DIGITAL COMMUNICATION

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BASEBAND SHAPING FOR DATA TRANSMISSION

Pulse shaping (line coding) techniques

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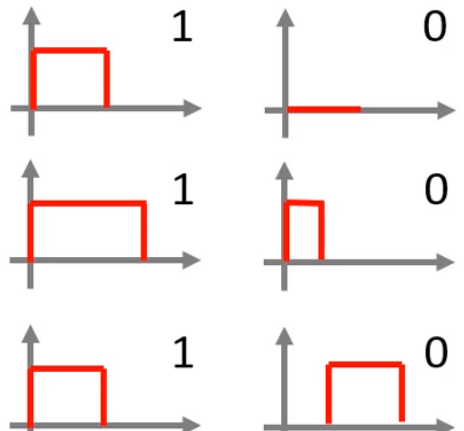
Baseband Shaping For Data Transmission

Pulse Modulation Schemes

- At the end of quantization, we now have a bit sequence to transmit
- Pulse shaping is required, which is a process of representing a bit stream in terms of an electrical (analog) waveform

- In discrete pulse modulation, the amplitude, duration or position of the transmitted pulses are varied according to the binary data to be transmitted.
- This is called Baseband Shaping or Pulse Modulation.

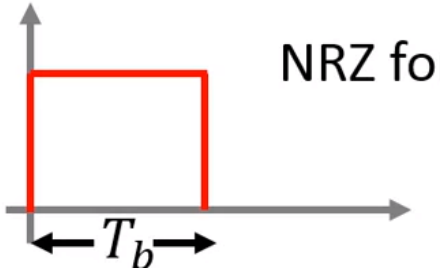
- Some pulse modulation schemes are:
  - Pulse Amplitude Modulation (PAM)
  - Pulse Duration Modulation (PDM)
  - Pulse Position Modulation (PPM)



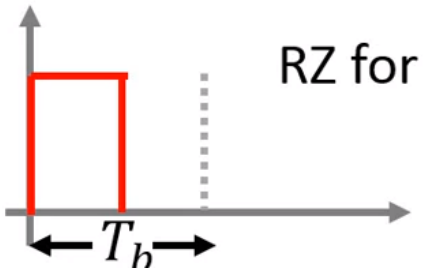
Baseband Shaping For Data Transmission

Pulse Modulation Schemes

- Among these techniques, PAM is preferred since it is the most efficient among all in terms of bandwidth and power
- In baseband transmission, we assume that the digital pulses are rectangular, and the transmission lines to be distortionless
- We consider the rectangular pulse as a basic shape. Let T_b denote the bit duration
- PAM signals are of two types
  - Non-return to zero (NRZ): Pulse occupies entire duration of T_b
  - Return to zero (RZ): Pulse occupies a fraction of duration T_b



NRZ for bit 1



RZ for bit 1

Baseband Shaping For Data Transmission

Discrete PAM Signals

Digital Data, a sequence of binary digits are coded into electrical pulses or waveforms for the purpose of transmission over the channel. This process is called Line Coding or Transmission Coding. They are also called Signal Formats.

An amplitude variant version of such baseband shaping is called pulse amplitude modulation. It is of two kinds:

- Non Return to Zero Coding (NRZ)
- Return to Zero Coding (RZ).

Baseband Shaping For Data Transmission

Non-Return to Zero Coding (NRZ) or Type I Coding

In NRZ Coding, the pulse shape does not return to zero after every bit transition.

It however proceeds to shape the next pulse at the position at which the previous pulse ends. NRZ coding is of six types:

- Unipolar NRZ Technique
- Polar NRZ Technique.
- Bipolar NRZ Technique.
- Manchester Coding.

