Digital Data Transmission

- There are two types of Digital Data Transmission:

1) Base-Band data transmission
   - Uses low frequency carrier signal to transmit the data
2) Band-Pass data transmission
   - Uses high frequency carrier signal to transmit the data

Line Coding Techniques

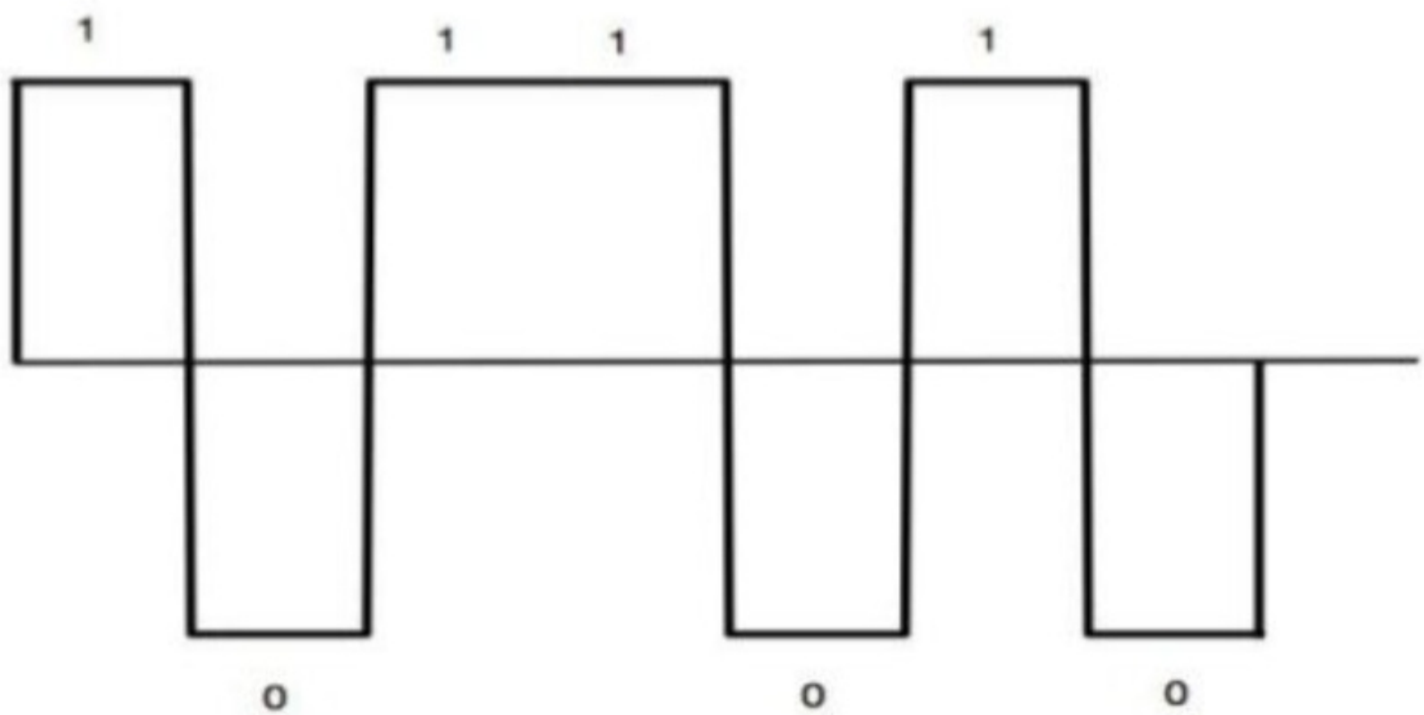
- Non-Return to Zero (NRZ)
- Unipolar Return to Zero (Unipolar-RZ)
- Bi-Polar Return to Zero (Bi-polar RZ)
- Return to Zero Alternate Mark Inversion (RZ-AMI)
- Non-Return to Zero – Mark (NRZ-Mark)
- Manchester coding (Biphase)

Non-Return to Zero (NRZ)

- The “1” is represented by some level
- The “0” is represented by the opposite
- The term non-return to zero means the signal switched from one level to another without taking the zero value at any time during transmission.

