

EEL4330 : SPEECH PROCESSING

Assignment-1 Report

Dhruv Shah (B20EE017)

Signals

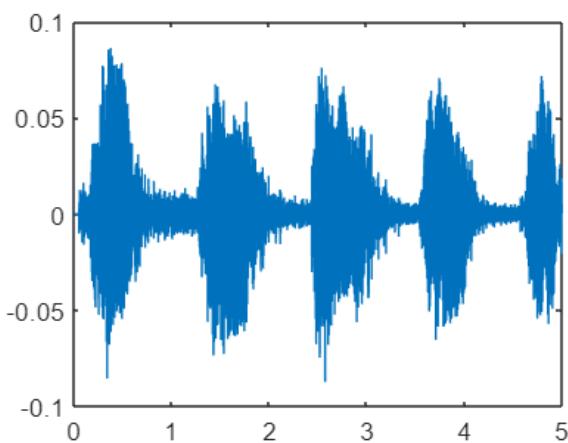


Figure 1: Signal 1 ($F_s = 8000\text{Hz}$)

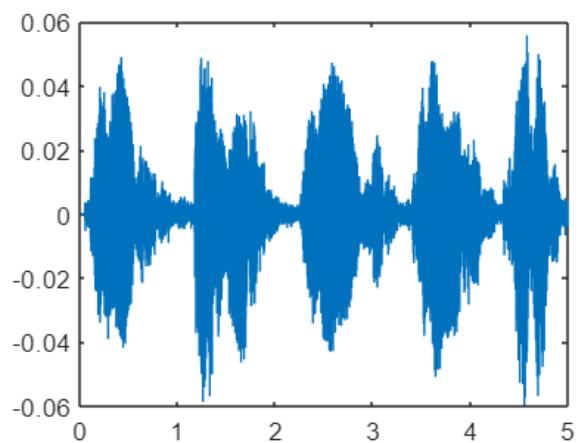


Figure 2: Signal 2 ($F_s = 1000\text{Hz}$)

Short Time Fourier Transform

Signal 1

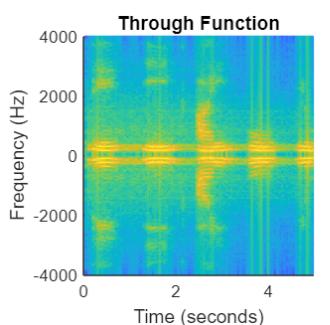


Figure 3: Rectangular Window

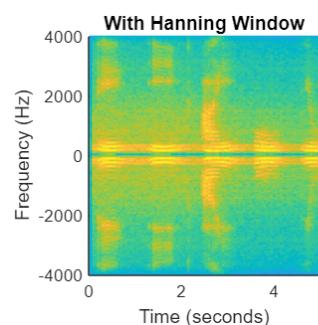


Figure 4: Hanning Window

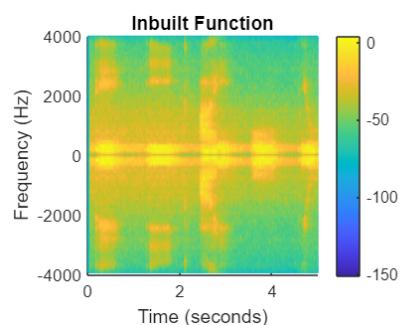


Figure 5: Inbuilt Function

Signal 2

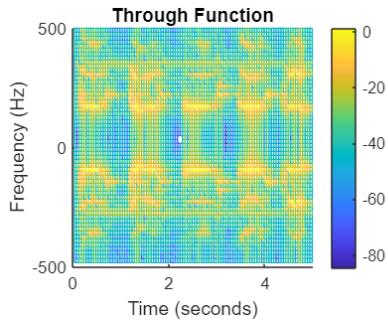


Figure 6: Rectangular Window

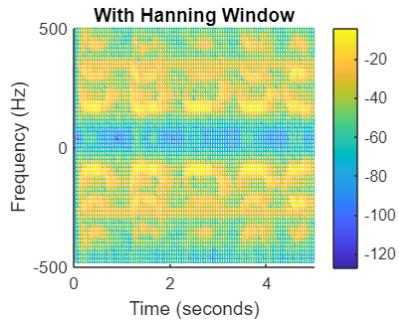


Figure 7: Hanning Window

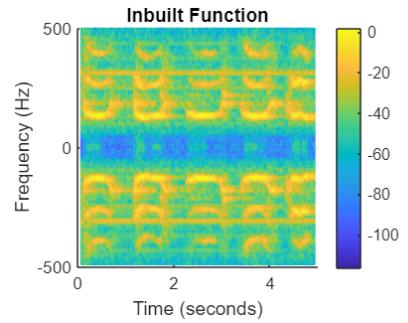


Figure 8: Inbuilt Function

Linear Predictive Coding

Levinson Durbin Algorithm

Signal 1

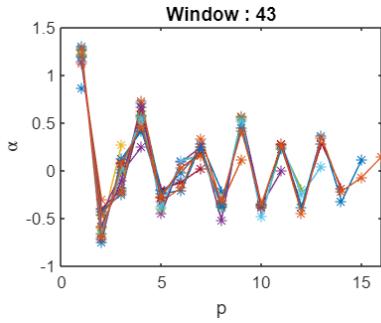


Figure 9: Coefficients

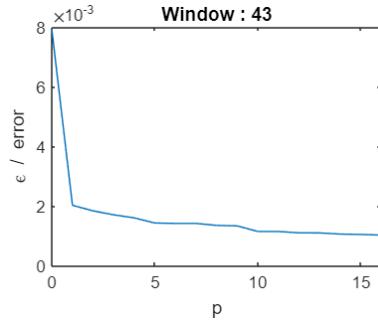


Figure 10: ϵ^p

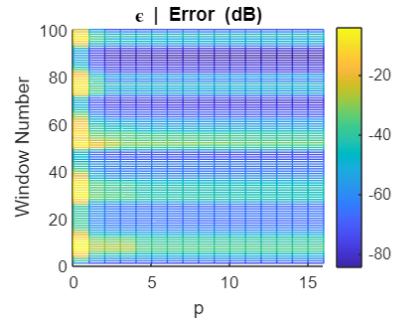


Figure 11: All ϵ^p

- Figure 9 : Coefficients of order 1 to 16 for a randomly selected window (here 46th).
- Figure 10 : ϵ^p values for p from 0 to 16 for the same window.
- Figure 11 : ϵ^p for all windows. All values decrease with p.

Signal 2

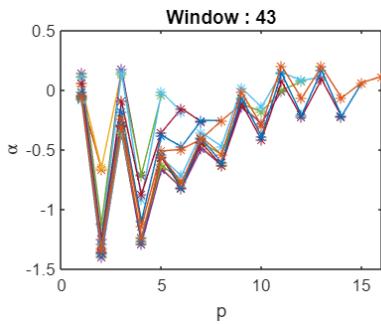


Figure 12: Coefficients

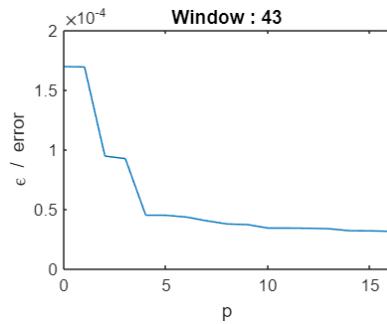


Figure 13: ϵ^p

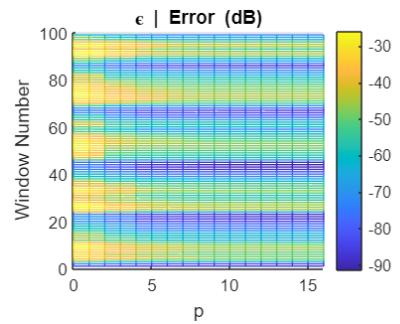
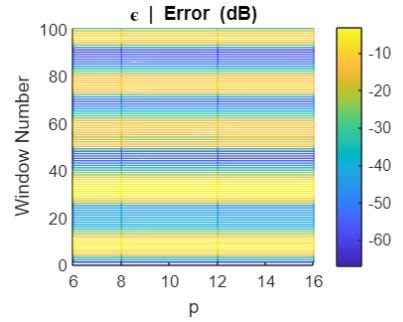
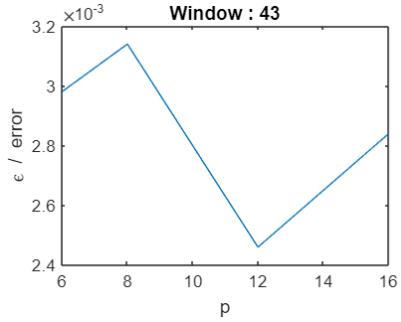
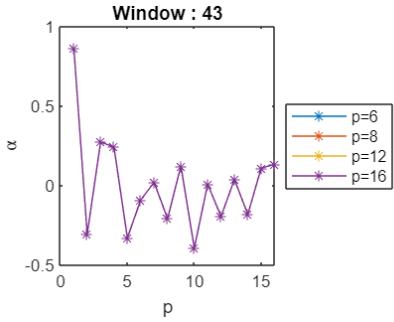