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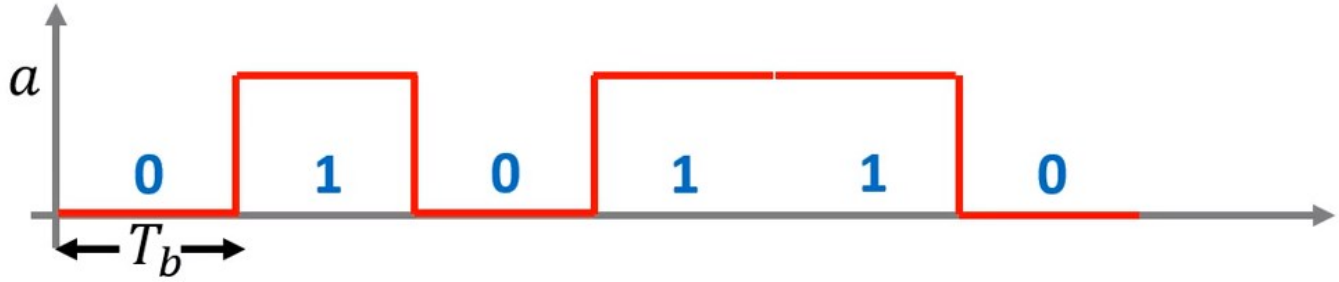
Unipolar NRZ Technique

- In unipolar NRZ, the bits 1 and 0 have amplitudes a and 0, respectively

- Example of unipolar NRZ: Consider the bit sequence – 010110



- Major issue: Presence of a non-zero DC value
- This DC component contains no information, and only drains the power
- Repeaters in the channel typically use transformers, which block DC
- Creates problems in magnetic storage (due to hysteresis)

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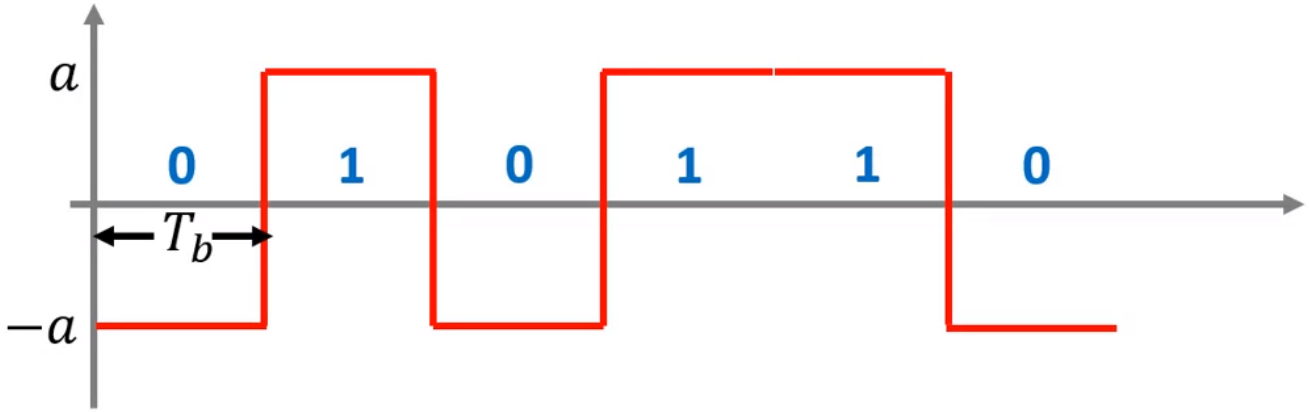
Polar NRZ Technique

- In polar NRZ, the bits 1 and 0 have amplitudes a and $-a$, respectively

- Example of polar NRZ: Consider the bit sequence – 010110

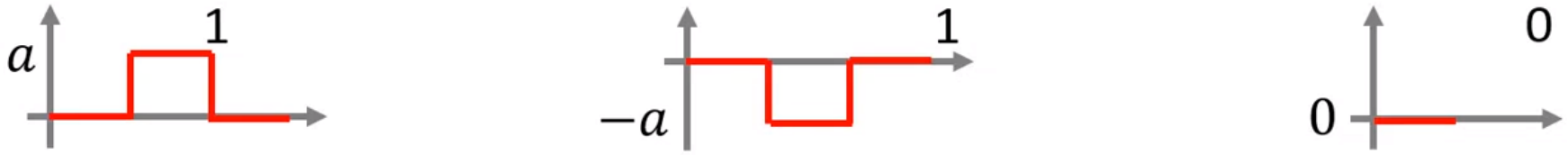


- If 1 and 0 occur with equal probabilities, then this scheme has zero DC value
- Major issue: Polarity inversion (switched telephone networks) is problematic
- Efficient scheme, since it consumes least power among all other techniques

