COMM THEORY REPORT

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Abstract

Simulation of a communication block using matlab to analyze and simulate a specific signal and to perform some operations.

1-Sampling:

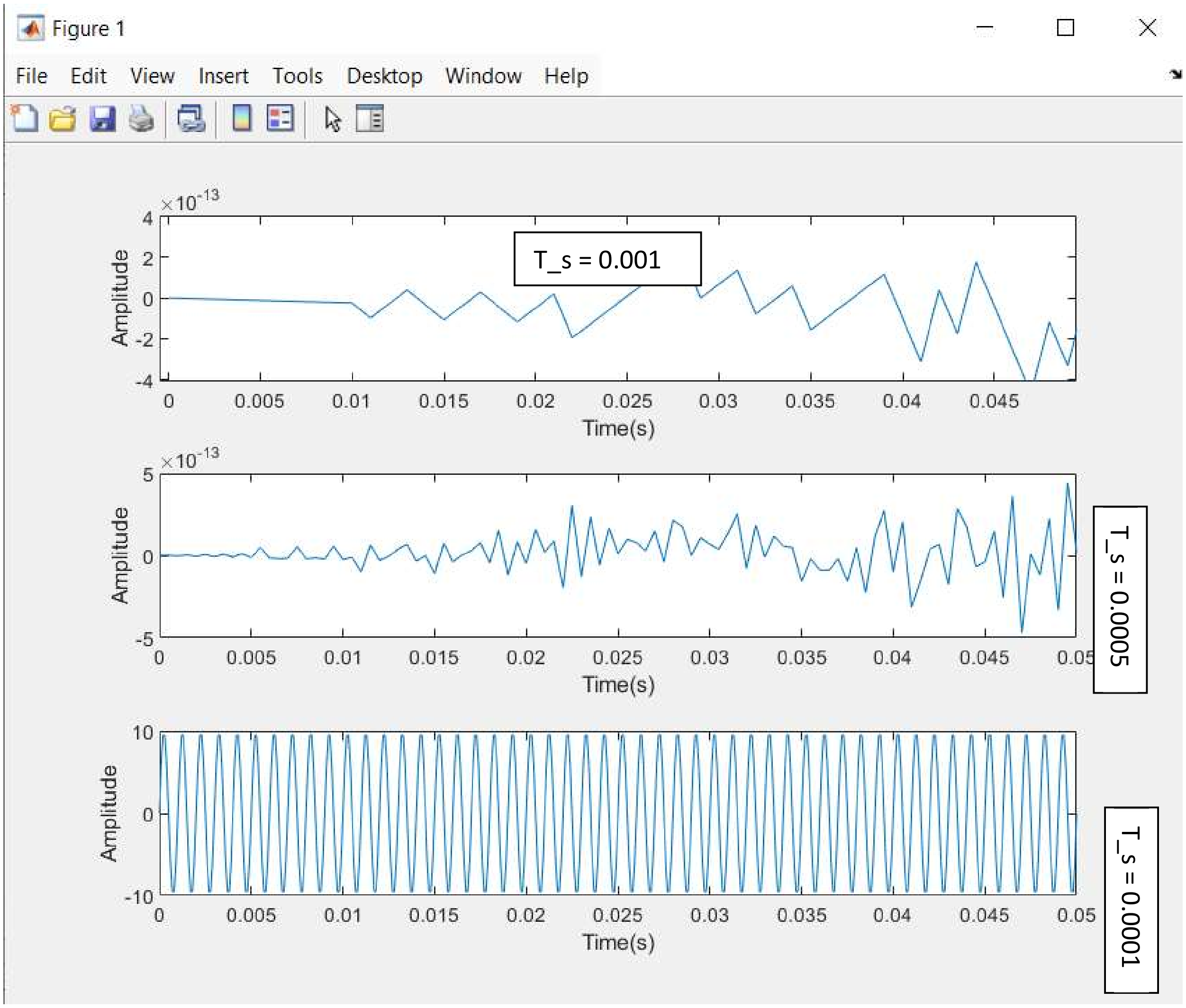


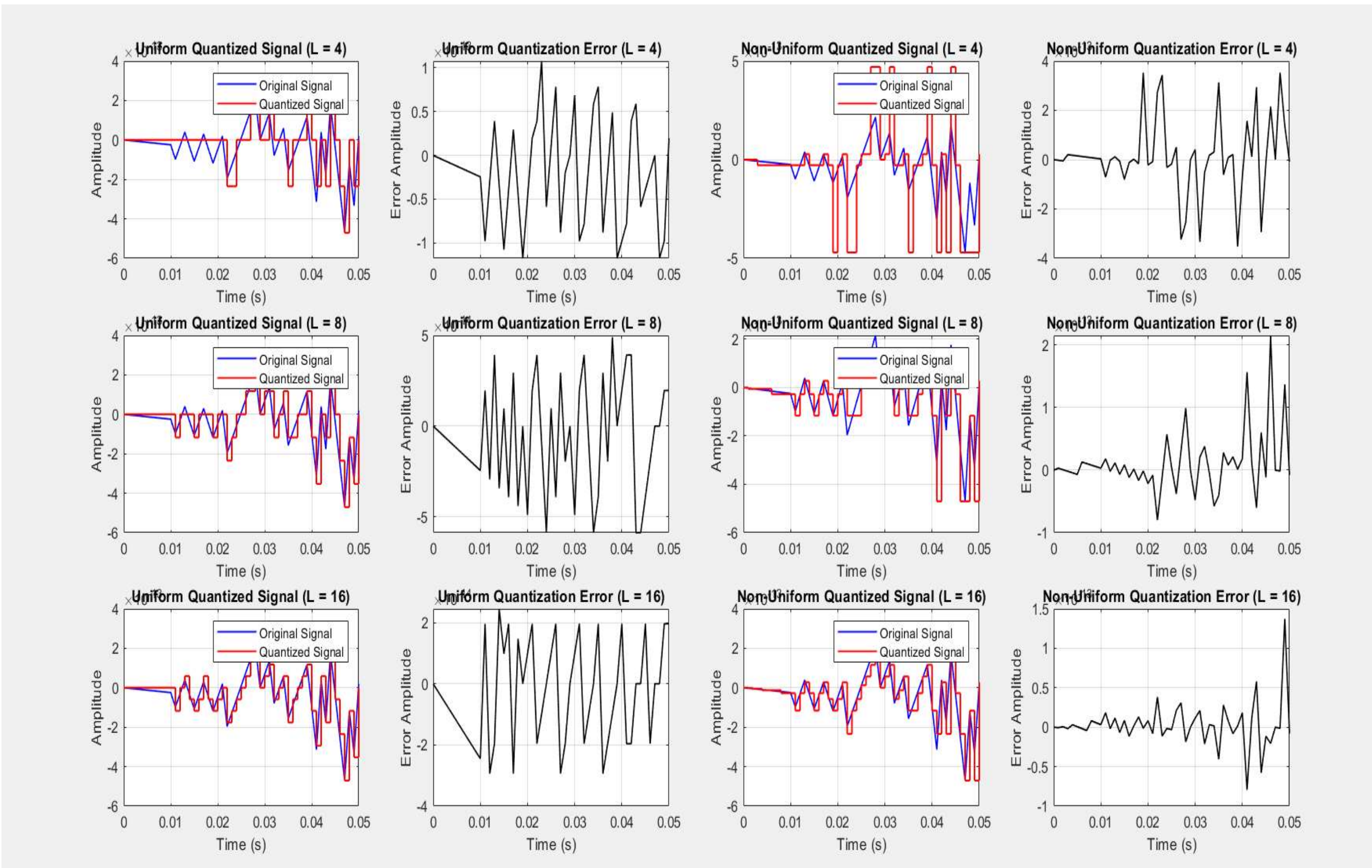
Figure 1
File Edit View Insert Tools Desktop Window Help
T_s = 0.001
T_s = 0.0005
T_s = 0.0001
Amplitude
Time(s)

2- Quantization:

Applied a uniform quantizer for every L and plotted the error for it and from the graphs we can conclude that when the L increases the error decreases.

Applied a non-uniform quantizer for every L with a μ = 0.255 and also plotted the error for each L.

When comparing both the uniform and non-uniform quantizers, we can conclude that the non-uniform has less errors due to the reduction of quantization noise.