Figure 14: All ϵ^p

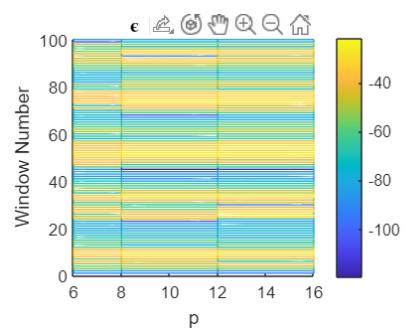
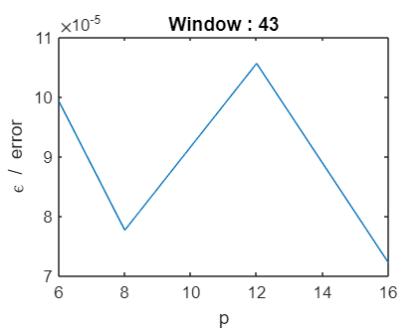
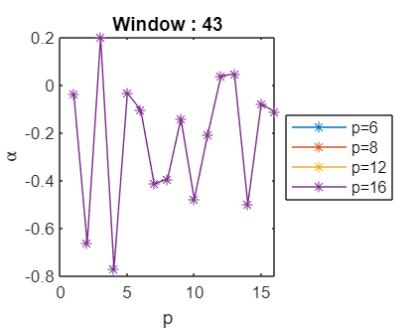
Cholesky Decomposition Method

Signal 1

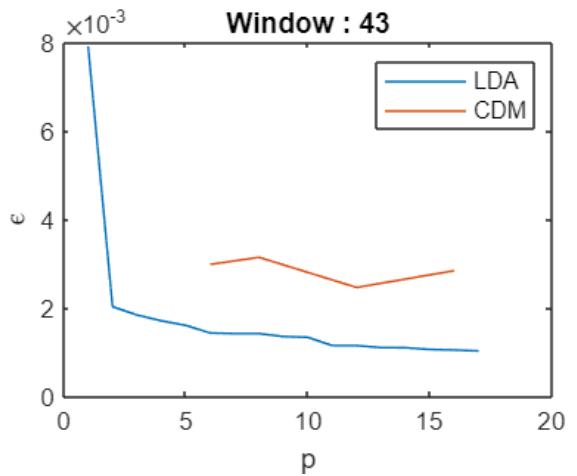
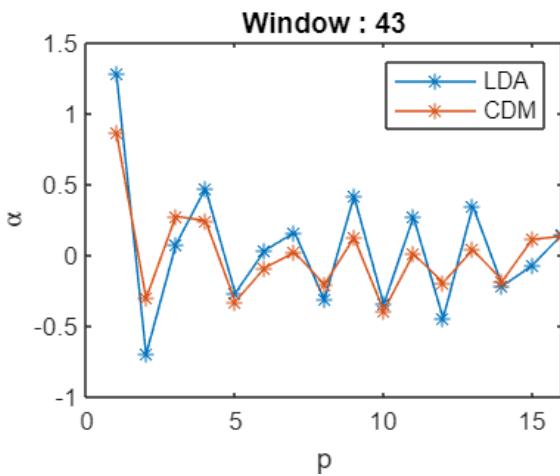


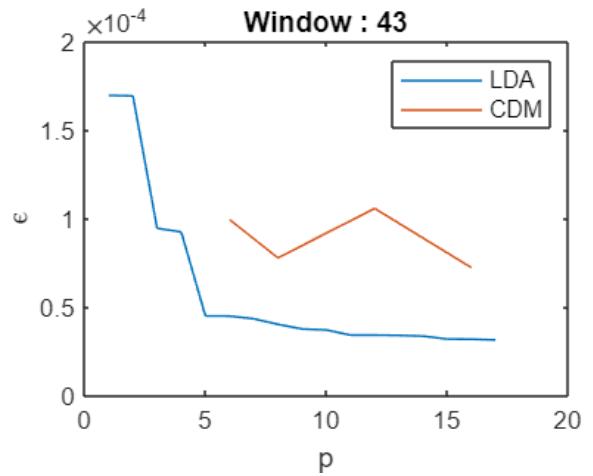
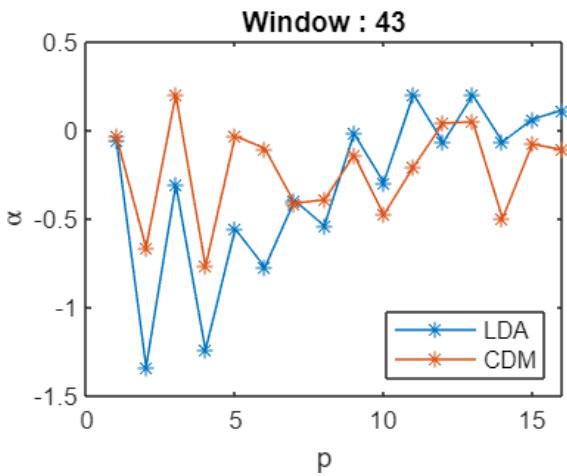
Coefficients found for p value 6, 8, 12 and 16. Figure 15 shows that α_i for any order comes the same.

Signal 2

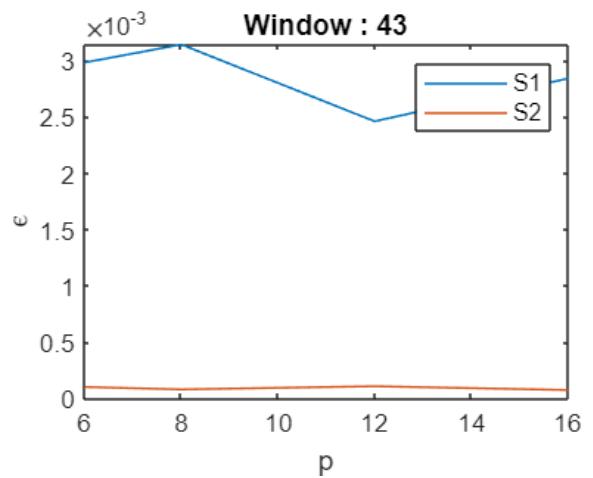
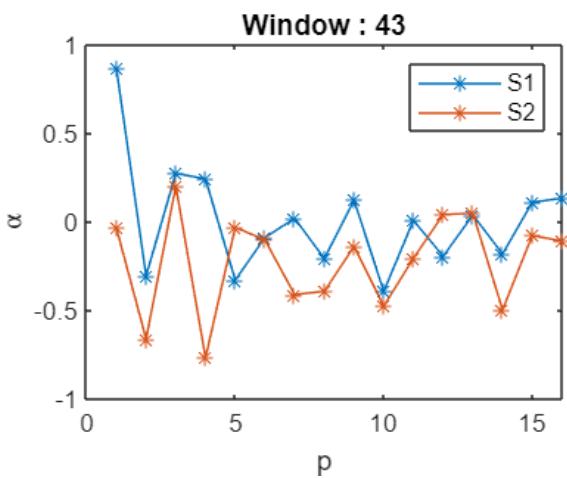
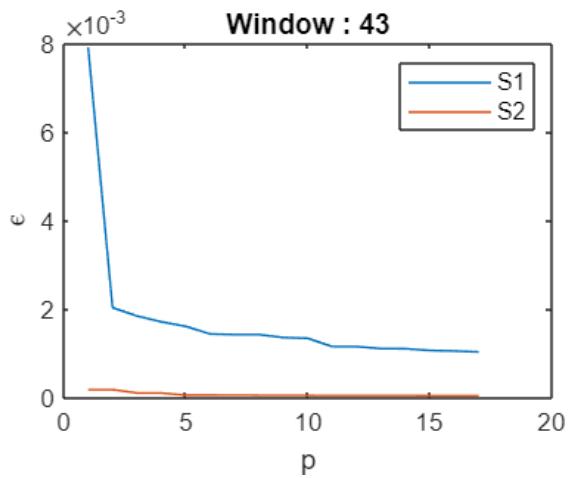
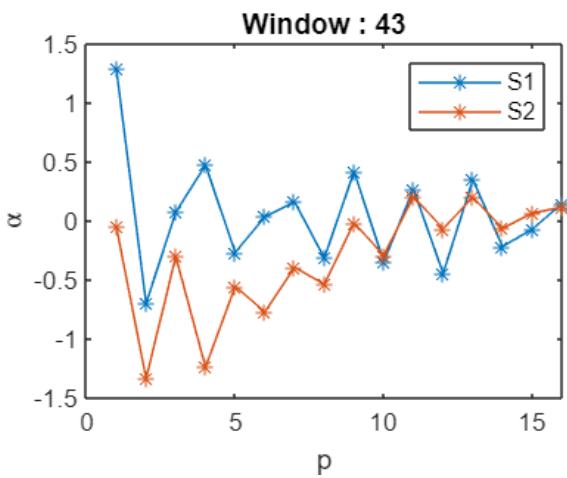


