EECE 340 Project - Section 2.2 Reconstruction

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Introduction

In this section, we implemented a reconstruction function to rebuild a continuous-time signal from its sampled points using sinc interpolation. The goal was to assess how well a signal can be recovered based on the sampling rate and to observe the effects of under-sampling, aliasing, critical sampling, and over-sampling.

MATLAB Files Description

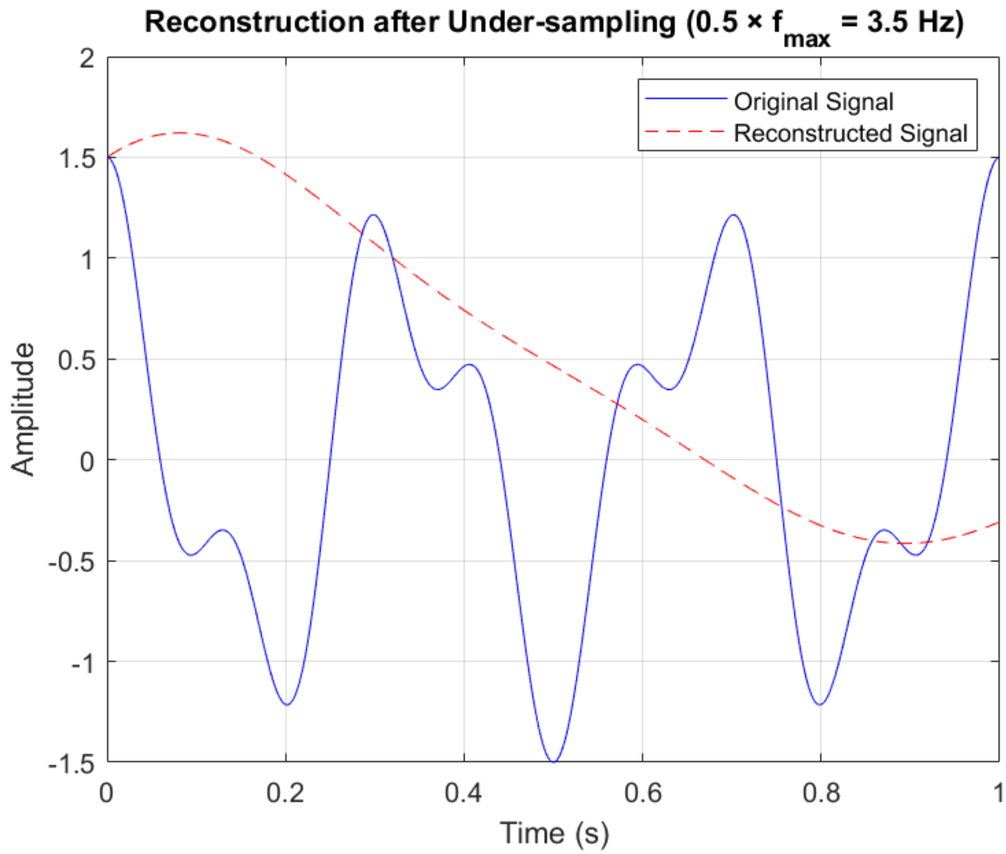
reconstruct.m:
This function manually reconstructs a signal by summing shifted and scaled sinc functions centered at each sampled point. It does not rely on MATLAB's built-in signal processing functions and directly uses the sinc formula for interpolation.

reconstructtesting.m:
This script tests the reconstruction function. It first samples a known signal ($\cos(2\pi 3t) + 0.5\cos(2\pi 7t)$) at different rates (0.5 × fmax, fmax, 2 × fmax, and 4 × fmax) and then attempts to reconstruct the signal using sinc interpolation. It also includes an additional test using a Gaussian pulse to validate reconstruction on non-periodic signals.

