Tutorial – Sampling and DFT

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Question 1

With the aid of a diagram, demonstrate the effect of the folding of an aliased signal.

For a sampling frequency of 4000 samples/second, what is the apparent frequency resulting from sampling signals of respectively 1000 Hz, 5000 Hz, 7500 Hz and 11,500 Hz?

Question 2

With the aid of a diagram, demonstrate the effect of the folding of an aliased signal.

For a sampling frequency of 5000 samples/second, what is the apparent frequency resulting from sampling signals of respectively 2500 Hz, 6250 Hz, 10000 Hz and 13750 Hz?

Question 3

An FFT is a fast algorithm for implementing a DFT.

Estimate the approximate number of computations that are required to perform the FFT of an 8-point sequence.

One FFT structure is radix-2 decimation-in-time. Illustrate this FFT structure using the following 8-point sequence:

$$S[n] = [2, 6, 3, 9, 7, 4, 1, 11]$$

Question 4

Suppose we have a signal of bandwidth 15kHz that is sampled at a rate of 45,000 samples/second.

Sketch a portion of the frequency spectrum of the sampled signal showing the baseband spectrum and the first upper sideband.

Estimate the order of low-pass filter required to reduce the amplitude of alias frequencies to less than 5% of the baseband amplitudes.

Question 5

Suppose we have a recording of a piece of music of duration 5 minutes.

We wish to obtain a DFT of the music.

Assume the quality of the recording is high with a bandwidth of 15kHz.

What is the minimum sampling rate?

What length of sequence is obtained from this sampling rate?

How could the implementation time of the DFT be reduced, and what would be the effect on the accuracy of the output?