Compression of LDA and CDM





Compression of Signal 1 and Signal 2



Histogram

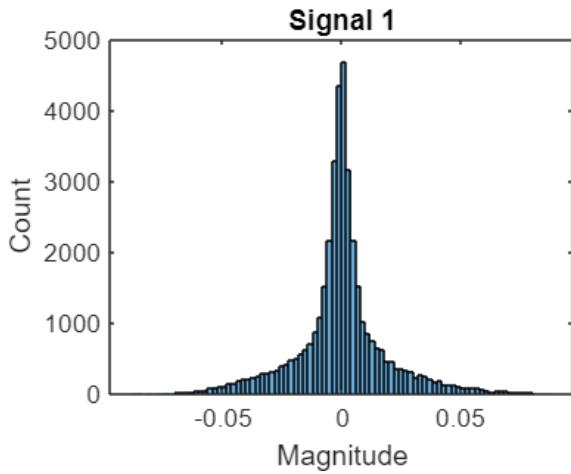


Figure 29: Signal 1

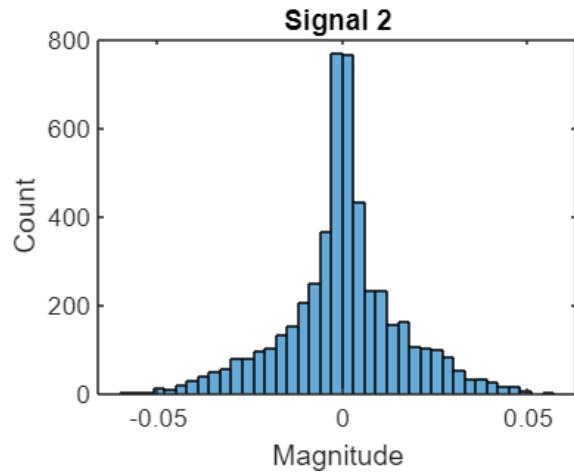


Figure 30: Signal 2

Figure 29 and figure 30 shows that speech signals follow Laplace distribution.

Uniform Quantization

- Original speech signal, quantised speech signal and quantization error for different bits.
- Histogram of error signal. Found nearly uniform.

