Lab Report: Implementation of Different Encoding and Decoding Schemes

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April 23, 2025

1. Introduction

In data communication systems, encoding and decoding techniques play a crucial role in transmitting data over communication channels. These methods convert the digital data into a signal format that is suitable for transmission, ensuring reliable communication. Each encoding scheme has its advantages, helping in reducing signal distortion, maintaining synchronization, and improving signal quality. In this report, I will shortly brief about these:

- **NRZ-L (Non-Return-to-Zero Level)**: A simple encoding where the signal level remains constant for each bit. A '1' is represented by a high level, and a '0' by a low level.
- **NRZ-I (Non-Return-to-Zero Inverted)**: Uses a transition to represent '1'. A '0' causes no change in the signal level, whereas a '1' causes a level inversion.
- **Manchester Encoding**: Combines the clock and data into a single signal, with the transition occurring in the middle of each bit period. A logical '1' is represented by a high-to-low transition, while a '0' is represented by a low-to-high transition.
- **AMI (Alternate Mark Inversion)**: Represents binary '1' with alternating positive and negative voltages, while a binary '0' is represented by zero voltage.
- **Pseudoternary**: Uses positive and negative voltage for '1', while '0' is represented by no voltage.

- **MLT-3 (Multi-Level Transmit)**: Uses three voltage levels: positive, zero, and negative, allowing better signal transmission over long distances.

These encoding schemes are essential for ensuring robust, efficient, and error-resistant data transmission.

2. Objectives

The objectives of this lab are:

1. To understand and implement various encoding and decoding techniques.
2. To analyze the differences in performance and effectiveness of each encoding scheme.
3. To simulate encoding and decoding operations for each scheme.
4. To visualize input signals and their encoded outputs using waveform diagrams.
5. To analyze the decoded signal for correctness.

3. Algorithms / Pseudocode

For each encoding scheme, the following basic steps were followed:

- **NRZ-L Encoding**:
  - Traverse the input bit stream.
  - If the bit is '1', output a high signal level.
  - If the bit is '0', output a low signal level.
- **NRZ-I Encoding**:
  - Traverse the input bit stream.
  - If the bit is '1', invert the signal level from the previous state.
  - If the bit is '0', keep the signal level unchanged.
- **Manchester Encoding**:

  - Traverse the input bit stream.
  - For ‘1’, output a high-to-low transition in the middle of the bit period.
  - For ‘0’, output a low-to-high transition in the middle of the bit period.

- **AMI Encoding**:
  - Traverse the input bit stream.
  - For every ‘1’, alternate between positive and negative voltage levels.
  - For ‘0’, output a zero voltage level.

- **Pseudoternary Encoding**:
  - Traverse the input bit stream.
  - For ‘1’, output a zero voltage level.
  - For ‘0’, alternate between positive and negative voltage levels.

- **MLT-3 Encoding**:
  - Traverse the input bit stream.
  - For each ‘1’, alternate between positive, zero, and negative levels.
  - For each ‘0’, maintain the current level.

Mainly I tried to do every encoding and decoding in the same way:

1. I wrote code in python and get help from numpy and matplotlib.pyplot
2. I needed two functions, one for encoding or decoding, and another for ploting,
3. In GitHub, I stored all codes and graphs using Jupiters Notebook
4. Beside encoded graphs are attached here in the report