Reconstruction Results

Case 1: Reconstruction after Under-sampling (0.5 × fmax)

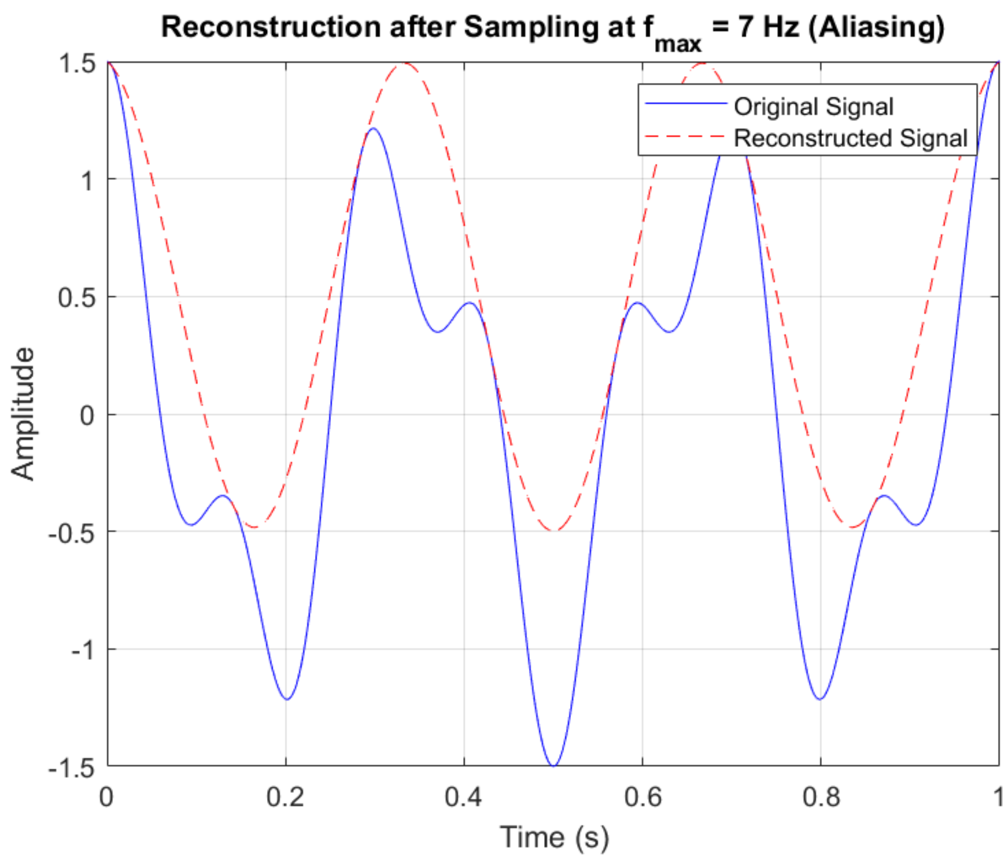
Sampling frequency: 3.5 Hz
Result: Due to aliasing, the reconstructed signal does not resemble the original. The loss of high-frequency information results in severe distortion.



Case 2: Reconstruction at fmax (Aliasing Present)