Signal 1

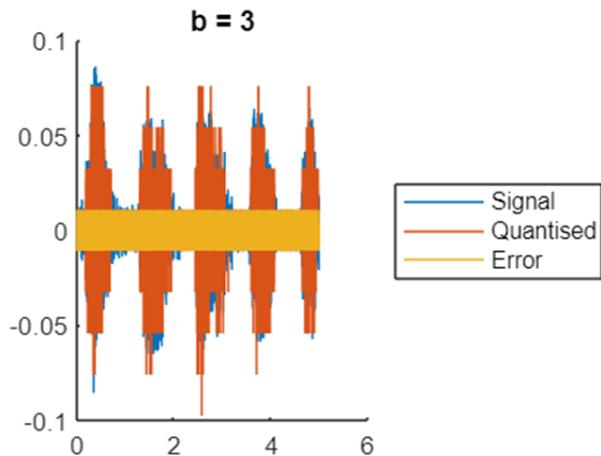


Figure 31: Signals

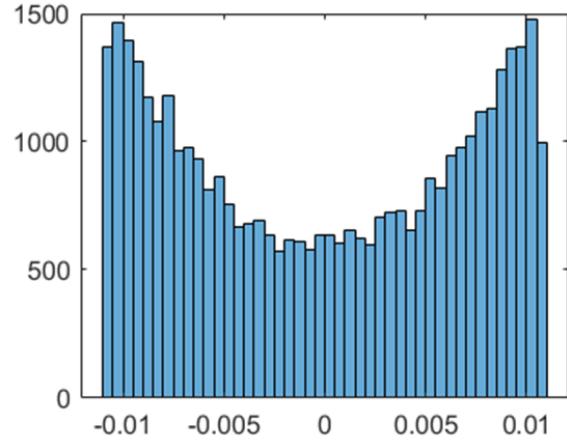


Figure 32: Histogram

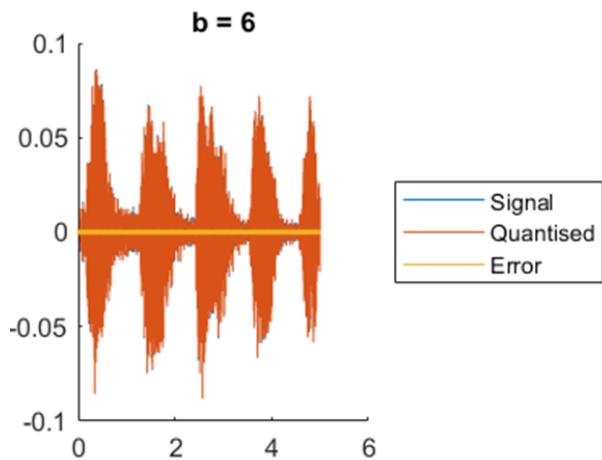


Figure 33: Signals

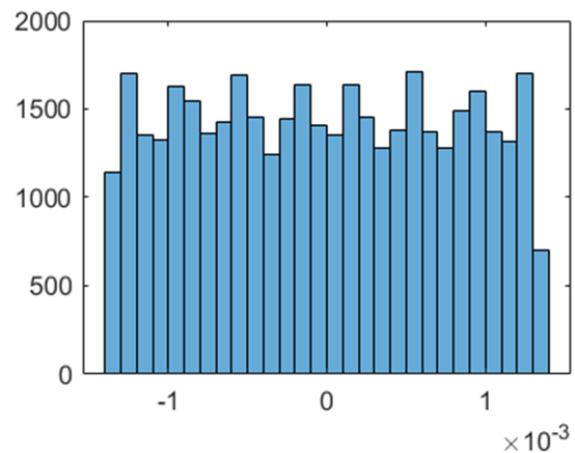


Figure 34: Histogram

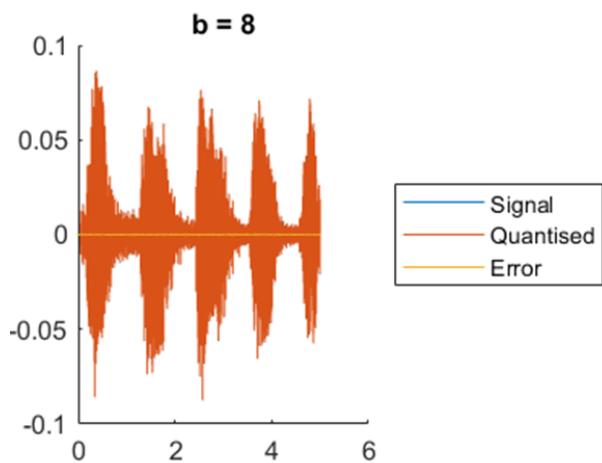


Figure 35: Signals

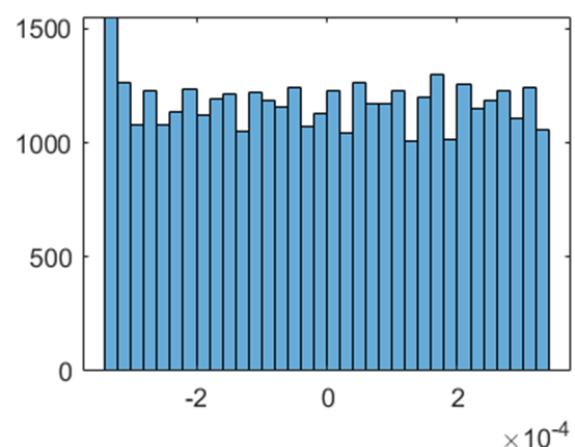


Figure 36: Histogram

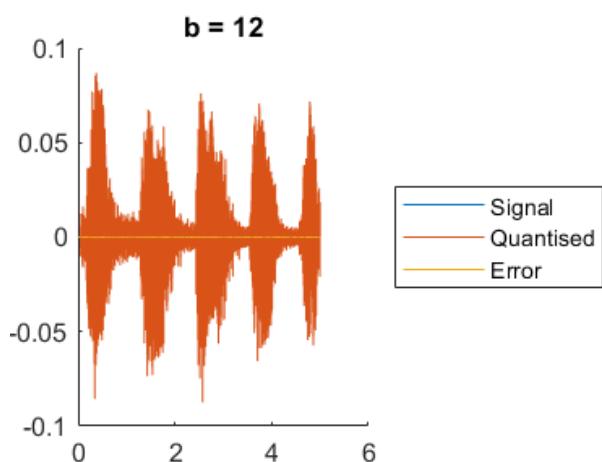


Figure 37: Signals

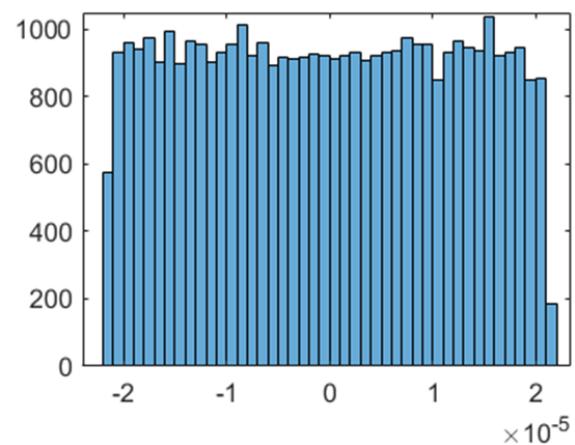


Figure 38: Histogram

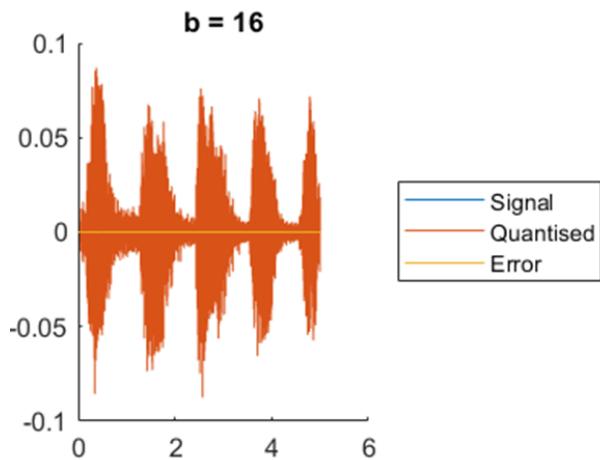


Figure 39: Signals

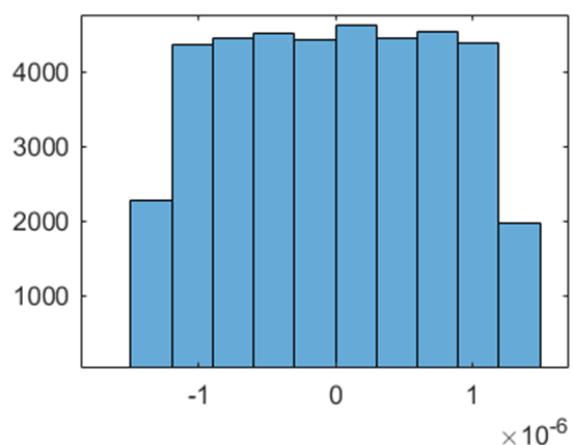


Figure 40: Histogram

Signal 2

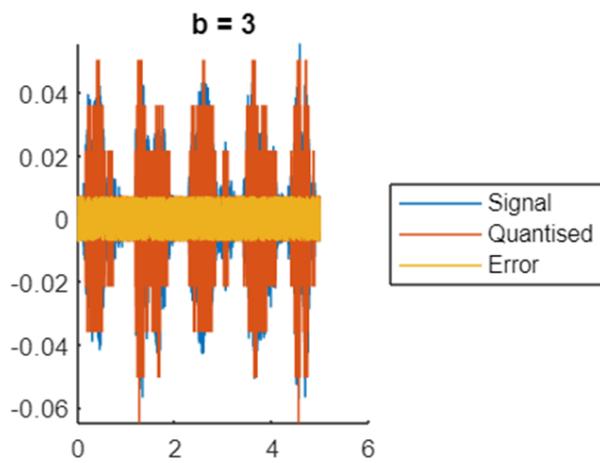