NRZ - Example

- We want to transmit m=1011010

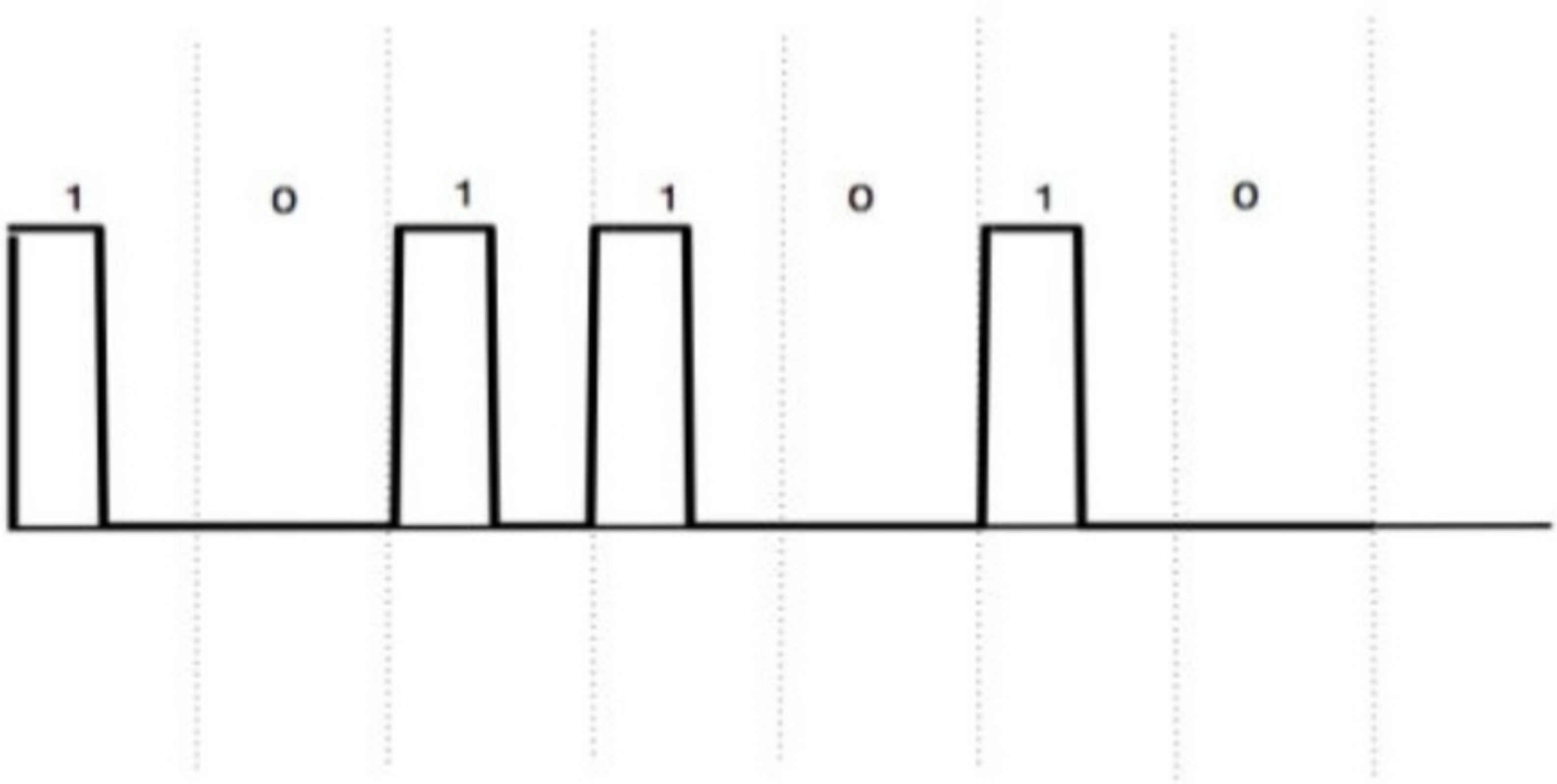


Unipolar Return to Zero (Unipolar RZ)

