EECE 340 Project - Section 2.1 Sampling

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Introduction

In this section, we implemented a sampling function to discretize continuous-time signals at various sampling rates. The purpose was to study the effects of sampling frequency on signal reconstruction quality and to observe phenomena like aliasing.

The sampling operation approximates continuous signals by selecting values at discrete time intervals defined by the sampling rate (fs).

MATLAB Files Description

sample.m:
This function takes a continuous time vector t, corresponding signal values xt, and a specified sampling frequency fs. It returns the sampled times t_sample and the sampled signal values x_sample.

Linear interpolation (interp1) was used to precisely extract sampled values even when t is not perfectly aligned with t_sample.

sampletesting_updated.m:
This script tests the sampling function on the signal:
$x(t) = \cos(2\pi 3t) + 0.5\cos(2\pi 7t)$

It applies sampling at four different rates:
- 0.5 × fmax (Under-sampling)
- 1 × fmax (Aliasing present)
- 2 × fmax (Critical sampling – Nyquist rate)
- 4 × fmax (Over-sampling)

It then plots the original signal and sampled points on the same graph to illustrate the effect of sampling rate.

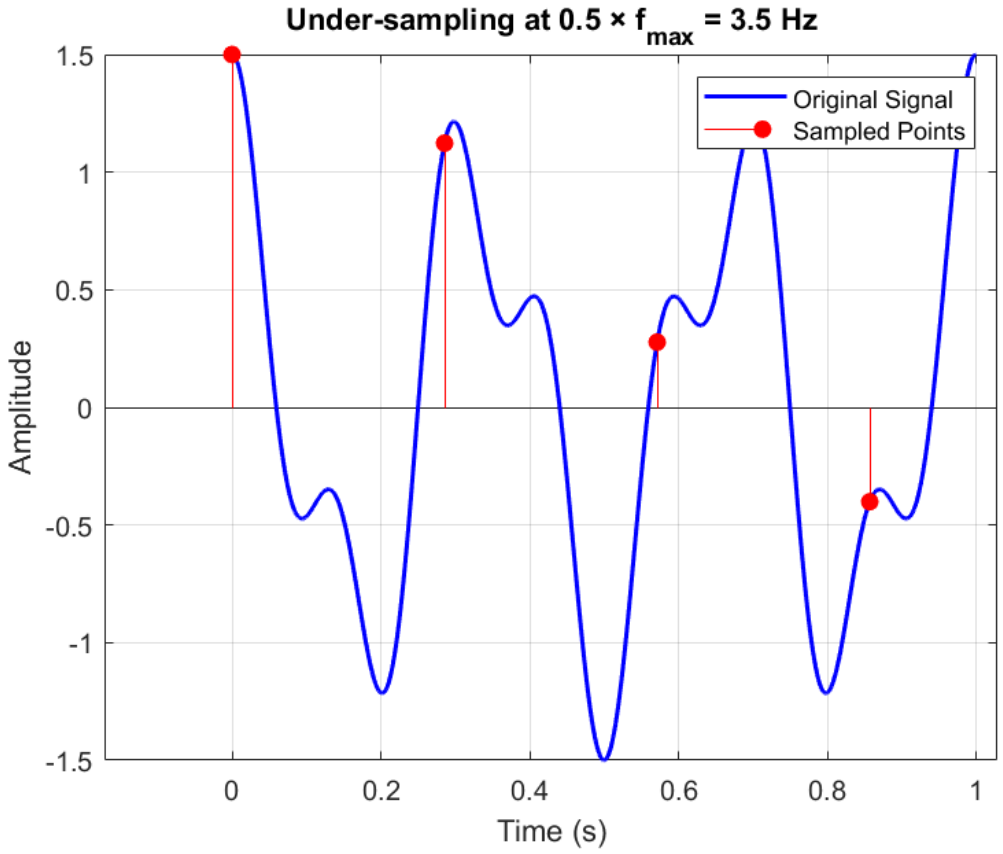
Sampling Results

The following sampling cases were tested on the signal:
$x(t) = \cos(2\pi 3t) + 0.5\cos(2\pi 7t)$

Case 1: Sampling at 0.5 × fmax (Under-sampling)

Sampling frequency: 3.5 Hz

Result: Severe aliasing observed. The sampled points fail to represent the original signal's shape.