Figure 41: Signals

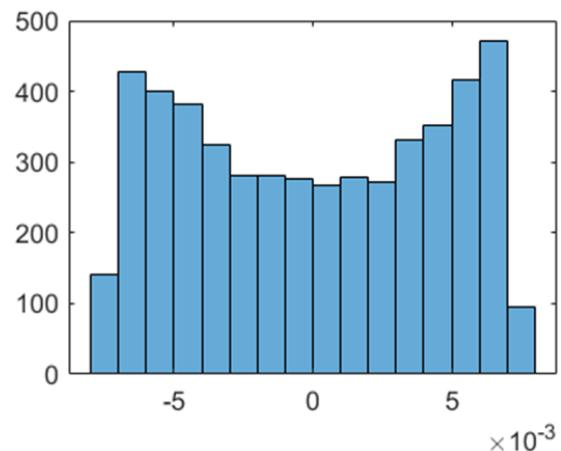


Figure 42: Histogram

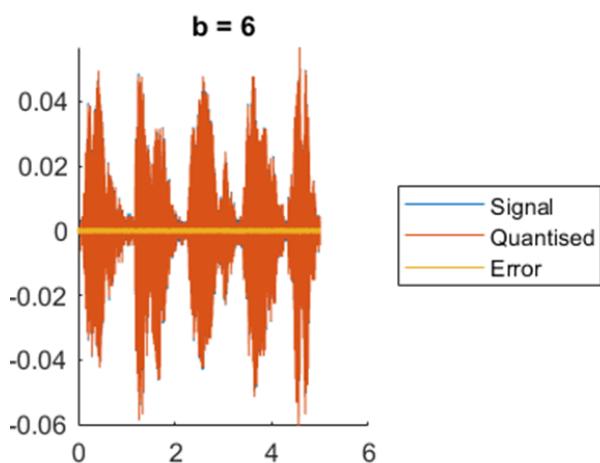


Figure 43: Signals

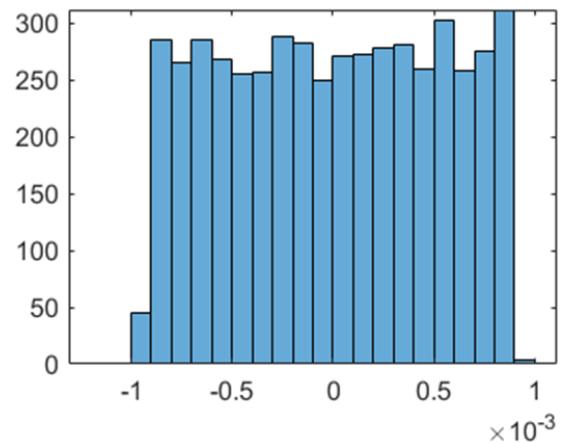


Figure 44: Histogram

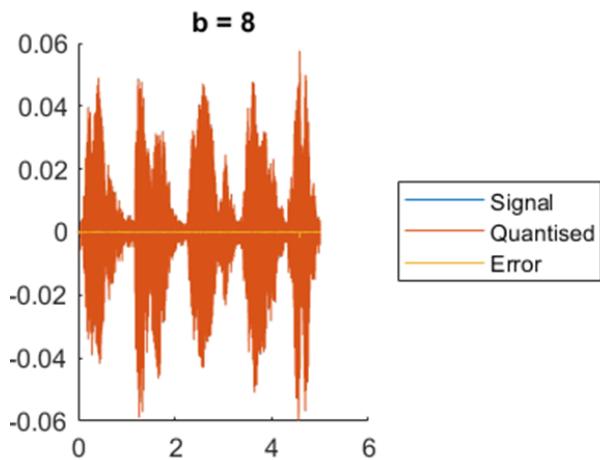


Figure 45: Signals

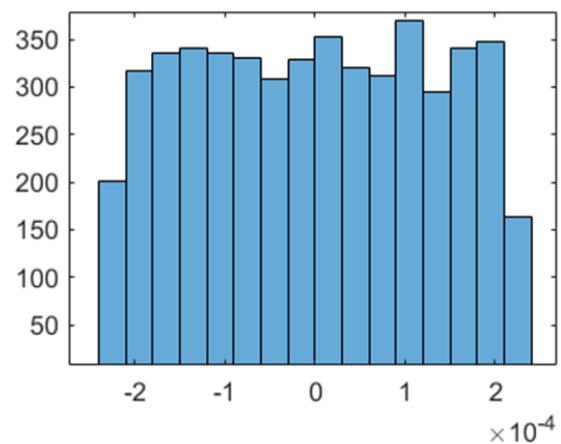


Figure 46: Histogram

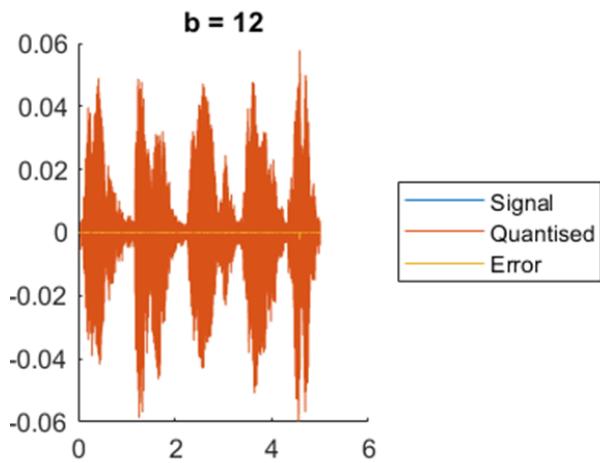


Figure 47: Signals

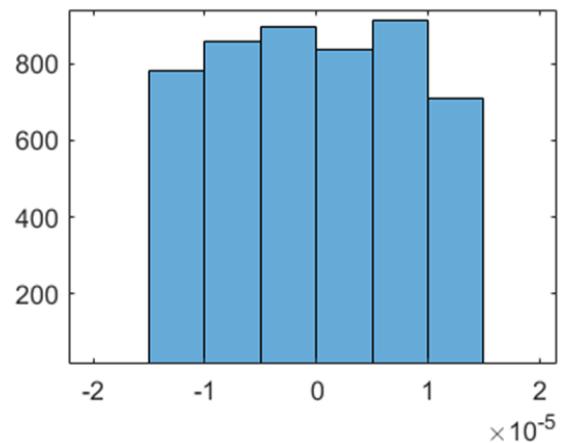


Figure 48: Histogram

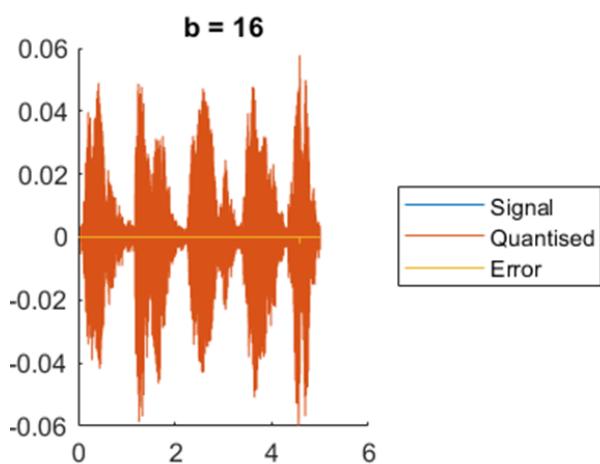


Figure 49: Signals

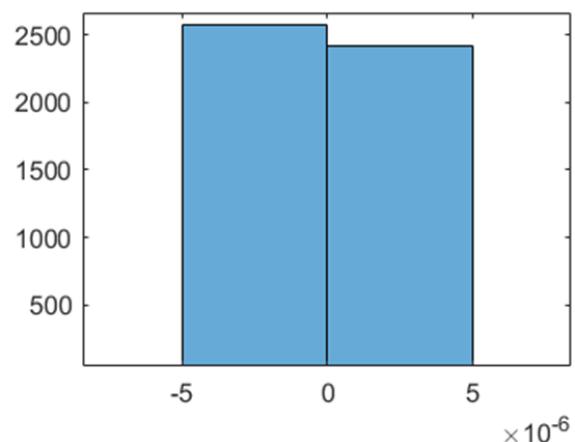


Figure 50: Histogram

μ -Law Compression

Signal 1

- Signal 1 compressed with $\mu = 60$ to get near to uniform histogram of signal.