Sampling frequency: 7 Hz

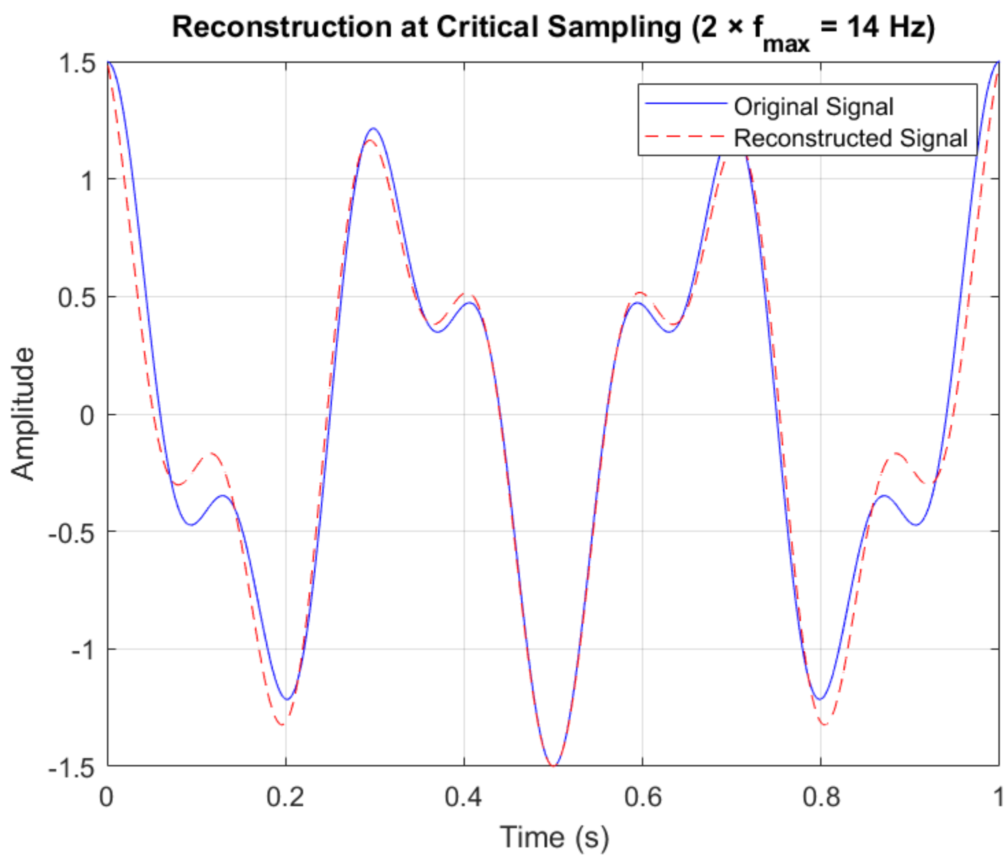
Result: Sampling at fmax does not meet the Nyquist criterion. Aliasing is still present, and the reconstructed signal shows significant distortion compared to the original.



Case 3: Reconstruction at Critical Sampling (2 × fmax – Nyquist Rate)

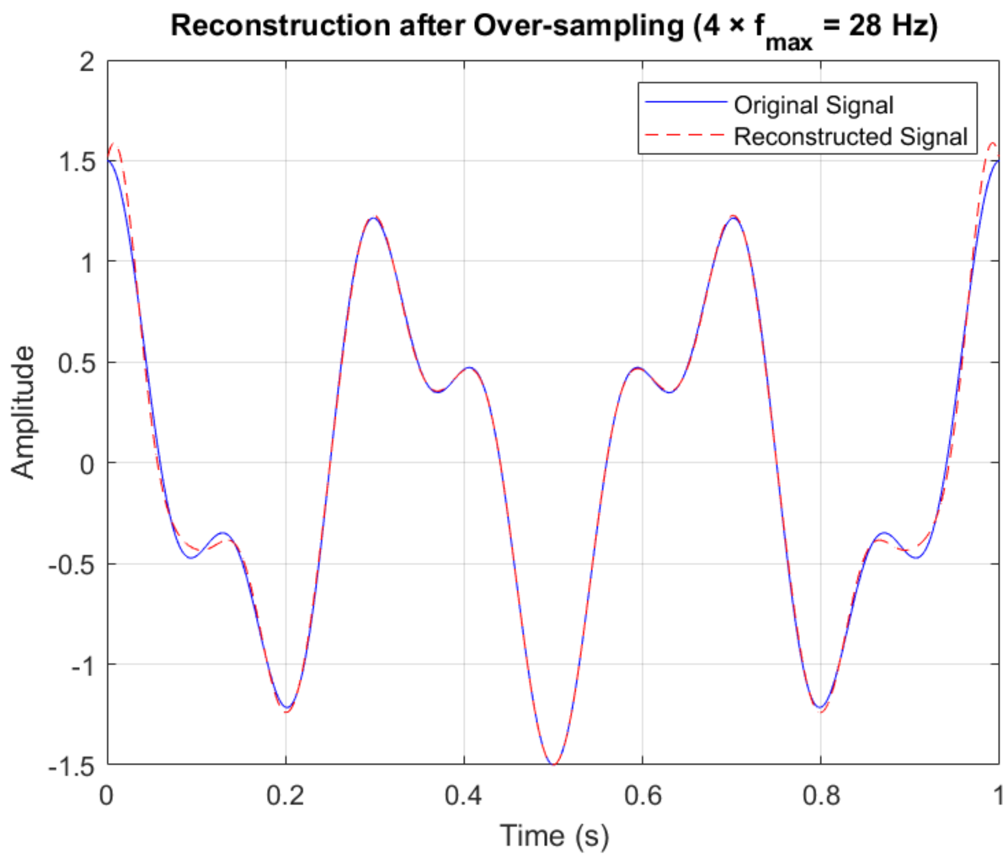
Sampling frequency: 14 Hz

Result: The reconstructed signal closely matches the original. This confirms that sampling at the Nyquist rate preserves signal integrity.



