EE451 LAB REPORT

LAB 2 – Delta Modulation

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Procedure

2.1 DM Modulator

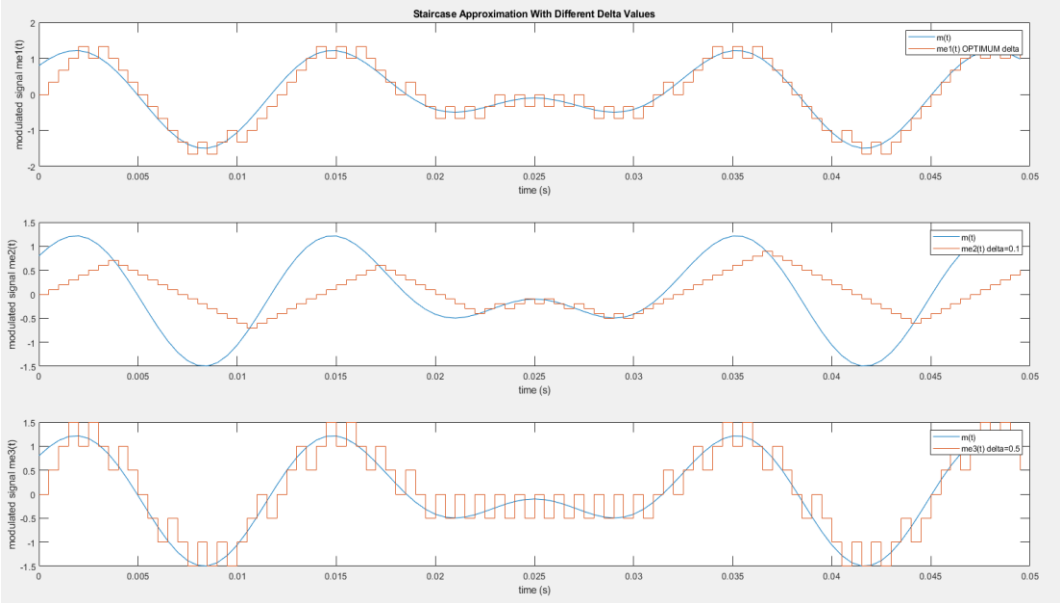

Figure 1: Staircase approximation of the original signal m(t) with different delta values

2.1.c. Comment

The limit step size (also defined as optimum delta) Δ which makes that the delta modulation has minimum granular noise and slope over distortion is found by the following formula:

- $\Delta \geq \max(\text{abs}(m_{der}(t))) / Ts$ (1)

, where m_{der} is derivative vector of the m(t) which is calculated as below:

```
for i = 1:(n-1)
    m_der(i) = (mt(i+1) - mt(i))/Ts;
end
```

2.2 DM Demodulator

Since the staircase approximated signal is not available form in order to use for decoding, there exists a requirement of an encoding operation that is calculated as below for modulations with different delta values:

```
encoder1(1) = 0;
for k=2:n
    if(sign(err1(k)) == 1)
        encoder1(k) = 1;
    else
        encoder1(k) = 0;
    end
end
encoder2(1) = 0;
for k=2:n
    if(sign(err2(k)) == 1)
        encoder2(k) = 1;
    else
        encoder2(k) = 0;
    end
end
encoder3(1) = 0;
for k=2:n
    if(sign(err3(k)) == 1)
        encoder3(k) = 1;
    else
        encoder3(k) = 0;
    end
end
```

This operation provides an encoded input for demodulation process such as the figure below:

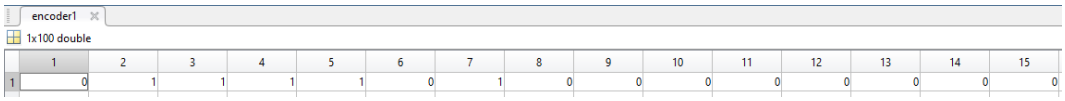

Figure 2: Encoded signal with minimum slope overload distortion step size

The encoded signal as input of the demodulation is transmitted through the delayed adder process to provide triangular approximation of the original signal. After a digital low-pass filter, reconstructed message signal is obtained.

3 Results

3.5 Comment

According to the equation (1) from the first page, it is understood that minimum slope overload distortion provides the optimum reconstruction. While comparing two reconstructions with delta=0.1 and delta=0.5, it can be obtained that if step size value is not greater or equal to the value for minimum slope overload distortion, then reconstruction is not correct. Also higher values provides more inaccurate reconstructions.

