Objective :

- To get introduced with Delta Modulation
- To get introduced with Line codding
- Implementation of Delta Modulation & Line Codding on MATLAB Simulink

Theory :

Delta Modulation

Delta Modulation (DM) is a method of analog-to-digital signal conversion where the difference between successive samples of the signal is encoded into binary form. Unlike Pulse Code Modulation (PCM), DM encodes the change in the signal rather than the actual sample values.

DM operates on the principle of tracking the input signal by a staircase approximation, adjusting the step size based on the input changes.

Key Features of Delta Modulation:

- **Step Size**: Fixed increment or decrement to the staircase waveform.
- **Slope Overload Distortion**: Occurs when the step size is too small to track a rapidly changing signal.
- **Granular Noise**: Occurs when the step size is too large for small variations in the input signal.

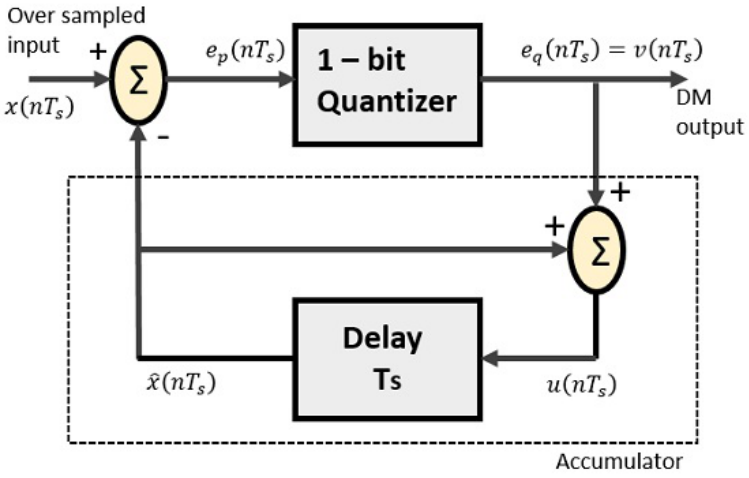

Figure 5.1: Delta Modulator

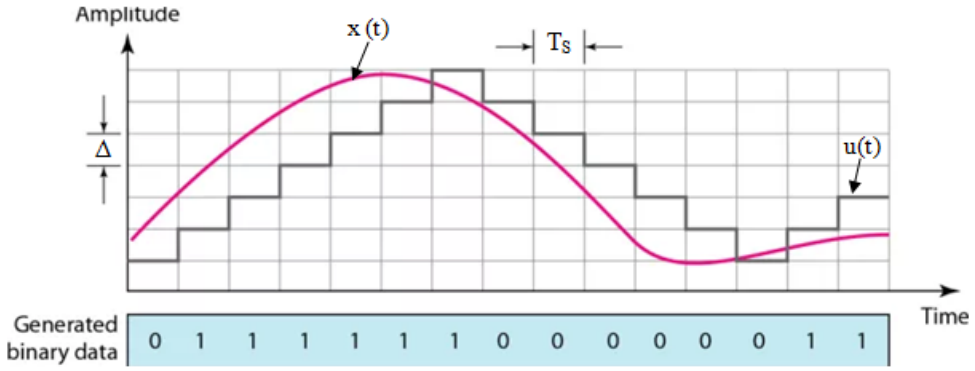

Figure 1 : Wave Shape Of Delta Modulation

Line Coding

Line coding is a technique for representing digital data in a form suitable for transmission over physical media. It determines how binary data is converted into electrical pulses or optical signals.

Line coding formats include various schemes to represent '0' and '1', with different characteristics for each. Key line coding techniques include:

Unipolar RZ (Return-to-Zero):

- A '1' is represented by a positive pulse, and '0' is represented by no pulse.
- Signal returns to zero within one bit duration.
- Mathematically:

$$x(t) = \begin{cases} A & \text{for } 0 \leq t < T/2 \text{ (bit '1')} \\ 0 & \text{otherwise} \end{cases}$$

Unipolar NRZ (Non-Return-to-Zero):

- A '1' is represented by a positive pulse, and '0' is represented by no pulse.
- The signal does not return to zero within the bit period.
- Mathematically:

$$x(t) = \begin{cases} A & \text{for } 0 \leq t < T \text{ (bit '1')} \\ 0 & \text{for } 0 \leq t < T \text{ (bit '0')} \end{cases}$$

Polar RZ:

- A '1' is represented by a positive pulse, and '0' is represented by a negative pulse.
- Signal returns to zero within the bit duration.
- Mathematically:

$$x(t) = \begin{cases} +A & \text{for } 0 \leq t < T/2 \text{ (bit '1')} \\ -A & \text{for } 0 \leq t < T/2 \text{ (bit '0')} \\ 0 & \text{for } T/2 \leq t < T \end{cases}$$

Polar NRZ:

- A '1' is represented by a positive level, and '0' is represented by a negative level.
- Mathematically:

$$x(t) = \begin{cases} +A & \text{for } 0 \leq t < T \text{ (bit '1')} \\ -A & \text{for } 0 \leq t < T \text{ (bit '0')} \end{cases}$$

Bipolar NRZ:

- A '1' alternates between positive and negative levels, while '0' is represented by no pulse.
- Mathematically :

$$x(t) = \begin{cases} (+A \text{ or } -A) & \text{for } 0 \leq t < T \text{ (bit '1')} \\ 0 & \text{for } 0 \leq t < T \text{ (bit '0')} \end{cases}$$

Discussion

The MATLAB simulation of Delta Modulation and Line Coding demonstrated key principles and challenges in digital communication. Delta Modulation used a staircase waveform to approximate the input signal, with slope overload distortion in rapid changes and granular noise for small variations, both mitigated by step size optimization. Line Coding schemes, including Unipolar RZ/NRZ, Polar RZ/NRZ, and Bipolar NRZ, showed varied effects on DC components and spectral efficiency. Bipolar NRZ stood out for its ability to eliminate DC components, making it ideal for long-distance transmission, albeit with higher complexity. The simulation effectively highlighted the trade-offs and practical behavior of these techniques.

Conclusion

This lab demonstrated Delta Modulation and Line Coding in MATLAB, confirming theoretical concepts and practical considerations. Delta Modulation required step size optimization to reduce distortions, while Line Coding schemes revealed strengths and weaknesses, with Bipolar NRZ excelling in spectral efficiency. The exercise reinforced the importance of selecting parameters and coding schemes for efficient digital communication, laying a foundation for studying advanced techniques.

Reference:

- Communication System – Sanjay Sharma
- https://electronicspost.com/explain-delta-modulation-in-detail-with-suitable-diagram/
- https://www.tutorialspoint.com/digital_communication/digital_communication_delta_modulation.htm