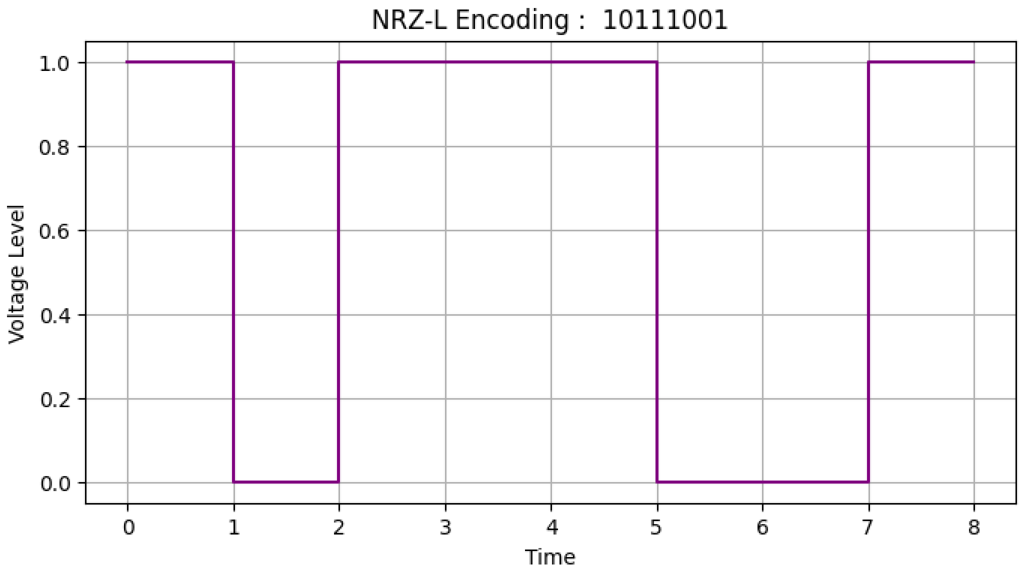

Figure 1: Waveform diagram for NRZ-L encoding.

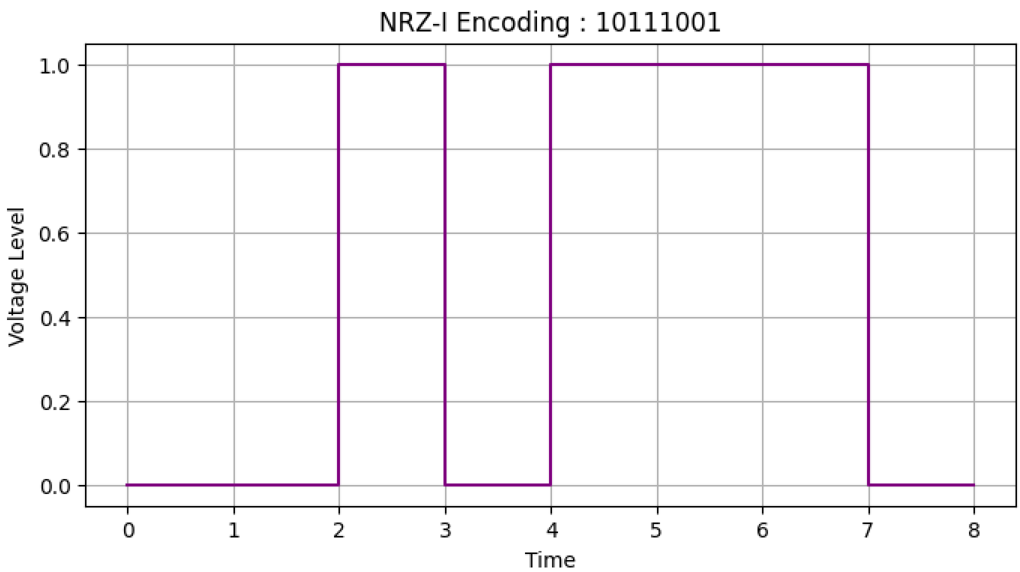

Figure 2: Waveform diagram for NRZ-I Encoding.