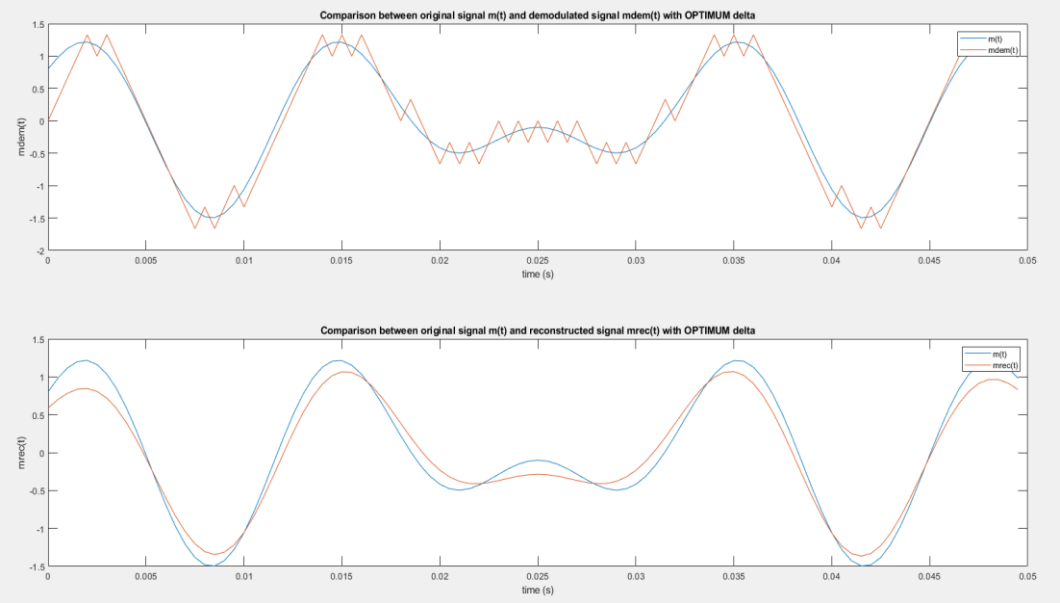

Figure 3: Comparison between original signal m(t), demodulated and reconstructed signals with optimum delta value

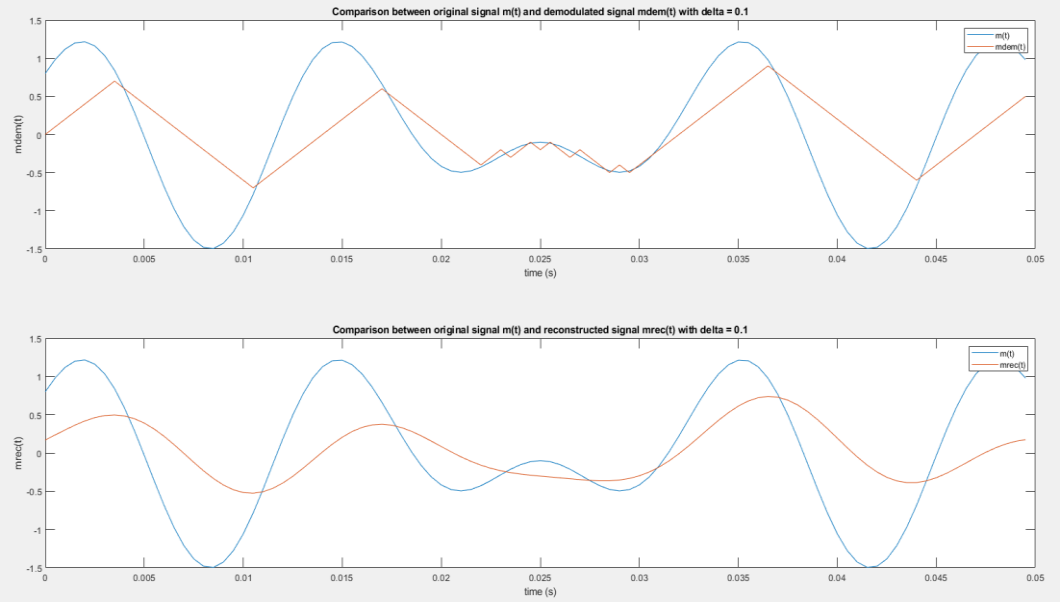

Figure 4: Comparison between original signal m(t), demodulated and reconstructed signals with delta=0.1