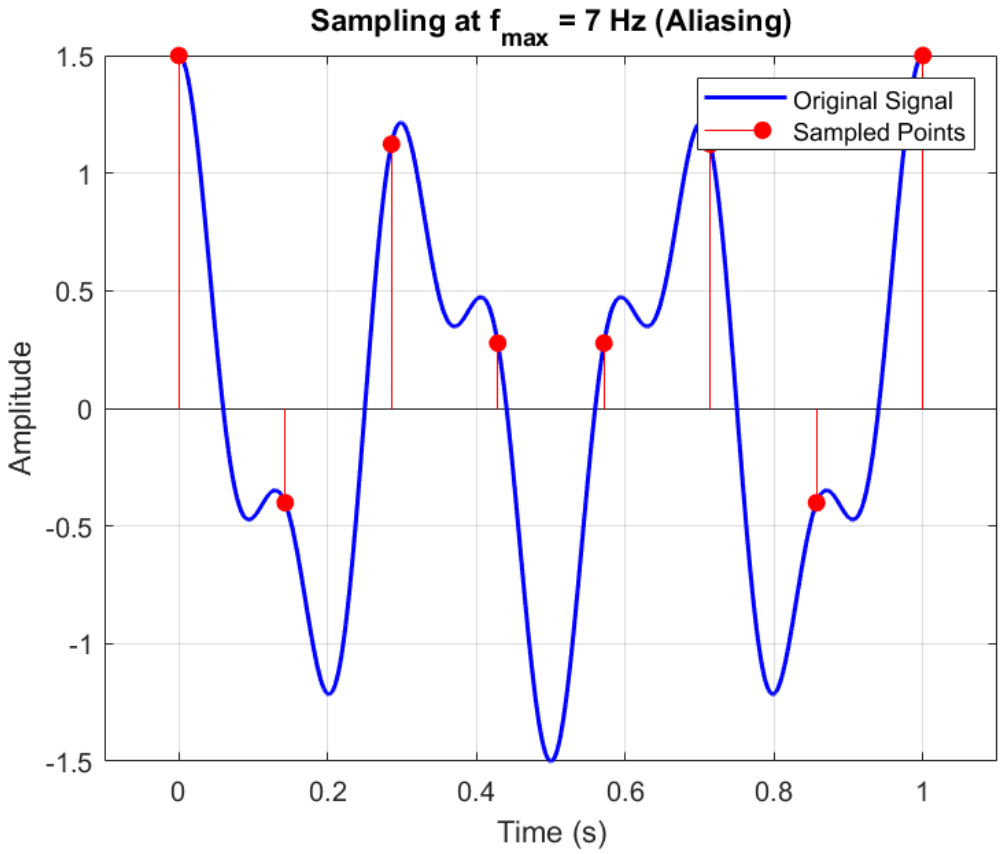


Case 2: Sampling at fmax (Aliasing Present)

Sampling frequency: 7 Hz

Result: Sampling at fmax is not sufficient. The sampled points do not prevent aliasing, and

reconstruction would still be inaccurate.