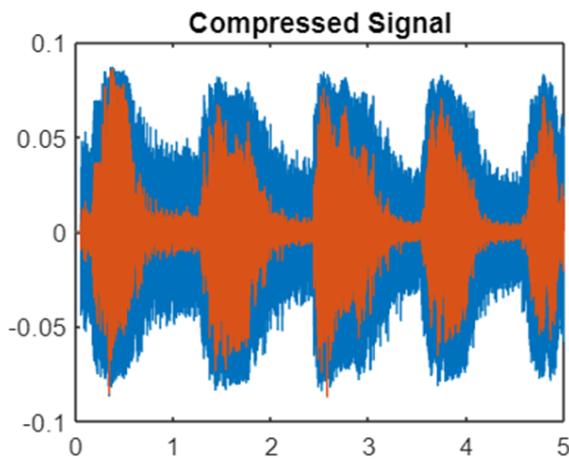


Figure 51: Compressed Signal

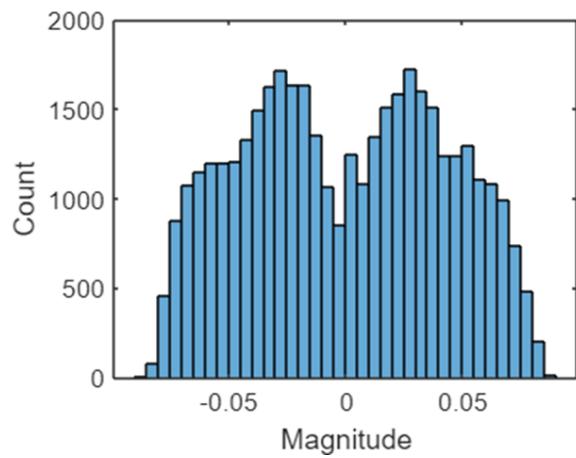


Figure 52: Histogram

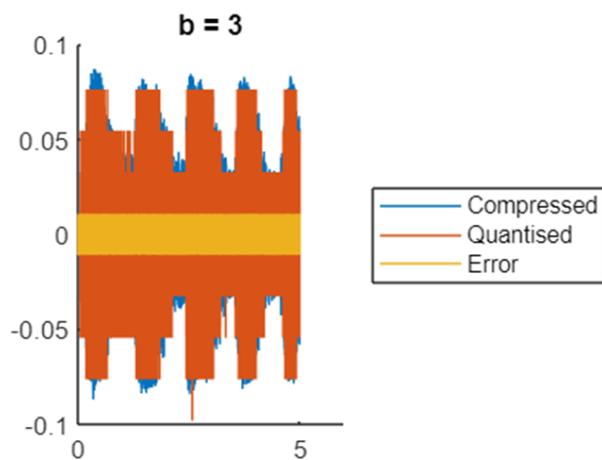


Figure 53: Signals

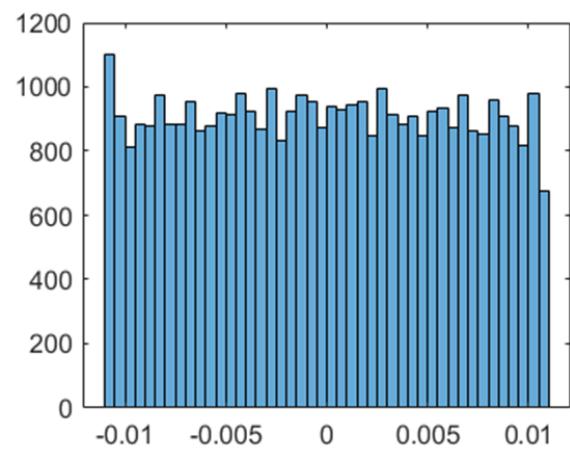


Figure 54: Histogram

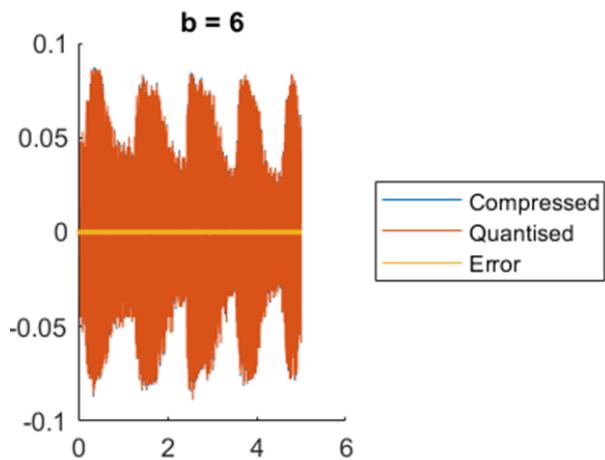


Figure 55: Signals

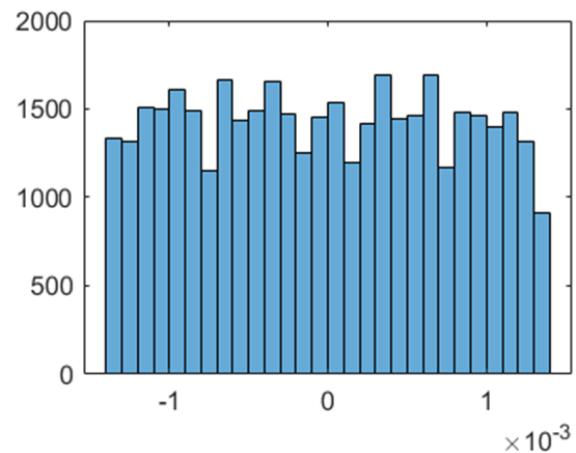


Figure 56: Histogram

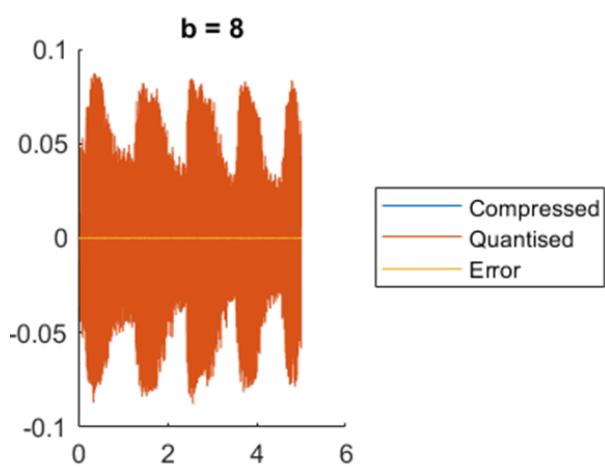


Figure 57: Signals

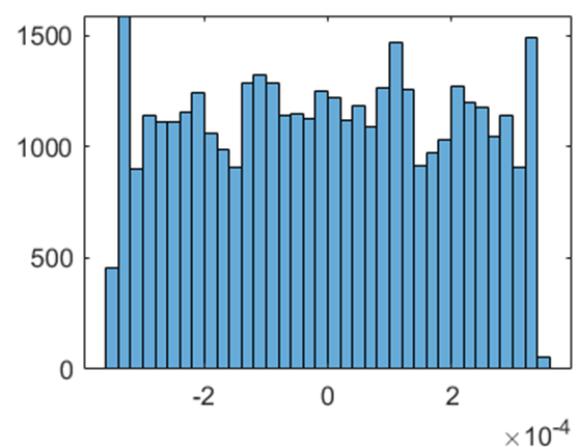


Figure 58: Histogram

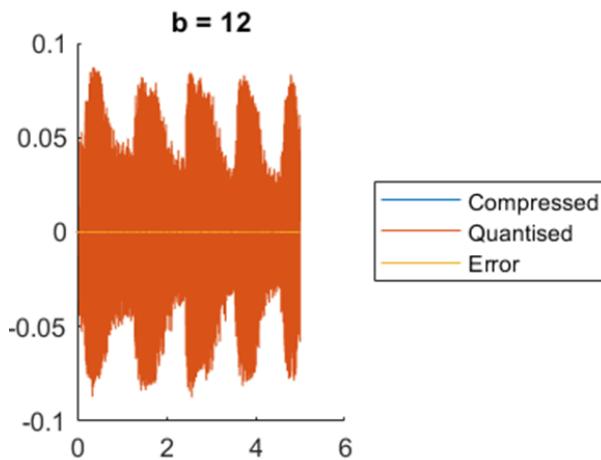


Figure 59: Signals

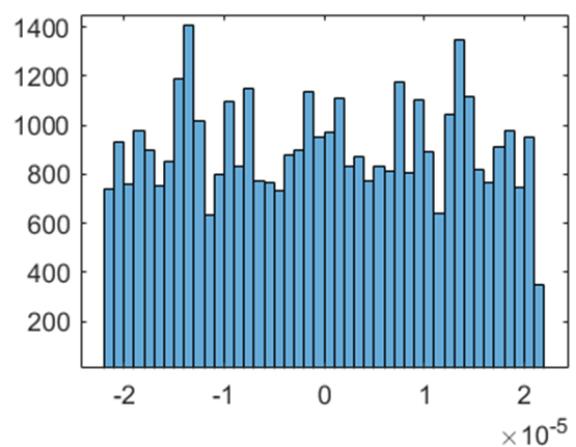


Figure 60: Histogram

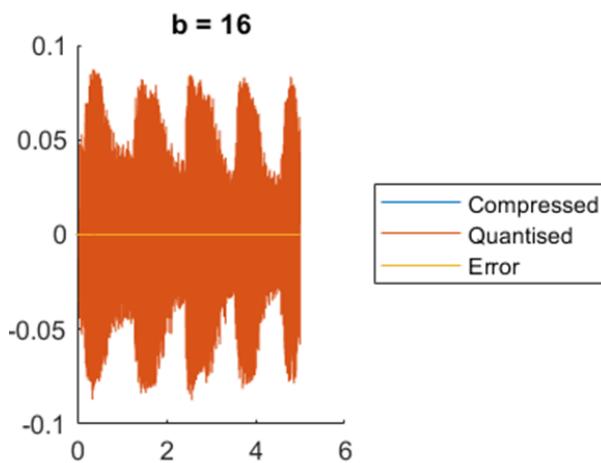


Figure 61: Signals

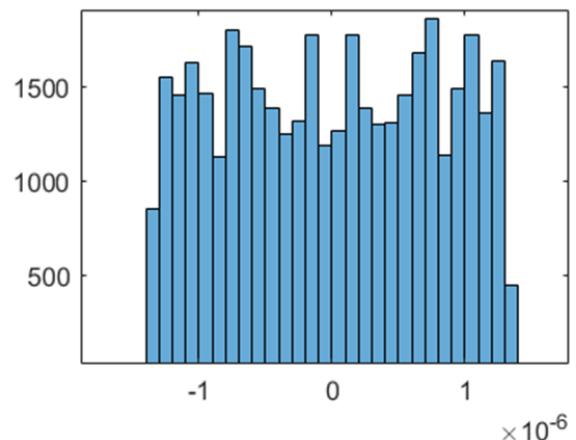


Figure 62: Histogram

Signal 2

- Signal 2 compressed with $\mu = 40$ to get near to uniform histogram of signal.