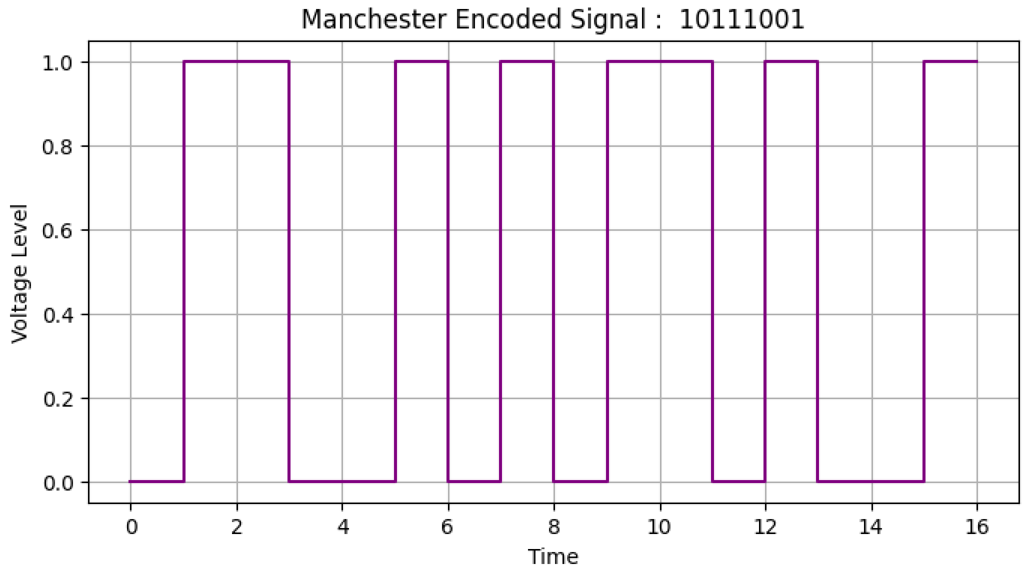

Figure 3: Waveform diagram for Manchester Encoding.

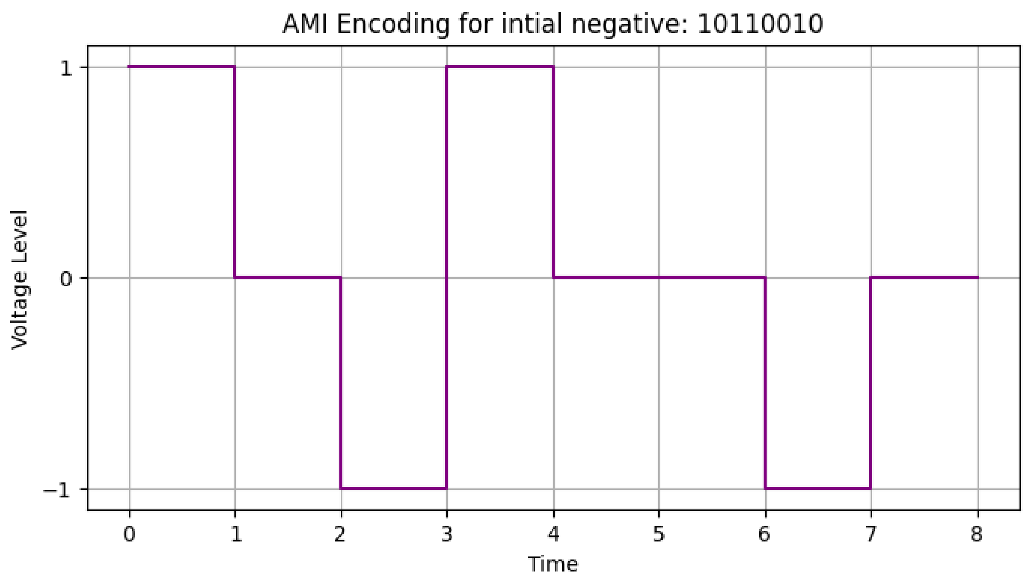

Figure 4: Waveform diagram for AMI Encoding.

Figure 5: Waveform diagram for Pseudoternary Encoding.