- Binary “1” is represented by some level that is half the width of the signal
- Binary “0” is represented by the absence of the pulse

Unipolar RZ - Example

- We want to transmit m=1011010

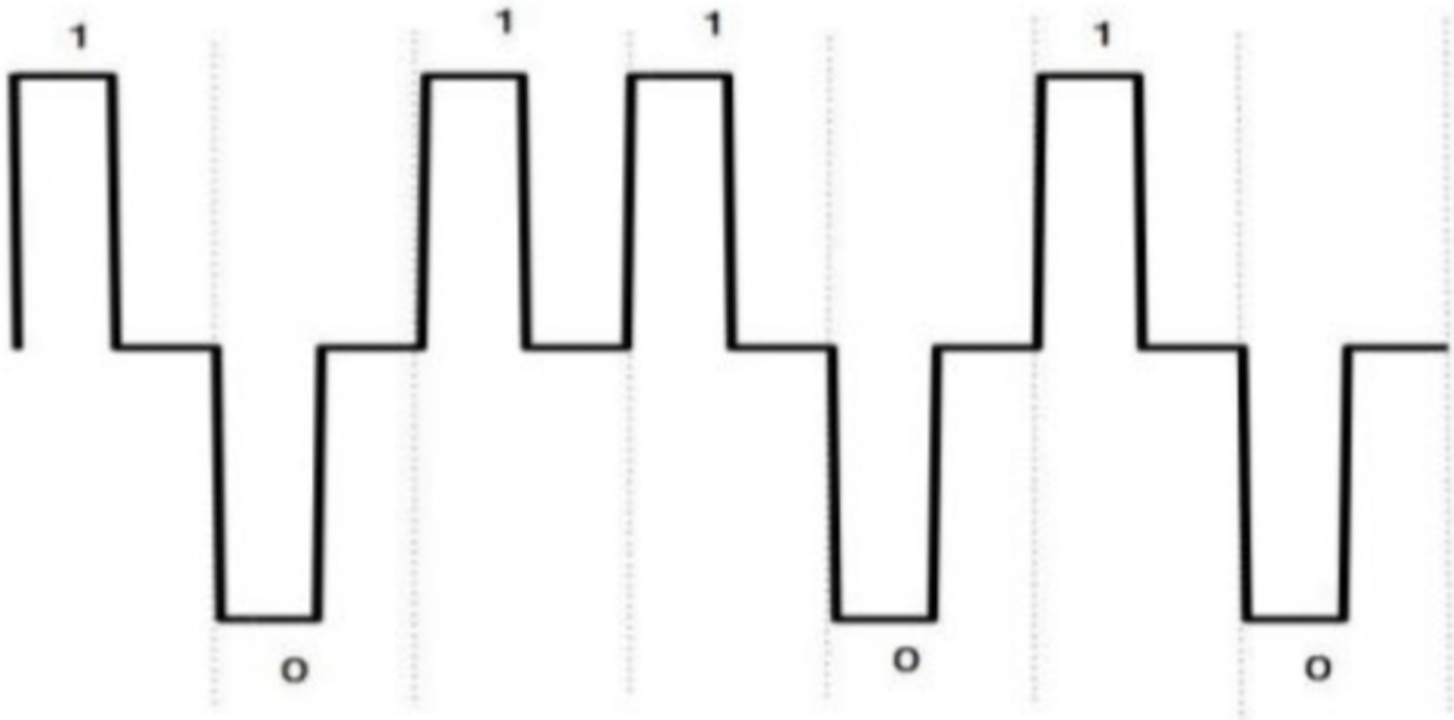


Bipolar Return to Zero (Bipolar RZ)

