EE386 Digital Signal Processing Lab	21 August 2023

2: Experiment 2 Report

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Problem 1 (Sampling and frequency-domain aliasing)

Q.1. Plot the following waveforms in one single plot for $1/\alpha$ second duration:

(a) Cosine function with amplitude α and frequency 5α Hz.

(b) Cosine function with amplitude $\alpha/2$ and frequency 6α Hz.

(c) Cosine function with amplitude $\alpha/4$ and frequency 10α Hz.

Solution:

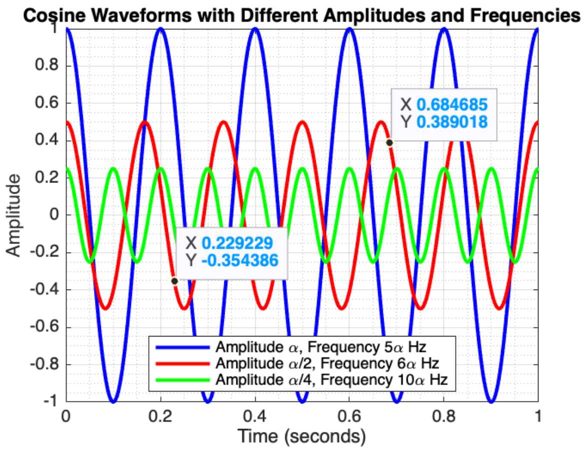

Figure 1: Waveforms in single plot

- I generated plots for various signals, depicting y(t) against time (t). To accomplish this, I utilized built-in functions such as plot(), xlabel(), ylabel(), title(), figure, and enabled grid using grid on. This allowed me to visualize the plotted signals.

Q.2. Plot the summation of all the three functions in another figure.

(a) Cosine function with amplitude α and frequency 5α Hz.

(b) Cosine function with amplitude $\alpha/2$ and frequency 6α Hz.

(c) Cosine function with amplitude $\alpha/4$ and frequency 10α Hz.

Solution:

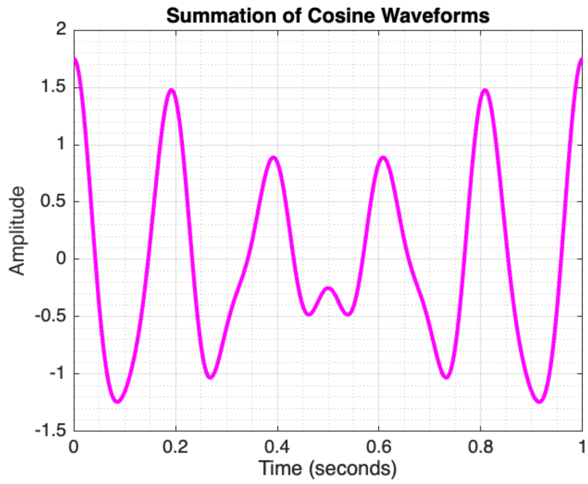

Figure 2: Waveform of summation of three functions

- Plotted the summation of all 3 functions and the waveform obtained was symmetrical about Y axis.

$\boxed{\textbf{Q.3.}}$ Sample the cumulative signal with the following sampling frequency and plot the discrete-time waveforms (using stem) in another figure (as subplots).

(a) Fs $= 14\alpha$ samples/second.
(b) At the Nyquist rate of the signal.
(c) At a sampling rate such that 6α Hz is aliased to 3α Hz.
Solution:

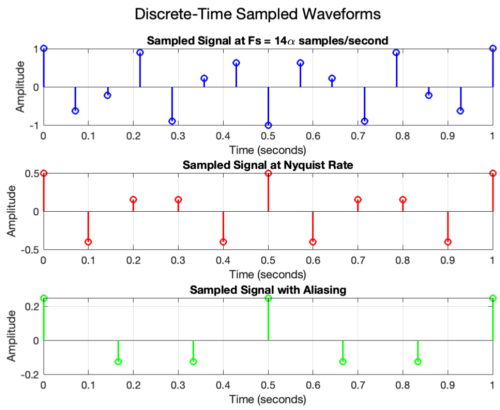

Figure 3: Discrete-time waveforms

- I created Discrete Time spectra for all 3 signals, and the resulting spectra exhibited symmetry.