3-Quantization Error Analysis:

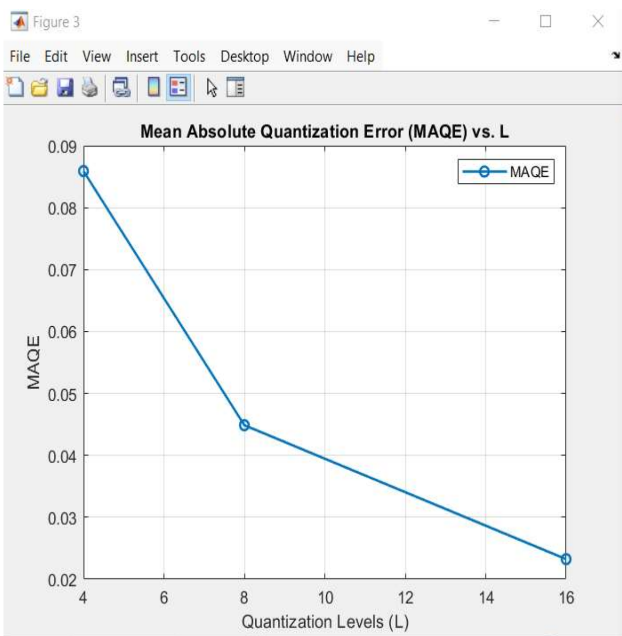
Values calculated of MAQE and Variance for every L

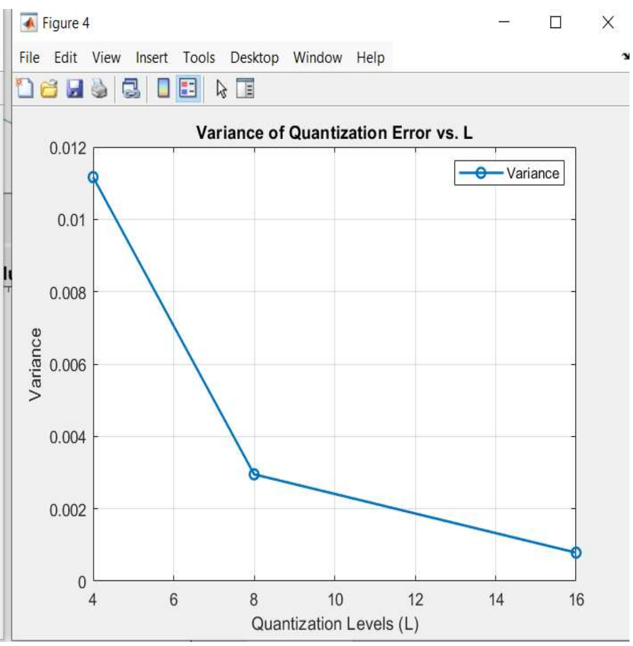
```
>> Project
For L = 4:
  Mean Absolute Quantization Error (MAQE): 0.0859
  Variance of Quantization Error: 0.0112

For L = 8:
  Mean Absolute Quantization Error (MAQE): 0.0449
  Variance of Quantization Error: 0.0030

For L = 16:
  Mean Absolute Quantization Error (MAQE): 0.0232
  Variance of Quantization Error: 0.0008
```

Graphs:





4- Signal-to-Quantization Noise Ratio (SQNR):