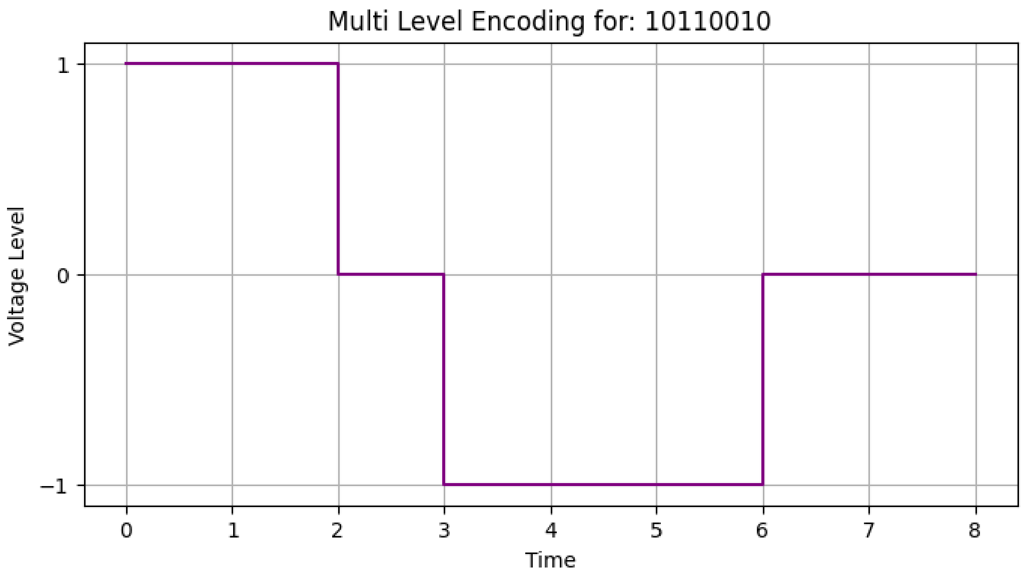

Figure 6: Waveform diagram for Multi Level Line Encoding.

4. Sample Input and Output

Sample Input:

```
Input Stream: 10111001
```

Encoded Output for Each Scheme:

- **NRZ-L Encoding**: High, Low, High, High, High, Low, Low, High (10111001)
- **NRZ-I Encoding**: Low, Low, High, Low, High, High, High, Low (00101110)
- **Manchester Encoding**: Low to High, High to Low, Low to High, Low to High, Low to High, High to Low, High to Low, Low to High (+-+++–+)

Sample Input:

```
Input Stream: 10110010
```

Encoded Output for Each Scheme:

- **AMI Encoding**: Positive, Zero, Negative, Positive, Zero, Zero, Negative, Zero (+0-+00-0)
- **Pseudoternary Encoding**: Zero, Negative, Zero, Zero, Positive, Negative, Zero, Positive (0-00+-0+)
- **MLT-3 Encoding**: Positive, Positive, Zero, Negative, Negative, Negative, Zero, Zero (++0—00)

5. Learning and Difficulties

Learning:

- I learned how different encoding schemes affect the transmission of binary data over a communication medium. Each scheme has its advantages, such as reducing signal distortion or maintaining synchronization, which is crucial for reliable data transmission.

Difficulties:

- One of the challenges encountered was understanding the differences in signal representation across the encoding schemes, especially for schemes like AMI and MLT-3, which involve alternating voltage levels.
- The difficulty in visualizing the waveform transitions for Manchester and MLT-3 encoding also required additional practice to fully understand the timing and transitions.

6. Conclusion

This lab report successfully demonstrated the implementation of various encoding and decoding schemes. Through the implementation and analysis of these schemes, it became evident that each encoding technique has unique properties that make it suitable for specific applications. NRZ-L and NRZ-I are simple and easy to implement, while Manchester encoding ensures better synchronization. AMI and Pseudoternary encoding are useful for minimizing DC bias, and MLT-3 helps reduce signal bandwidth and transmission errors over longer distances. Understanding these schemes is crucial in designing efficient and reliable communication systems.