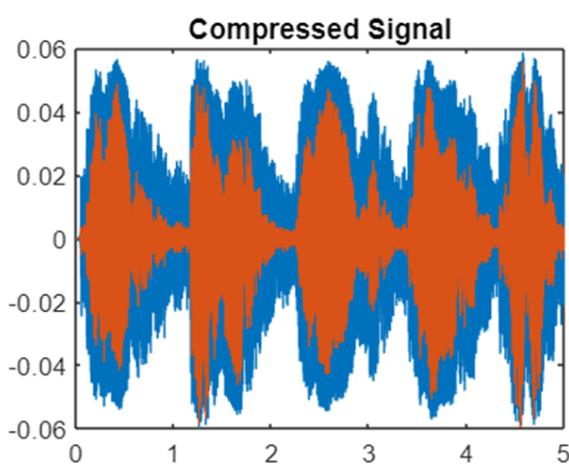


Figure 63: Compressed Signal

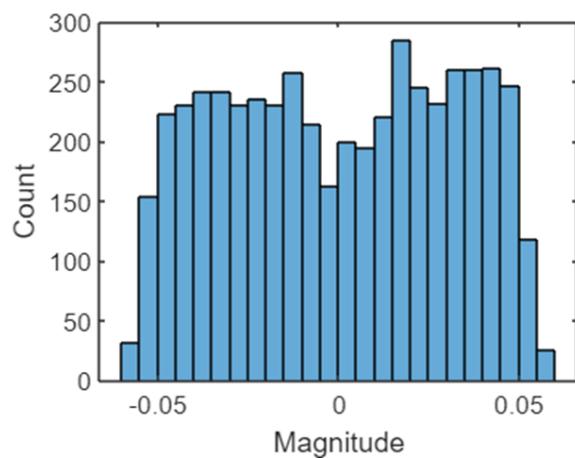


Figure 64: Histogram

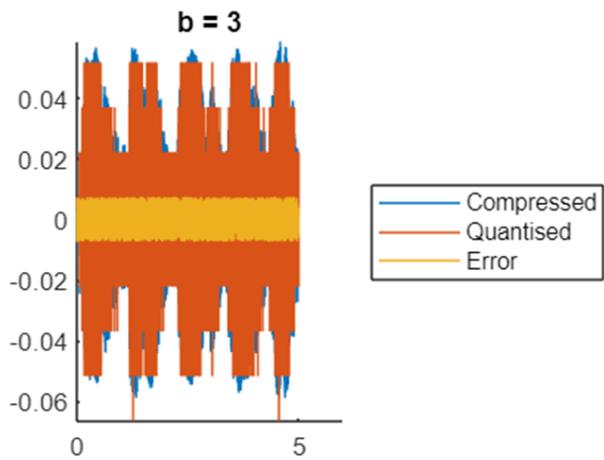


Figure 65: Signals

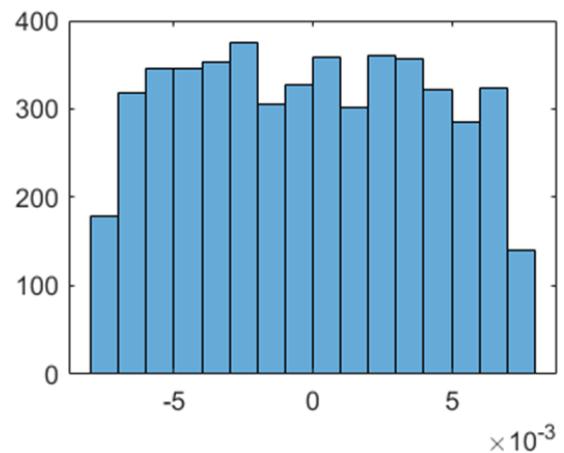


Figure 66: Histogram

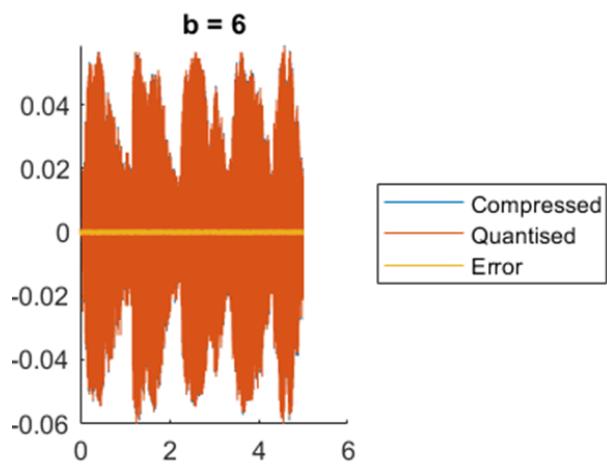


Figure 67: Signals

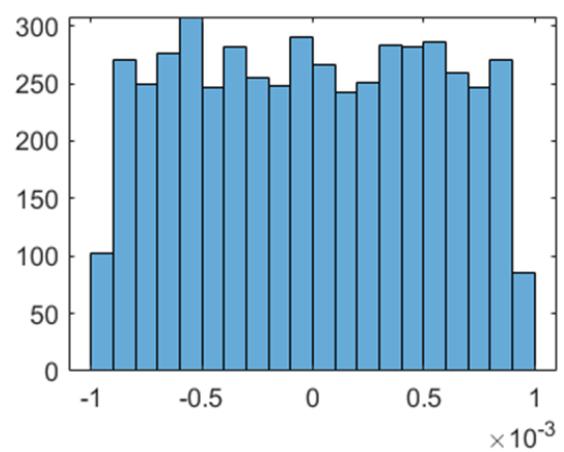


Figure 68: Histogram

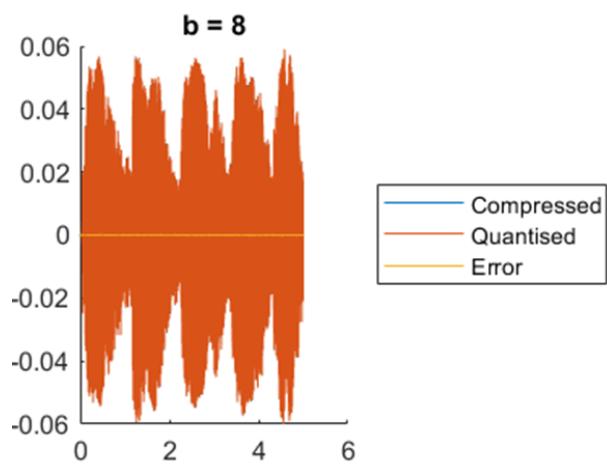


Figure 69: Signals

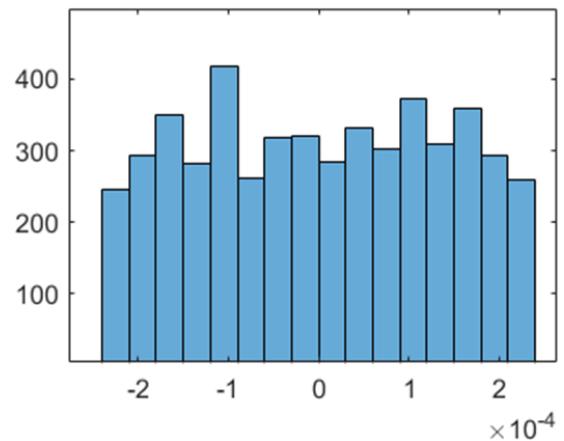


Figure 70: Histogram

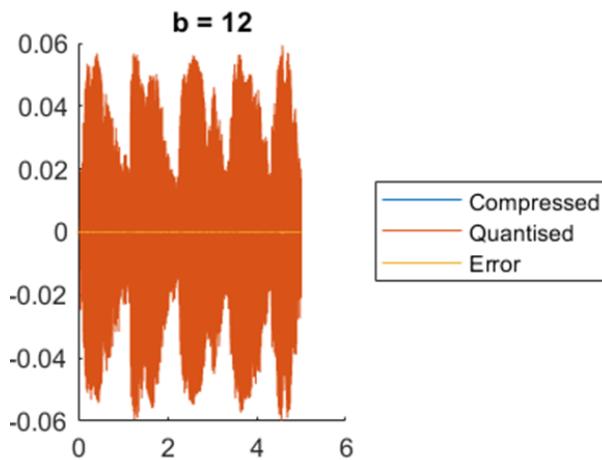


Figure 71: Signals

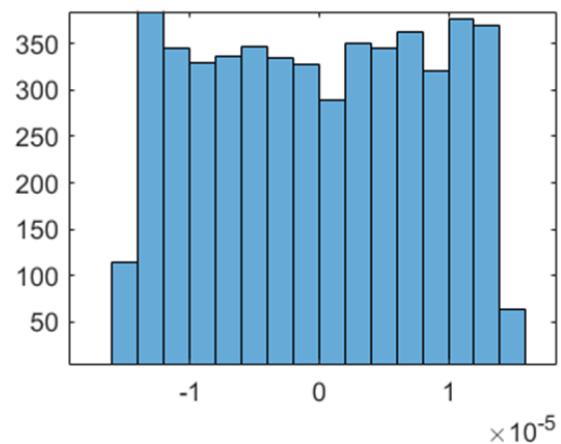


Figure 72: Histogram

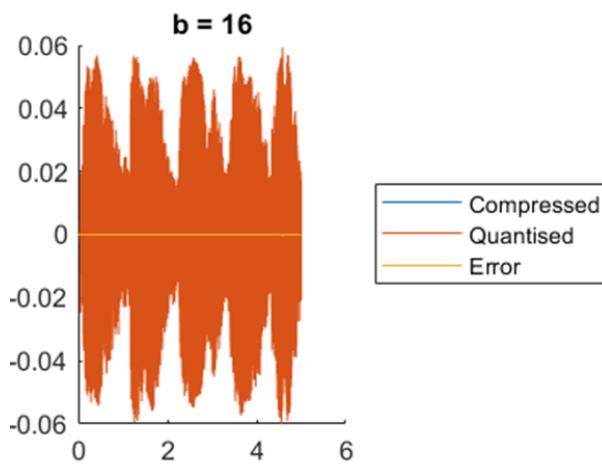


Figure 73: Signals

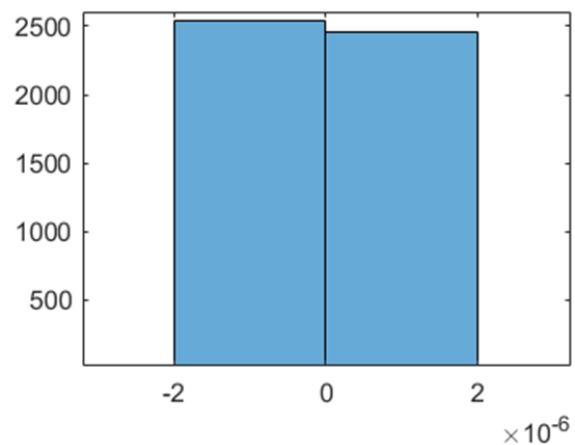


Figure 74: Histogram

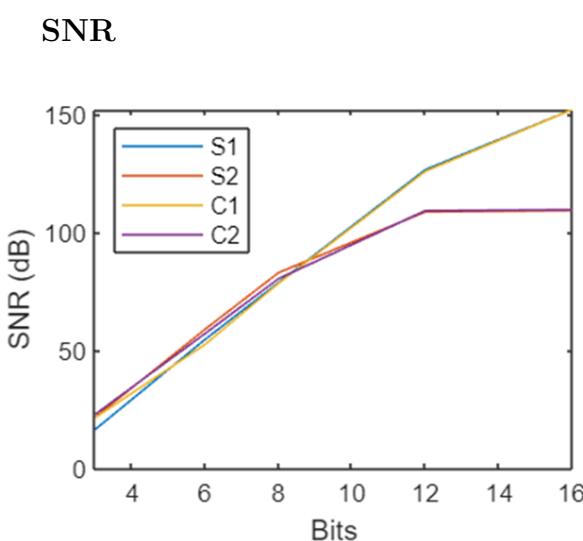


Figure 75: SNR

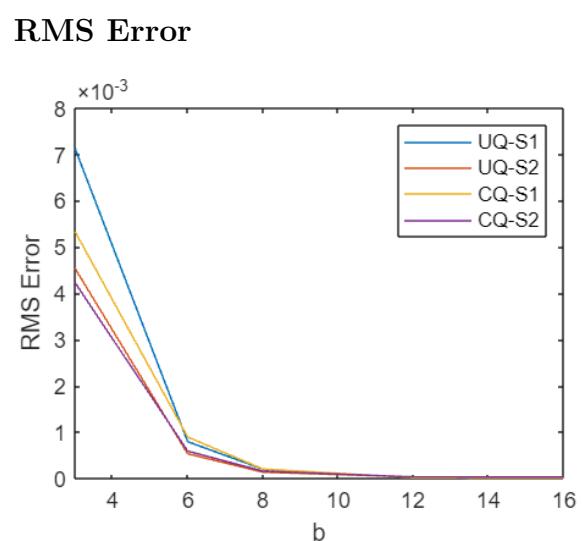


Figure 76: Quantization Error

- For low b SNR is almost same but for high b good SNR is observed for 8000 Hz sampled signal.
- UQ - Uniform Quantization , CQ - Compressed Quantization
