refers to a form of digital data transmission in which the binary low and high states, represented by numerals 0 and 1, are transmitted by voltage pulses having certain characteristics. The signal state is determined by the voltage during the first half of each data binary digit .



Line coding (HDB3, AMI,CMI, NRZ, RZ)

- HDB3 is a line code developed to avoid long strings of zeros in a data stream.
- It uses AMI (alternate mark inversion) coding.
- There are four rules for HDB3 coding

(1) More than three consecutive zeros are not allowed to be present in the data waveform. For the fourth zero the code inserts a "violation bit" denoted by "V"

(2) Violation bits have to be of the same polarity as the previous mark

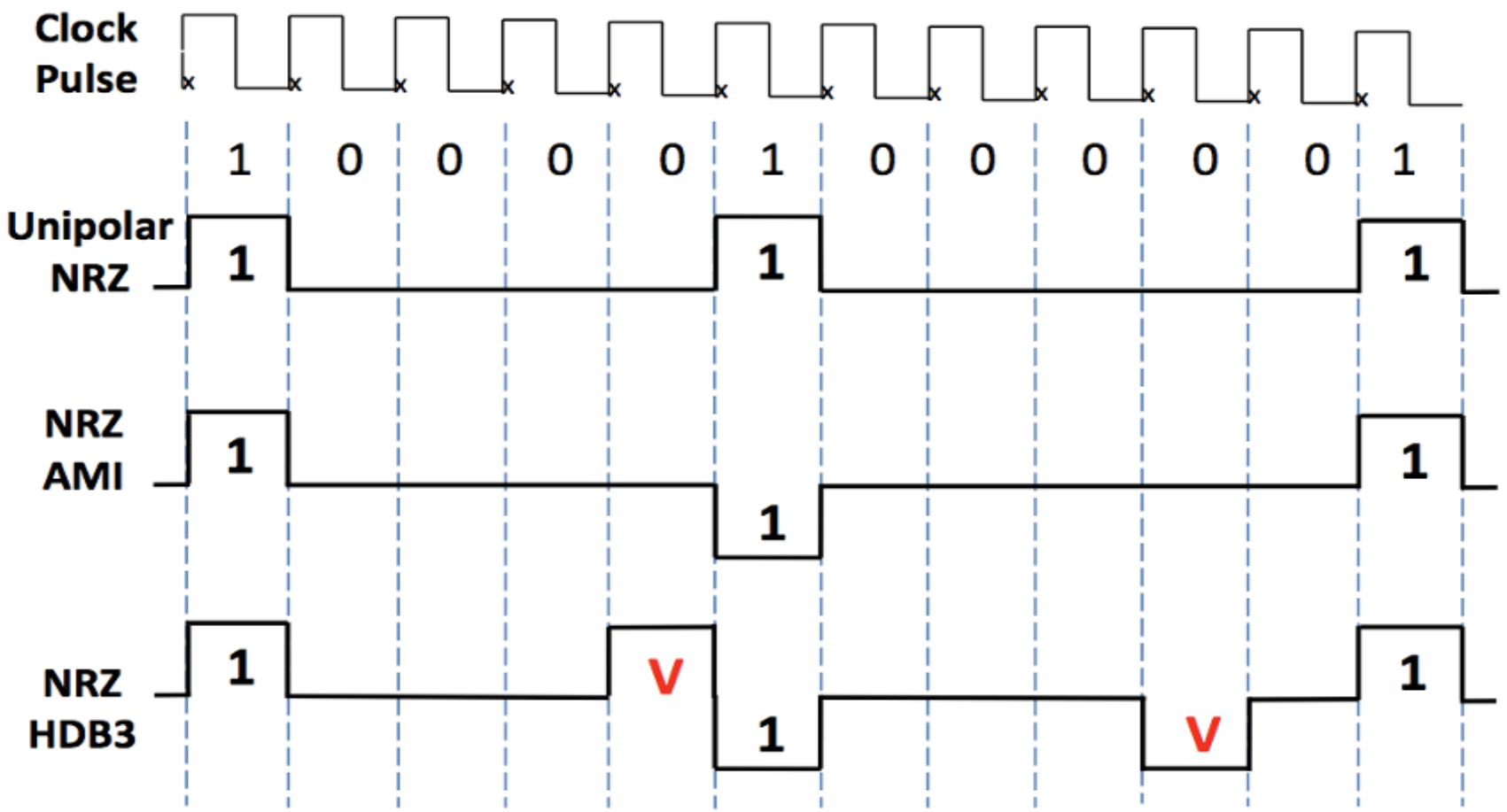
(3) Two consecutive "violation bits" must be of opposite polarity