- Binary “1” is represented by some level that is half the width of the signal
- Binary “0” is represented a pulse that is half width the signal but with the opposite sign

Bipolar RZ - Example

- We want to transmit m=1011010



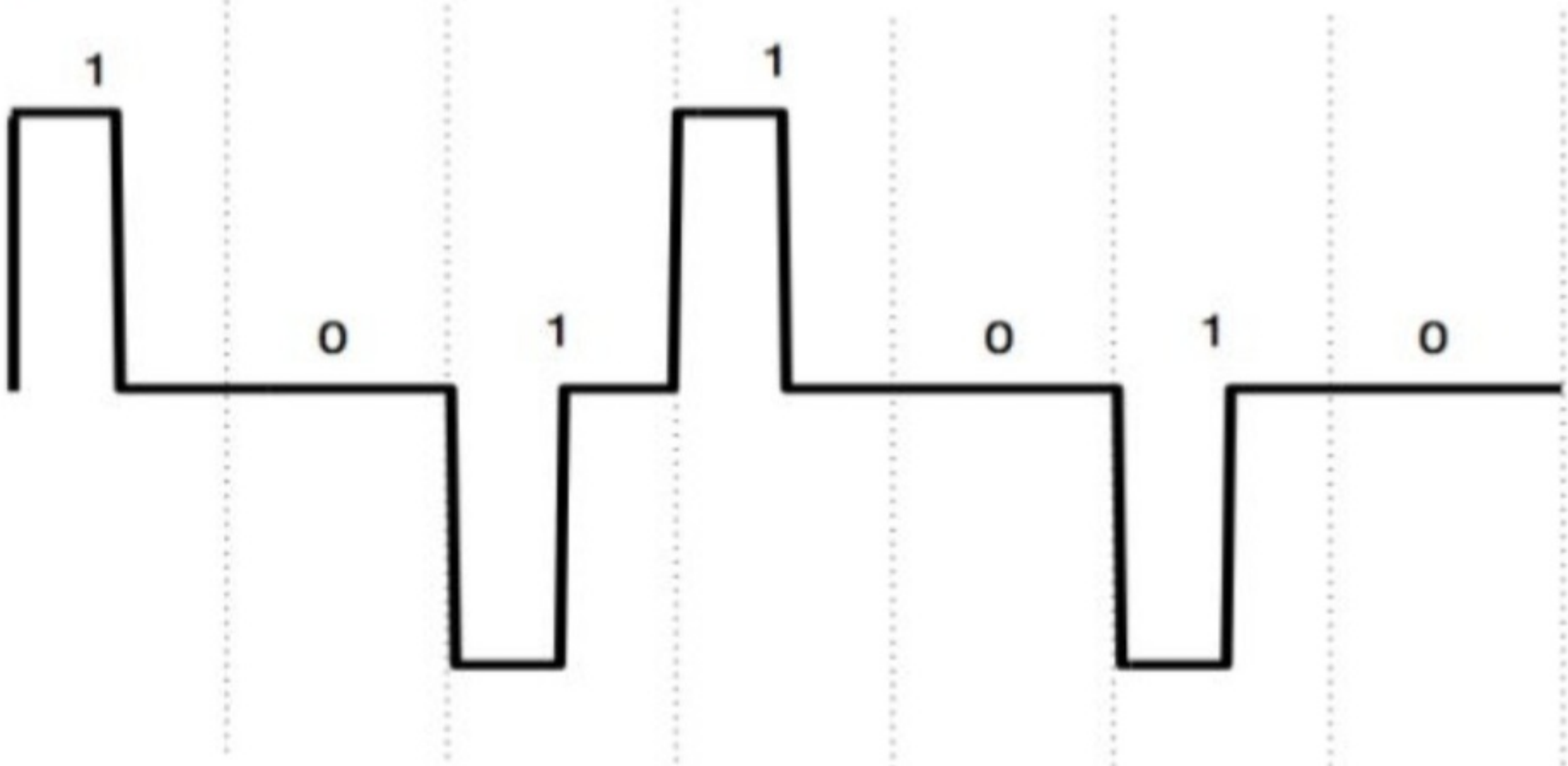
Return to Zero Alternate Mark Inversion (RZ-AMI)