- For low b Compression technique is giving less error. For high b very less difference is observed.
- Quantization error for 1000 Hz sampling rate is less than that of 8000 Hz sampling rate.

Mel-Frequency Cepstral Coefficients

Signal 1

- In signal 1, 22 mel-filters are used for analysis.

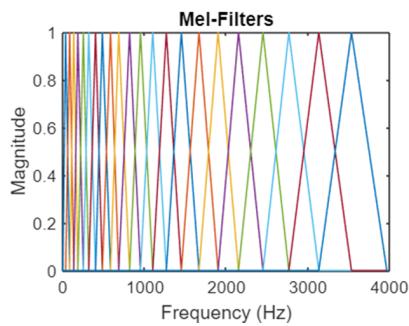


Figure 77: Mel-Filters

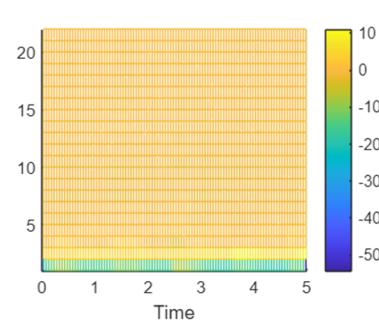


Figure 78: MFCC

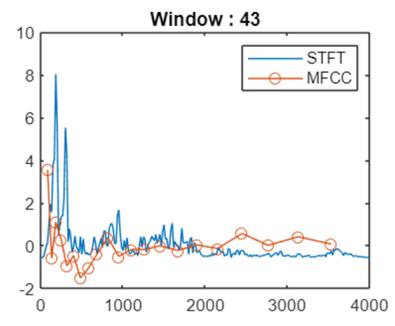


Figure 79: STFT v/s MFCC

Signal 2

- In signal 2, 20 mel-filters are used for analysis.

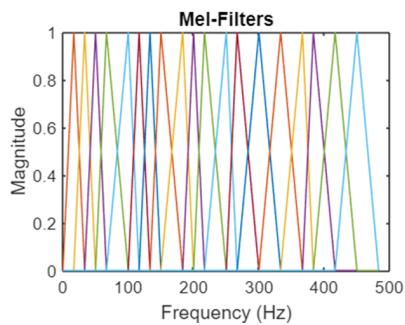


Figure 80: Mel-Filters

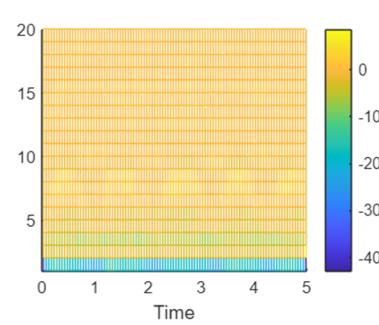


Figure 81: MFCC

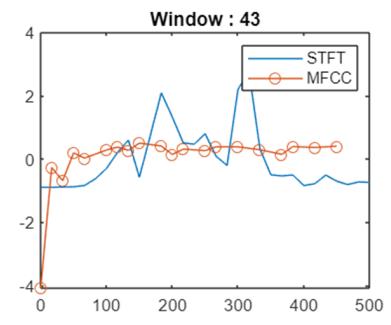


Figure 82: STFT v/s MFCC

MFCC of Different Speaker

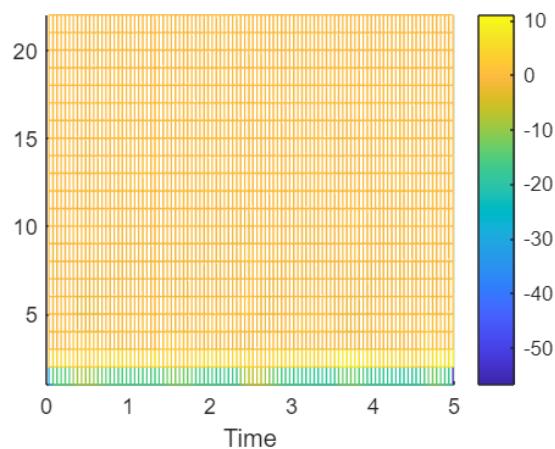


Figure 83: $F_s = 8000$ Hz

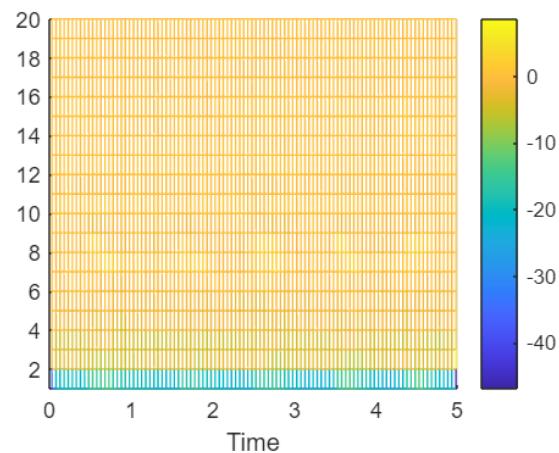


Figure 84: $F_s = 1000$ Hz

- MFCC of the different speaker has almost similar pattern.
- The euclidean distance between the mfccs of both speaker is high.