ECE113: DSP

Homework 4

Due 04/30/2021 11:59pm

Problem 1: Problem 4.3 in R1

Problem 2: Problem 4.6 (Part (b) only) in R1

Problem 3: Problem 4.7 (Part (a) only) in R1

Problem 4: Problem 4.9 (Part (d) only) in R1

Problem 5: Problem 4.10 (Parts (c) and (d) only) in R1

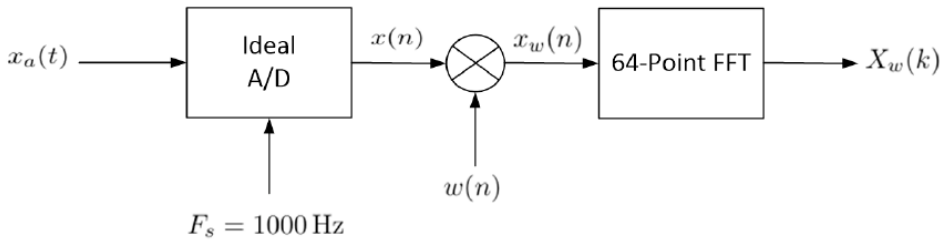
Problem 6: Problem 7.18 in R1

Problem 7: Problem 7.23 (Part (h) only, assume *N* odd) in R1

Problem 8: Assume that an *N*-point DFT, performed on an *N*-sample *x(n)* sequence, results in a DFT frequency sample spacing of 100Hz. What would be the DFT frequency domain sample spacing in Hz if the *N*-sample sequence *x(n)* is zero padded with *4N* zero-valued samples and we perform DFT on that extended time sequence?

Problem 9:

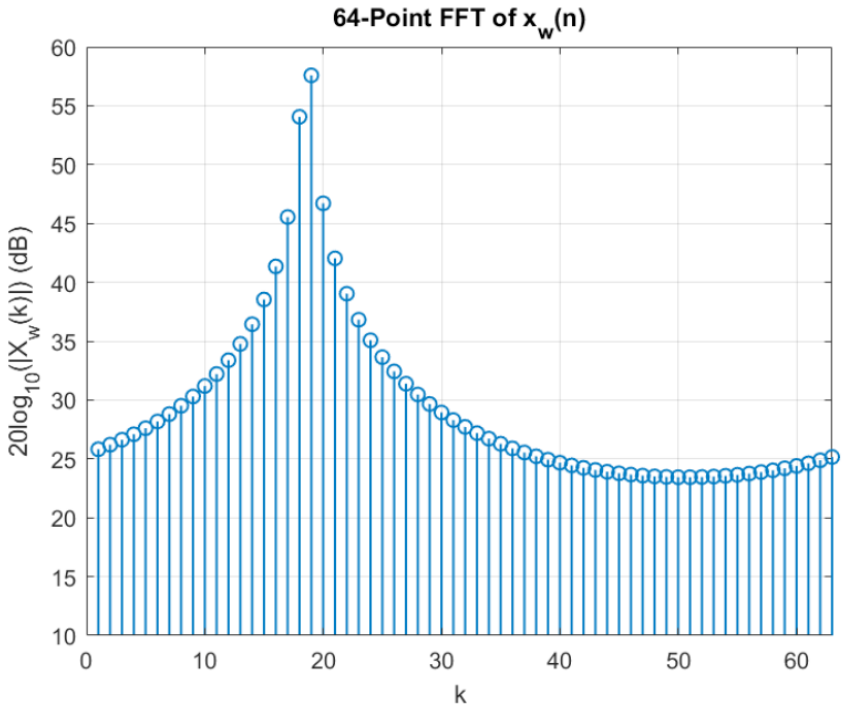
A system for discrete-time spectral analysis of a continuous-time signal is shown below:



where $w(n)$ is a rectangular window:

$$w(n) = \begin{cases} \frac{1}{64}, & \text{for } 0 \le n \le 63 \\ 0, & \text{otherwise} \end{cases}$$

We have obtained the 64-point FFT, $X_w(k)$, the magnitude of which is shown below with the vertical axis in dB scale:



The associated continuous-time input signal, $x_a(t)$, could be one or more of the following signals. Identify which one(s) of the signals below could have produced this FFT. And clearly explain your reasoning for your choice(s).

Hint: Do not try to analyze the signals one at a time. Instead, first look at all the signals and, from what you know about DFT's, try to divide and conquer!

- ☐ $x_{a1}(t) = 10\cos(550\pi t)$
- ☐ $x_{a2}(t) = 1000\cos(550\pi t)$
- ☐ $x_{a3}(t) = 10e^{j550\pi t}$
- ☐ $x_{a4}(t) = 1000e^{j550\pi t}$
- ☐ $x_{a5}(t) = 10\cos(531.25\pi t)$
- ☐ $x_{a6}(t) = 1000\cos(531.25\pi t)$
- ☐ $x_{a7}(t) = 1000e^{j531.25\pi t}$
- ☐ $x_{a8}(t) = 1000e^{j562.5\pi t}$
- ☐ $x_{a9}(t) = 1000\cos(562.5\pi t)$
- ☐ $x_{a10}(t) = 1000e^{j2562.5\pi t}$
- ☐ $x_{a11}(t) = 1000\cos(2550\pi t)$
- ☐ $x_{a12}(t) = 1000e^{j2550\pi t}$

MATLAB: (Please submit your source code along with any necessary analysis and plots)

P5.10 Plot the DTFT magnitude and angle of each of the following sequences using the DFT as a computation tool. Make an educated guess about the length N so that your plots are meaningful.

3. $x(n) = [\cos(0.5\pi n) + j\sin(0.5\pi n)][u(n) - u(n-51)]$.
4. $x(n) = \{1, 2, 3, \underset{\uparrow}{4}, 3, 2, 1\}$.

Note: For DFT calculation in MATLAB for this problem, you can either use the built-in "fft" function in MATLAB, or the following DFT function:

```
function [Xk] = dft(xn,N)
% Computes Discrete Fourier Transform
% ----------------------------------
% [Xk] = dft(xn,N)
% Xk = DFT coeff. array over 0 <= k <= N-1
% xn = N-point finite-duration sequence
%  N = Length of DFT
%
n = [0:1:N-1];                    % row vector for n
k = [0:1:N-1];                    % row vecor for k
WN = exp(-j*2*pi/N);              % Wn factor
nk = n'*k;                        % creates a N by N matrix of nk values
WNnk = WN .^ nk;                  % DFT matrix
Xk = xn * WNnk;                   % row vector for DFT coefficients
```

P5.38 An analog signal $x_a(t) = 2\sin(4\pi t) + 5\cos(8\pi t)$ is sampled at $t = 0.01n$ for $n = 0, 1, \ldots, N-1$ to obtain an N-point sequence $x(n)$. An N-point DFT is used to obtain an estimate of the magnitude spectrum of $x_a(t)$.

1. From the following values of N, choose the one that will provide the accurate estimate of the spectrum of $x_a(t)$. Plot the real and imaginary parts of the DFT spectrum $X(k)$.
   (a) $N = 40$, (b) $N = 50$, (c) $N = 60$.
2. From the following values of N, choose the one that will provide the least amount of leakage in the spectrum of $x_a(t)$. Plot the real and imaginary parts of the DFT spectrum $X(k)$. (a) $N = 90$, (b) $N = 95$, (c) $N = 99$.