Q.4. Perform a linear interpolation (you can use plot command which performs this) on the sampled responses for the different sampling rates. Do you observe any difference between the reconstructed waves for the three different sampling rates? Comment on the same.

Solution:

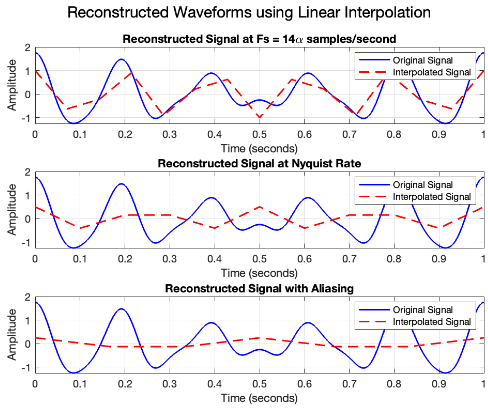

Figure 4: Waveforms after performing linear interpolation

- The red dotted lines represent the interpolated signals, while the blue line represents the original signal. When comparing the two, it's evident that the interpolated signals have a reduced amplitude compared to the original signals.

Q.5. Draw the energy density spectrum for 3(a), 3(b) and 3(c) using FFT. It is known that the case of 3(a) and 3(c) will have an alias. Which frequency(ies) is/are aliased and to what value?

Solution:

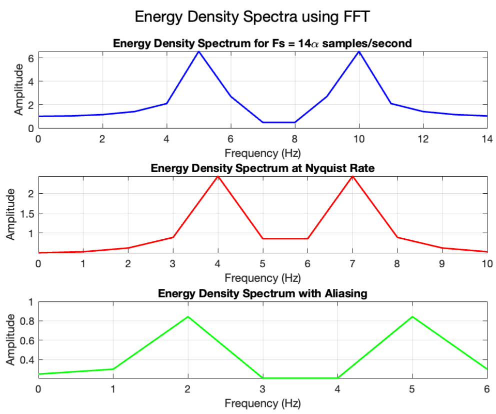

Figure 5: Energy Density spectrum

- I generated Energy Density spectra for all three signals and also plotted the amplitude (Energy) Frequency Spectrum. The resulting spectra exhibited a symmetrical pattern.

Problem 2 (Sampling and frequency-domain aliasing)
Generate a sequence containing the tones corresponding to "Do Re Mi Fa So La Ti Do" as done in the previous experiment. Append the signals together and save the resulting signal as a single .wav file. Use different sampling rates to generate the sequence and listen to the audio and comment on the differences.
Solution:

- I generated musical notes such as "Sa," "Re," "Ga," and others by specifying their precise frequencies. These notes were then organized into a musical sequence, which was subsequently saved as an audio file.
- Altering the sequence by adjusting its playback speed or sampling rates results in varying auditory experiences. Slower speeds impart a deeper and elongated quality to the music, while faster speeds create a higher-pitched and compressed rendition.

Problem 3 (Resampling)
Load Track001.wav and generate different .wav files with several values of the sampling rate (for example, half the original sampling rate, 1/3rd of the original sampling rate etc.) and see the effect of this different sampling rate on the audio. Try: It is easy to achieve downsampling. Is it possible to upsample the signal? If yes, suggest a method such that the frequency content in the signal does not change.
Solution:

- After trying different ways of playing the sound, a collection of audio versions is obtained, each having its own speed.
- The alteration of audio playback speed can produce shifts in perceived pitch, yielding intriguing effects such as the elongated and deeper sound as observed.
- When you increase the playback speed of the audio while maintaining its original musical pitch, you attain a smoother and extended effect.

1 Code Repositories

`https://github.com/harshaksachdeva/experiment-2`.