- Binary “1” is represented by a pulse alternating in sign

- Binary “0” is represented with the absence of the pulse

RZ-AMI - Example

- We want to transmit m=1011010

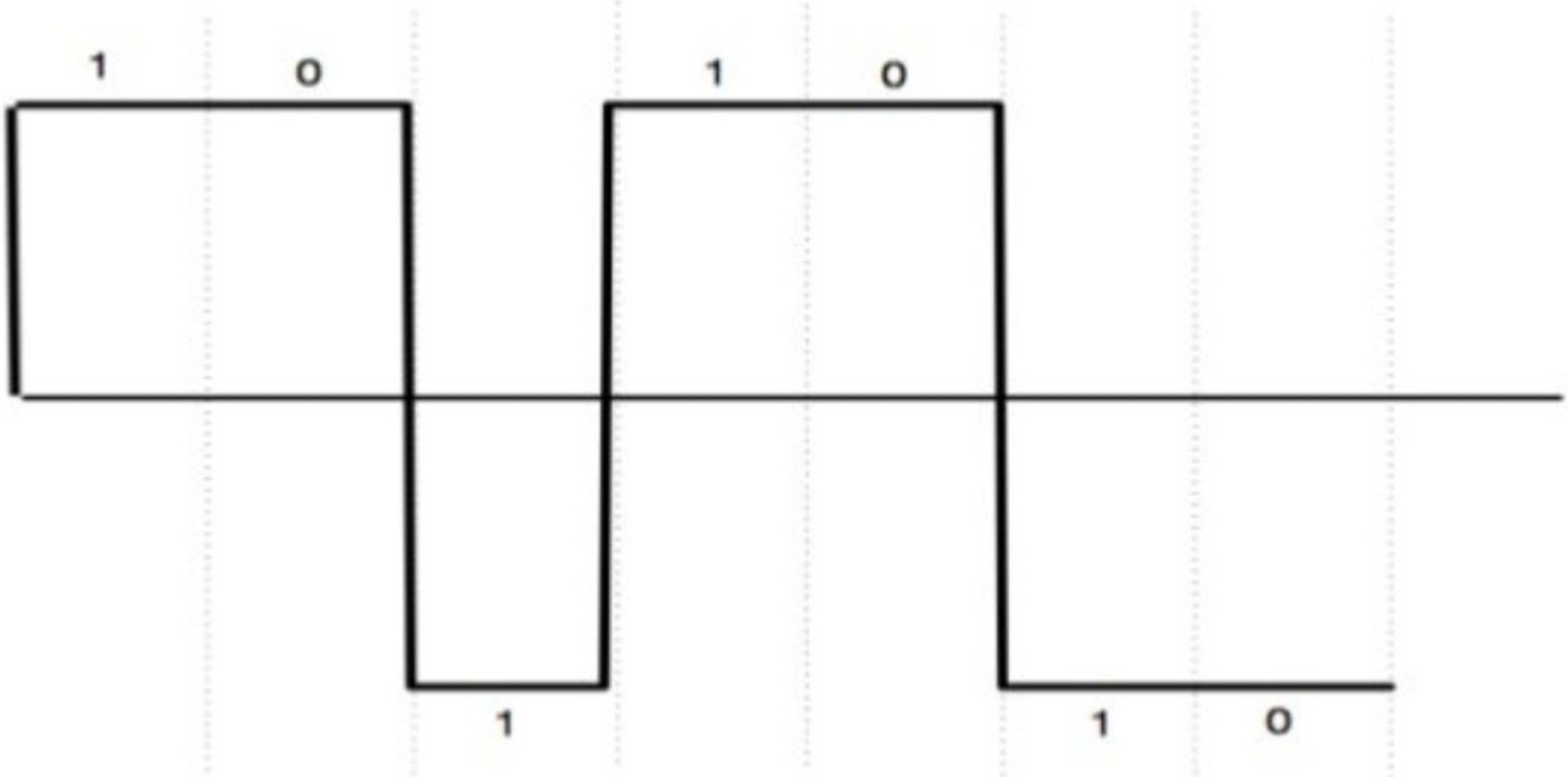


Non-Return to Zero – Mark (NRZ-Mark)