(4) If the number of marks between two consecutive violation bits is even, the format must be B00V, where bit "B" is a stuffing bit and of opposite polarity to the previous mark.

If the number of marks is an odd number, the format should be 000V,

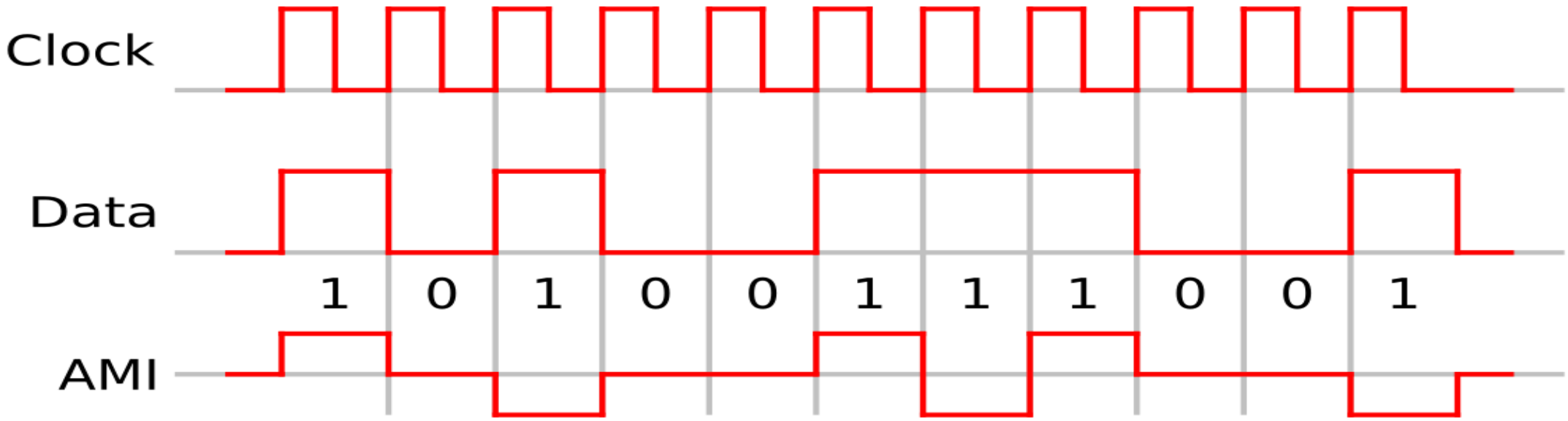
As an example of HDB3, consider the 12-bit data string of 100001000001 as shown below for unipolar NRZ, then for NRZ AMI and finally, expressed in NRZ HDB3 code. Clock Pulse 10000 1 0000 01 Unipolar NRZ 1 1 NRZ AMI 1 1 1 NRZ HDB3 1

Line coding (HDB3, AM1, CM1, NRZ, RZ)



Line coding (HDB3, AMI,CMI, NRZ, RZ)

AMI (Alternate Mark Inversion) : AMI is a synchronous clock **encoding** technique which uses bipolar pulses to represent logical 1 values. ... Successful transmission therefore relies on the user not wishing to send long runs of 0's and this type of **encoding** is not therefore transparent to the sequence of bits being sent.



Line coding (HDB3, AMI,CMI, NRZ, RZ)

CMI : In digital communication, **coded** mark inversion (**CMI**) is a non-return-to-zero (NRZ) **line code**. It encodes zero bits as a half bit time of zero followed by a half bit time of one, and while one bits are encoded as a full bit time of a constant level. The level used for one bits alternates each time one is **coded**.