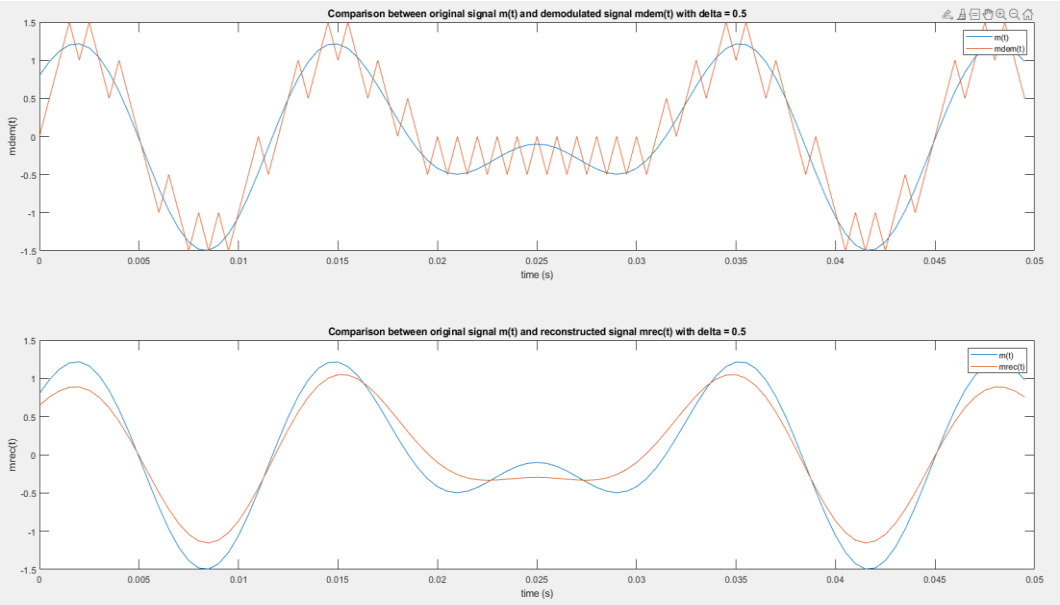

Figure 5: Comparison between original signal m(t), demodulated and reconstructed signals with delta=0.5

4 Remaining Questions for the Report

Q1. We give three different step size values. For which value does slope overload distortion? When does slope overload distortion occur?

A1. In delta modulation and demodulation, slope over distortion occurs when the rate of change (slope) of the input signal exceeds the maximum rate at which the delta modulation system can follow. This distortion occurs during the quantization process, where the continuous input signal is approximated by a staircase-like digital signal with fixed step sizes. In this configuration, there occurs slope overload distortion for delta=0.1.

Q2. We give three different step size values. For which value it occurs Granular noise? When does Granular noise occur?

A2. Granular noise in delta modulation typically occurs when the step size (delta) is relatively large compared to the magnitude of the signal's variations. It is more likely to occur with larger delta values. In this case, it is likely to observe granular noise with the third delta value, which is 0.5, as it is relatively large compared to the variations in modulating signal. The optimum delta value should provide a good balance to minimize granular noise and slope overload distortion for the specific signal.

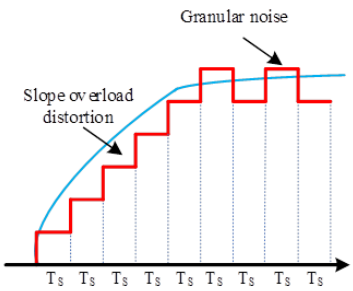

Figure 6: Slope overload distortion and Granular noise

Conclusion

In conclusion, this lab experiment provided insights into the performance of DPCM with different quantization step sizes. It was observed that an optimum delta resulted in the most faithful reproduction of the original signal, while lower or larger deltas led to increased slope overload distortion or granular noise in the demodulated and reconstructed signals. These results emphasize the importance of selecting an appropriate quantization step size in DPCM systems to achieve the desired level of fidelity in signal reconstruction.

Note: DM is the simplest form of differential pulse-code modulation (DPCM) where the difference between successive samples is encoded into n-bit data streams.