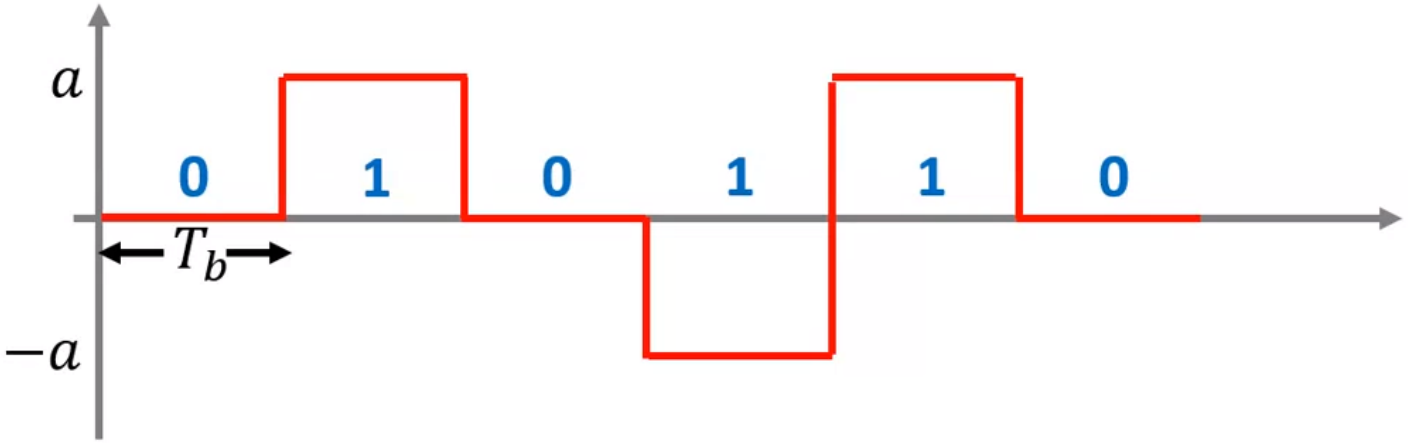
Baseband Shaping For Data Transmission

Bipolar NRZ Technique/Pseudo-Ternary Signalling

- In bipolar NRZ, the bit 1 has amplitudes a, and $-a$ alternatively, and bit 0 has an amplitude of 0. This is also called as pseudo-ternary coding technique



- Example of bipolar NRZ: Consider the bit sequence – 010110



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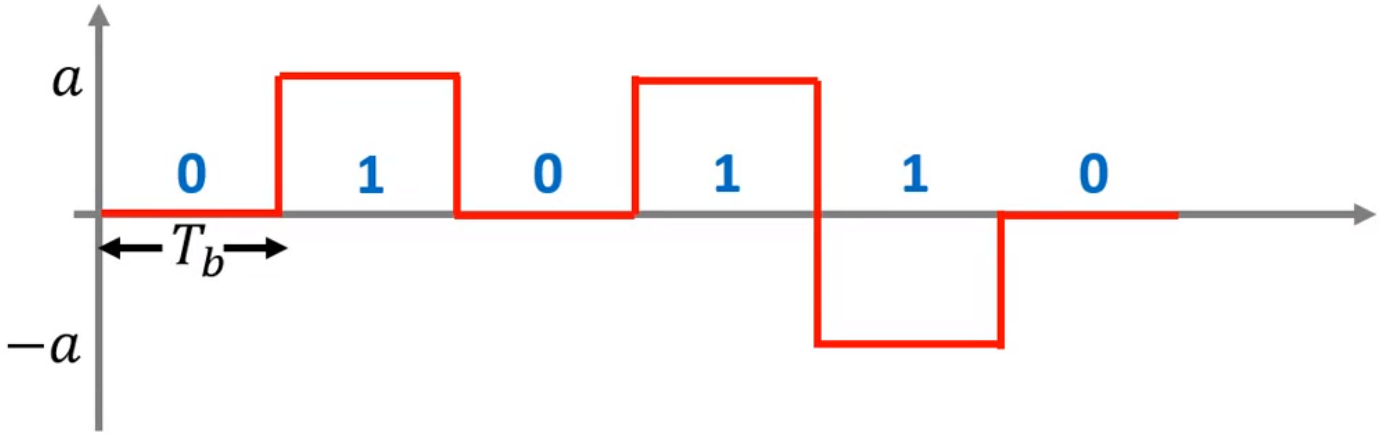
Bipolar NRZ Technique/Pseudo-Ternary Signalling