- Also known as differential encoding
- Binary “1” represented in the change of the level
  - High to low
  - Low to high
- Binary “0” represents no change in the level

NRZ-Mark - Example

- We want to transmit m=1011010

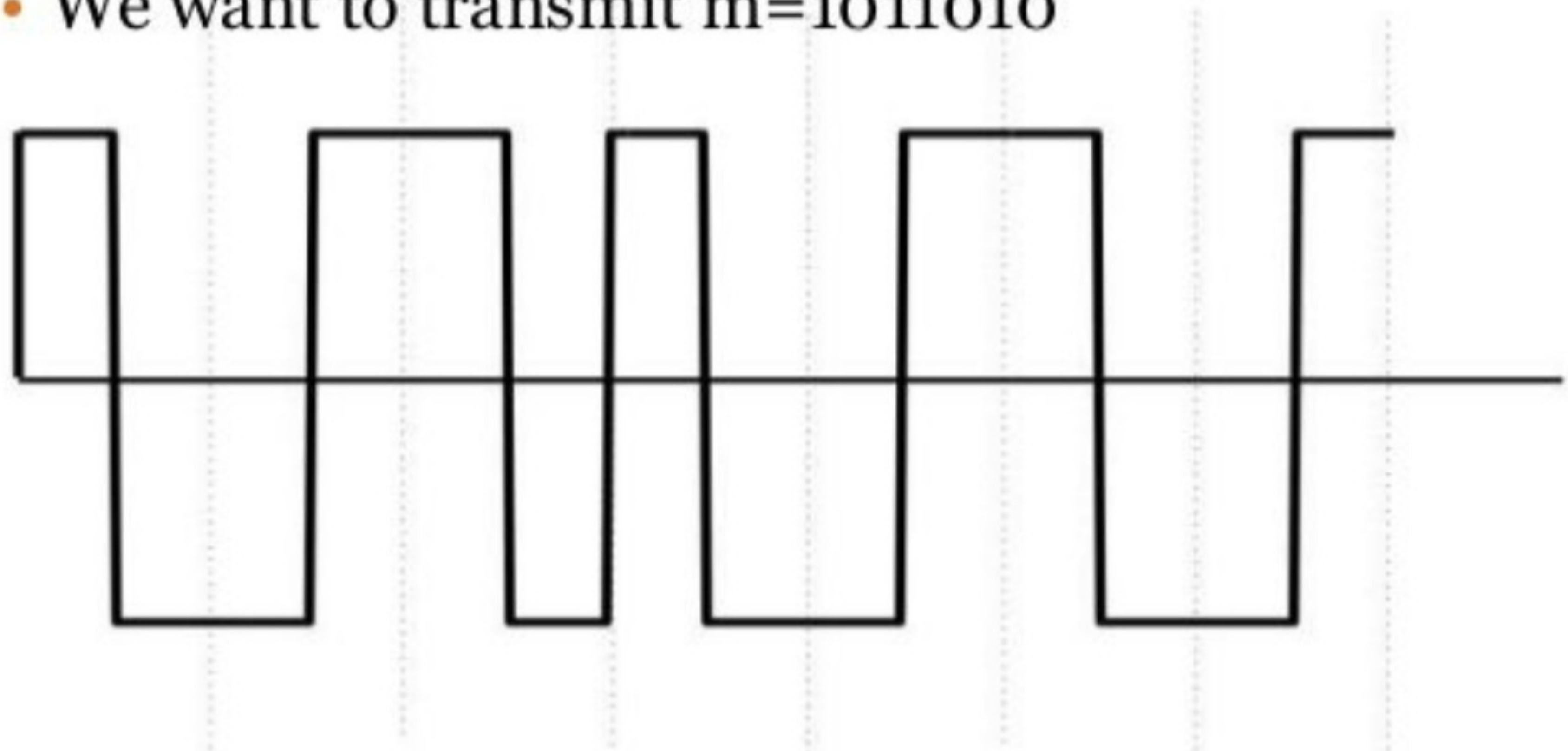


Manchester coding (Biphase)

- Binary “1” is represented by a positive pulse half width the signal followed by a negative pulse
- Binary “0” is represented by a negative pulse half width the signal followed by a positive pulse

Manchester coding - Example

- We want to transmit m=1011010



Transmission

- **Transmission bandwidth:** the transmission bandwidth of a communication system is the band of frequencies allowed for signal transmission, in another word it is the band of frequencies at which we are allowed to use to transmit the data.

Bit Rate

- **Bit Rate :** is the number of bits transferred between devices per second

- If each bit is represented by a pulse of width Tb, then the bit rate

$$R_b = \frac{1}{T_b} \quad bits/\mathrm{sec}$$

Example – Bit rate calculation

- Suppose that we have a binary data source that generates bits. Each bit is represented by a pulse of width Tb = 0.1 mSec
- Calculate the bit rate for the source

- ***Solution***

$$R_b = \frac{1}{T_b} = \frac{1}{0.1 \times 10^{-3}} = 10000 \quad bits/\text{sec}$$

Example – Bit rate calculation

- Suppose we have an image frame of size 200x200 pixels. Each pixel is represented by three primary colors red, green and blue (RGB). Each one of these colors is represented by 8 bits, if we transmit 1000 frames in 5 seconds what is the bit rate for this image?

Example – Bit rate calculation

- We have a total size of 200x200 = 40000 pixels
- Each pixel has three colors, RGB that each of them has 8 bits.
