University of Washington
Department of Electrical Engineering
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Report for Lab #4: Using FFT for Frequency Analysis

Report by:
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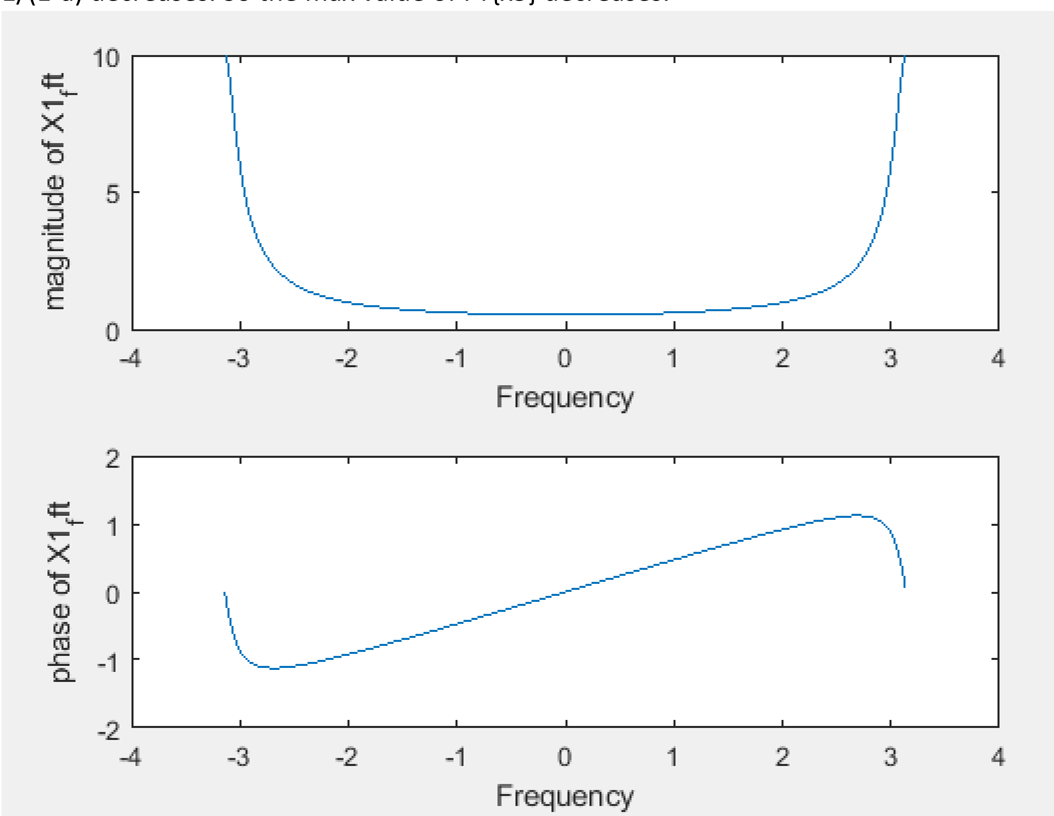