- Similar to polar NRZ, the DC value is zero. Polarity inversion is not a problem
- Some bit errors can be recovered, but cannot be corrected



- In case of bipolar NRZ, a long string of 0s can result in a loss of synchronization between the clocks at the transmitter and receiver
- A similar problem exists in unipolar and polar NRZ schemes as well, where a long string of 0s or 1s cause a loss of clock synchronization
- To overcome this, Manchester coding is used

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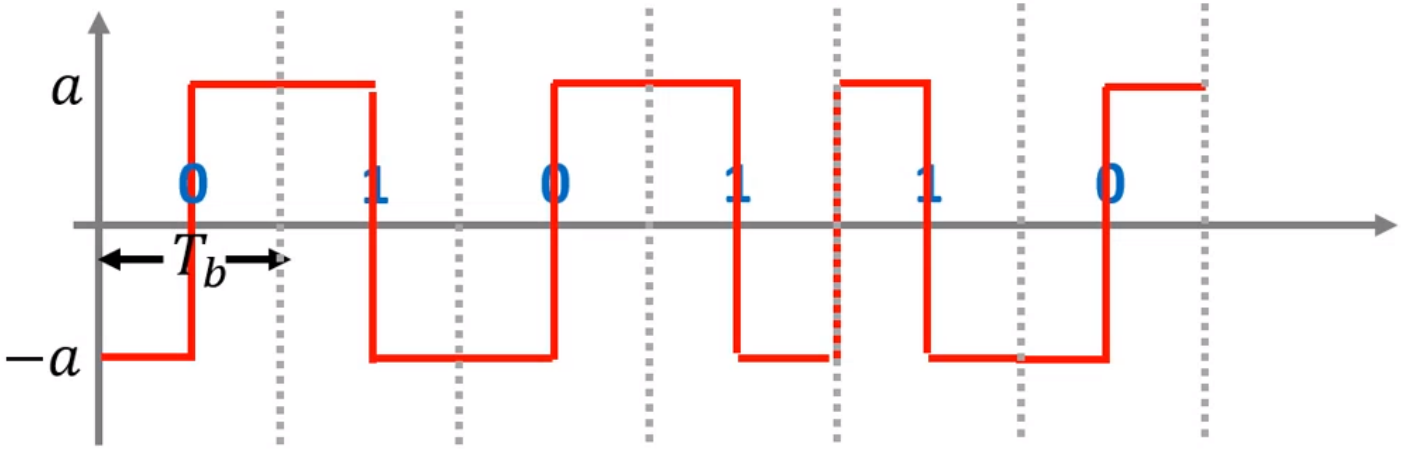
Manchester Coding

- In Manchester coding, the bits 1 and 0 have a transition in the middle of every bit duration, and hence clock recovery becomes easier

- Example of Manchester NRZ: Consider the bit sequence – 010110



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Manchester Coding

- Here symbol 1 is represented by transmitting a positive pulse for one half of the symbol duration followed by negative pulse for the other half. For symbol 0, the two pulses are transmitted in reverse order.
- It's DC value is zero.
- Clock can be recovered at the cost of increased bandwidth.
- Has an in-built synchronization capability because there is a predictable transition in the middle of every bit interval.