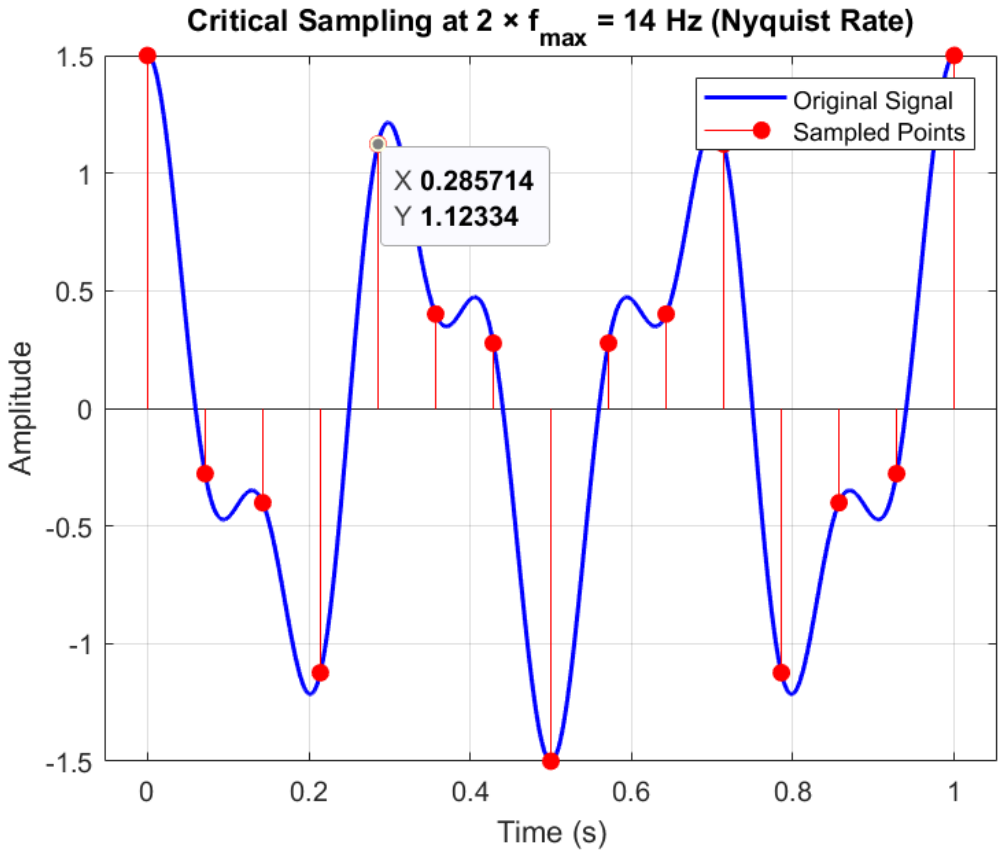


Case 3: Sampling at 2 × fmax (Critical Sampling / Nyquist Rate)

Sampling frequency: 14 Hz

Result: This is the minimum required rate according to the Shannon-Nyquist theorem. The

sampled points follow the signal accurately.

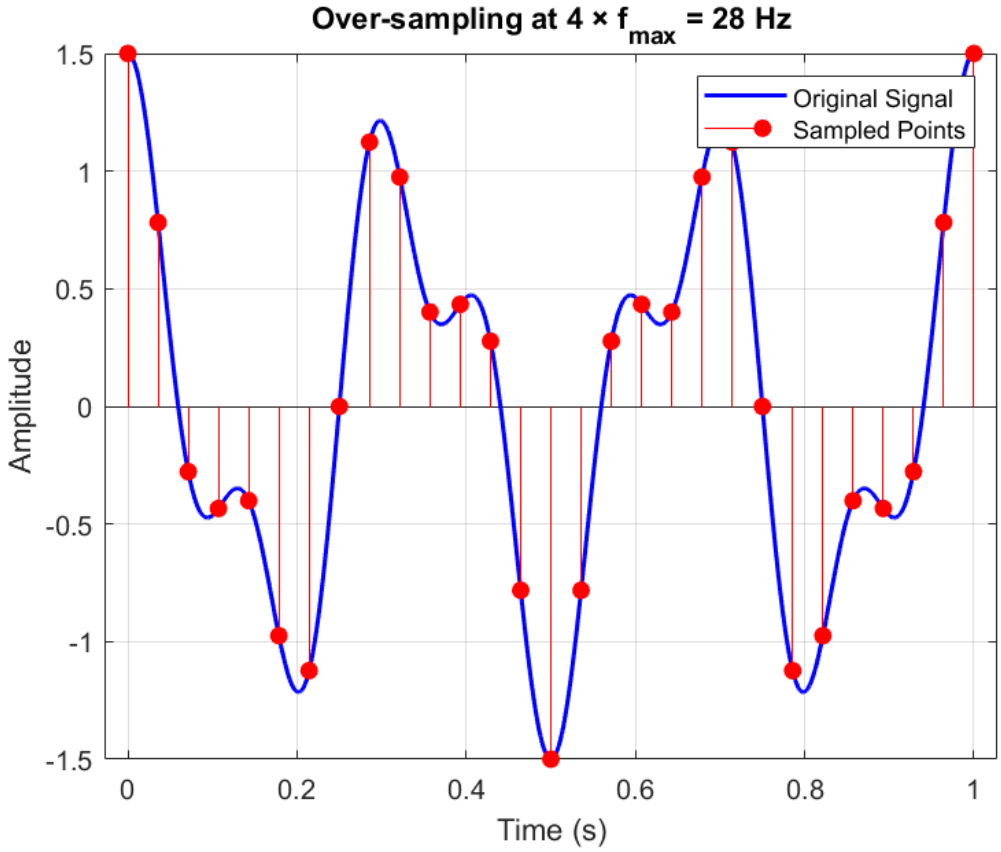


Case 4: Sampling at 4 × fmax (Over-sampling)

Sampling frequency: 28 Hz

Result: Over-sampling leads to a very dense representation of the signal. The sampled

points closely track every feature of the waveform.



Conclusion

Sampling rate greatly affects the quality of signal representation. Under-sampling and sampling at fmax lead to aliasing and loss of information. Sampling at the Nyquist rate (2 × fmax) provides accurate representation, while over-sampling increases robustness and fidelity.