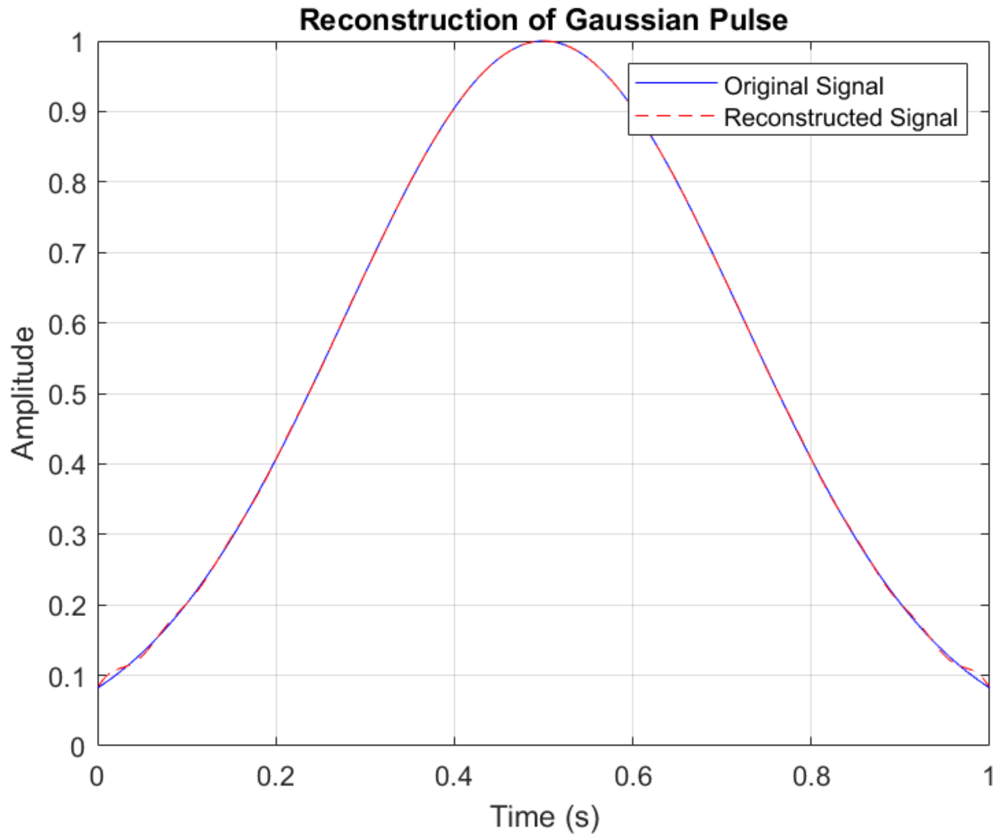
Case 4: Reconstruction after Over-sampling (4 × fmax)

Sampling frequency: 28 Hz
Result: Over-sampling provides dense samples that follow the signal very accurately. The reconstruction quality is excellent.



Extra Test: Gaussian Pulse Reconstruction

A Gaussian pulse was sampled and reconstructed using the implemented sinc interpolation method. The reconstructed signal accurately captured the smooth shape of the original pulse, demonstrating the method's effectiveness for non-periodic signals.



Conclusion

The reconstruction quality highly depends on the sampling rate. Under-sampling and sampling at fmax introduce aliasing and loss of detail. Critical sampling (2 × fmax) allows accurate reconstruction, and over-sampling improves fidelity further. Sinc interpolation was shown to be effective for both periodic and non-periodic signals.