  - 3 x 8 = 24 bits (for each pixel with RGB)
- Therefore, for the whole image we have a total size of 24 x 40000 = 960000 bits
- Since we have 1000 frames in 5 seconds, then the total number of bits transmitted will be 1000 x 960000 = 960000000 bits in 5 seconds
- Bit rate = 96000000/5 = 192000000 bits/second

Baud rate (Symbol rate)

- The number of symbols transmitted per second through the communication channel.
- The symbol rate is related to the bit rate by the following equation:

$$R_s = \frac{R_b}{N}$$

- Rb = bit rate
- Rs = symbol rate
- N = Number of bits per symbol

Baud rate (Symbol rate)

- We usually use symbols to transmit data when the transmission bandwidth is limited
- For example, we need to transmit a data at high rate and the bit duration Tb is very small; to overcome this problem we take a group of more than one bit, say 2, therefore :

$$Tb \rightarrow f_o = \frac{1}{Tb}$$

$$2Tb \rightarrow f = \frac{1}{2Tb} = \frac{1}{2} f_o$$

$$4Tb \rightarrow f = \frac{1}{4Tb} = \frac{1}{4} f_o$$

Baud rate (Symbol rate)

- We notice that by transmitting symbols rather than bits we can reduce the spectrum of the transmitted signal.
- Hence, we can use symbol transmission rather than bit transmission when the transmission bandwidth is limited

Example

- A binary data source transmits binary data, the bit duration is 1μsec, Suppose we want to transmit symbols rather than bits, if each symbol is represented by four bits. what is the symbol rate?
- Each bit is represented by a pulse of duration 1μ second, hence the bit rate

$$R_b = \frac{1}{1\times10^{-6}} = 1000000\ bits/\sec$$

Example (Continue)

- Therefore, the symbol rate will be

$$R_s = \frac{R_b}{N} = \frac{1000000}{4} = 250000 \ \ symbols/\mathrm{sec}$$