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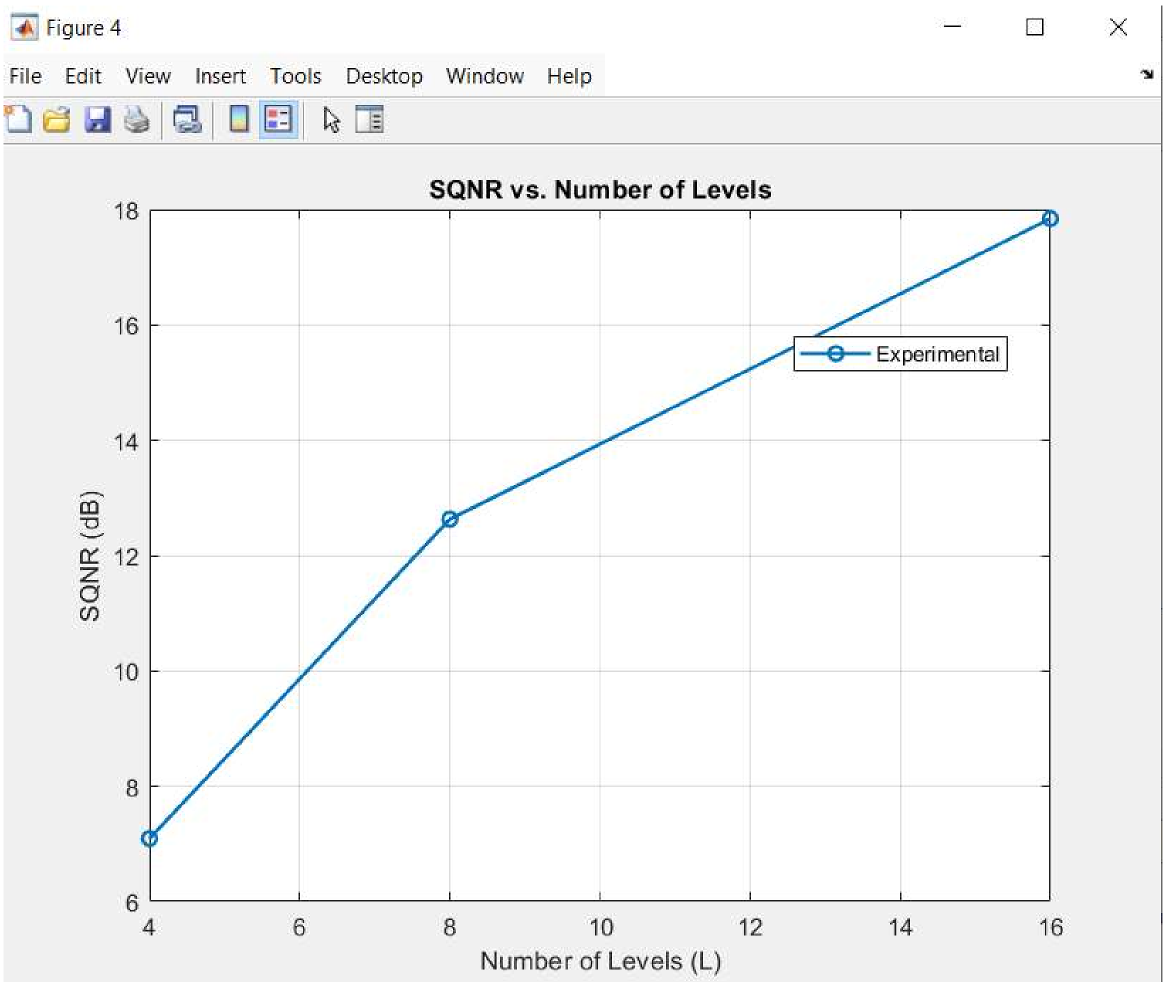
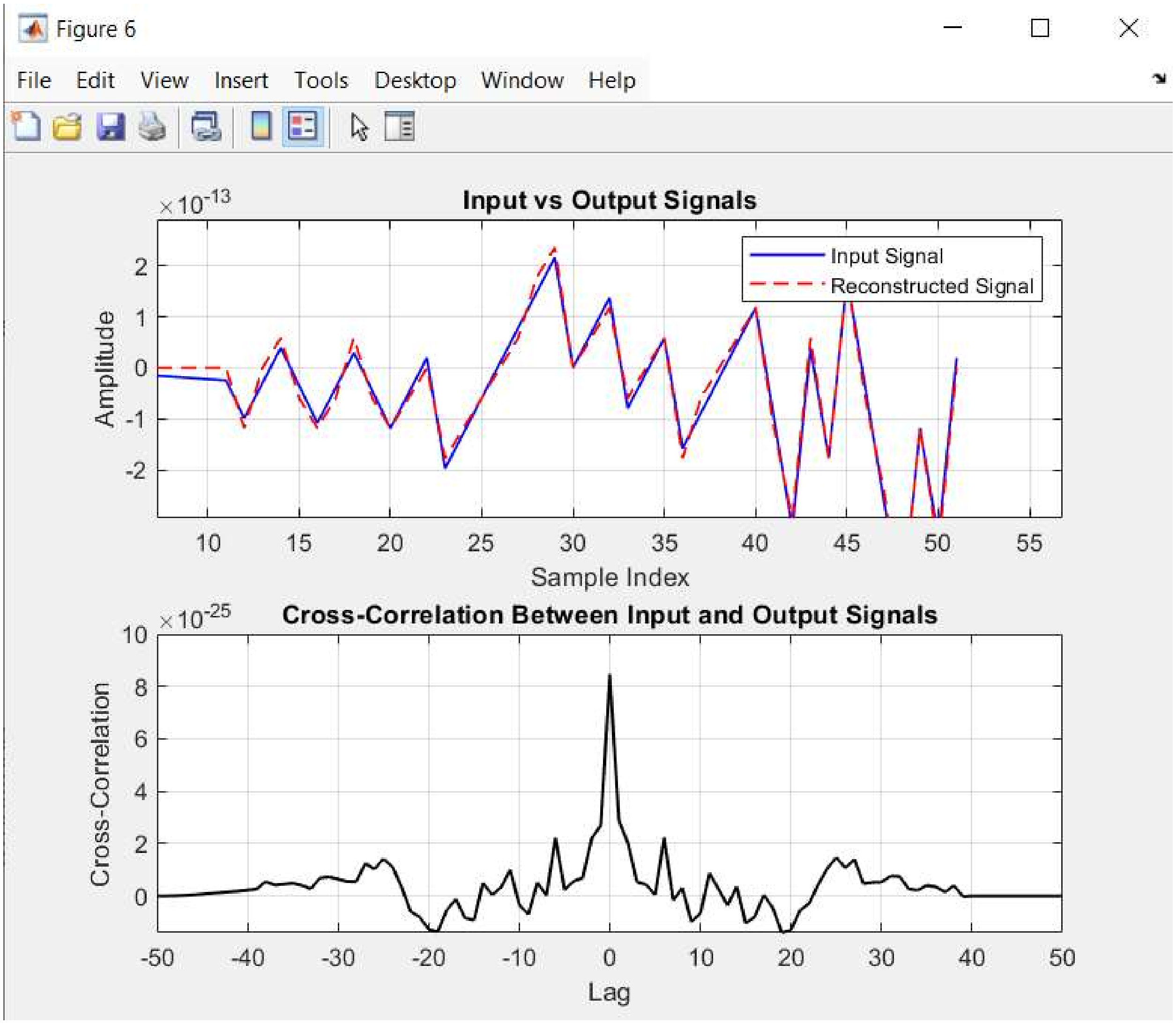
SQNR Results:
L      Experimental SQNR (dB)
4      7.10
8      12.63
16     17.84
```



7- Comparison of input and output and cross-correlation:

Cross-correlation = 0.847

We can conclude that input and output have a high similarity



8- Compression Rate: 26.4706%

Compression efficiency decreases by increasing L because the range of unique values increase.

Increasing L reduces quantization error but reduces the compression rate

9- List at least three ways to enhance the approximation of the output signal:

1. **Increase the Number of Quantization Levels (L)**:
   - **Explanation**: By increasing the number of quantization levels, the quantizer can represent the signal with finer resolution, reducing the quantization error.
   - **Effect**: Higher L reduces the step size between quantization levels, leading to a more accurate representation of the original signal.
2. **Use Non-Uniform Quantization (μ-law)**:
   - **Explanation**: Non-uniform quantizers allocate more quantization levels to ranges of the signal where it has a higher probability density (low amplitudes in speech signals). This reduces distortion in frequently occurring parts of the signal.
   - **Effect**: Improves the signal-to-quantization-noise ratio (SQNR) for signals with non-uniform distributions.
3. **Apply Error Correction Codes in Transmission**:
   - **Explanation**: If the signal is transmitted over a noisy channel, errors can be introduced. Adding error correction techniques, like Reed-Solomon or Hamming codes, ensures that the signal can be reconstructed even with some errors.
   - **Effect**: Improves the robustness of the output signal against channel noise.

- Discuss why there is a difference between the input and output signals:

1. **Quantization Error**:
   - **Cause**: Quantization maps the continuous amplitude of the input signal to discrete levels. The difference between the actual input value and the closest quantized level introduces an error.
   - **Impact**: This error is inversely proportional to the number of quantization levels (L) and is more prominent for signals with high dynamic ranges.
2. **Compression Loss**:
   - **Cause**: When Huffman encoding or similar methods are applied, some precision may be lost in the representation of the quantized signal.
3. **Channel Noise**:
   - **Cause**: If the quantized signal is transmitted through a noisy channel, errors (e.g., bit flips) can occur during transmission.
4. **Non-Ideal Reconstruction**:
   - **Cause**: The reconstruction process assumes that the quantized values can approximate the original signal within the quantization levels, but this is only an approximation.

Bonus:

The bit flips will cause a distortion in the reconstructed signal and will affect the correlation.