Baseband Shaping For Data Transmission

Return to Zero Coding (RZ) or Type II Coding

In RZ Coding, the pulse shape returns to zero after every bit transition. It proceeds to shape the next pulse after returning to zero from the ending of the previous pulse. Half of the bit period will be consumed in pulse shaping and another half in returning to zero. RZ schemes require less power but more bandwidth than the corresponding NRZ Schemes. They are primarily of three types:

- Unipolar RZ Technique.
- Polar RZ Technique.
- Bipolar RZ Technique.

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Return to Zero Coding (RZ) or Type II Coding

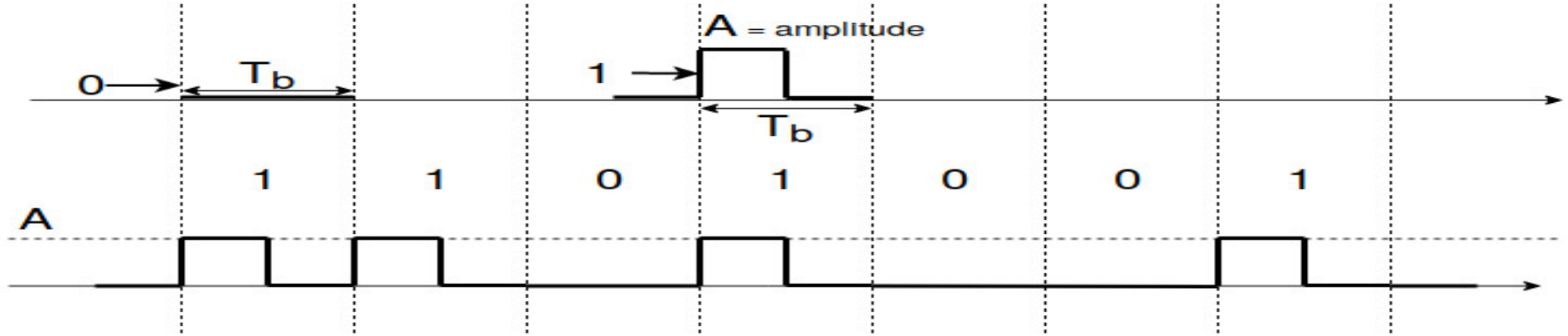

Figure:Unipolar RZ Waveform

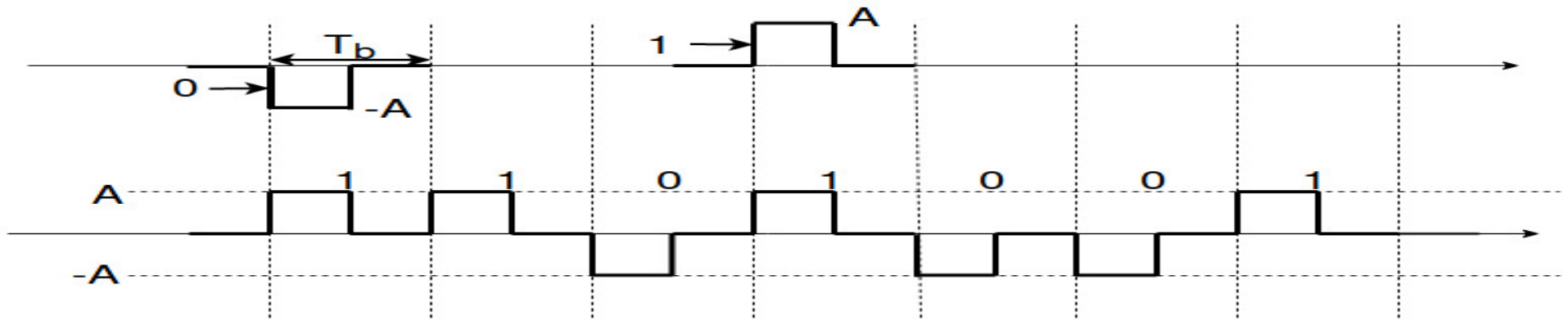

Figure:Polar RZ Waveform

Baseband Shaping For Data Transmission

Return to Zero Coding (RZ) or Type II Coding

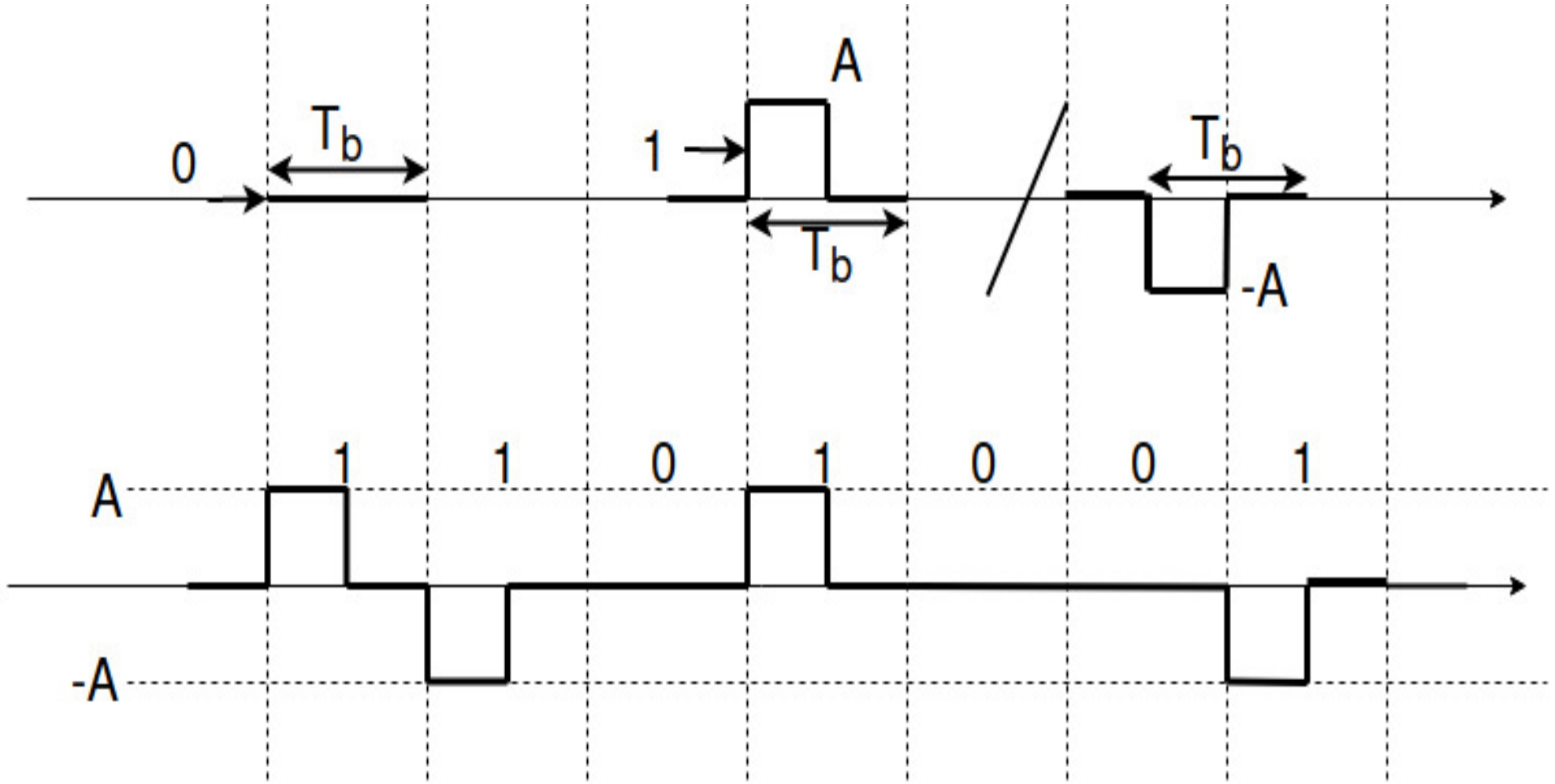

Figure:Bipolar RZ Waveform

THANK YOU

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