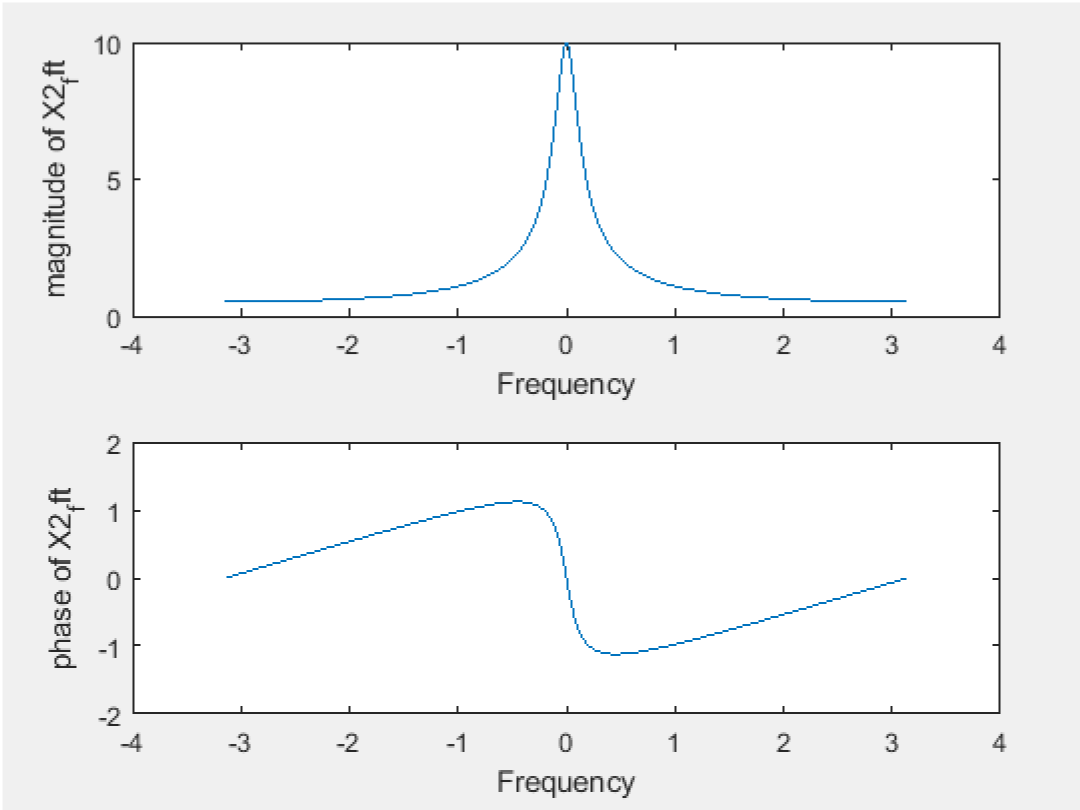
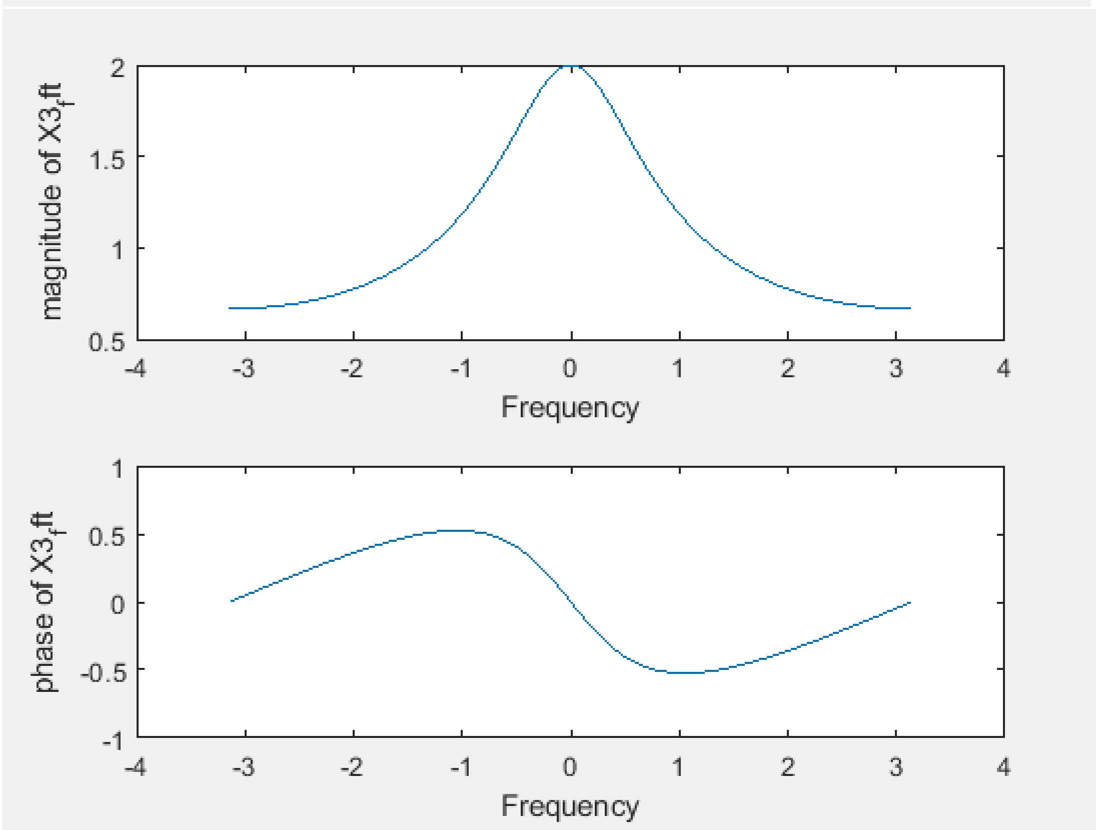
1 ASSIGNMENT I

Q1: Turn in the plots for the different signals. Specify the window length N and explain why the DFTs look different in terms of Fourier Transform properties.

A1: Since x1[n] = (-1)^n * u[n] = e^*(j*pi*n) * u[n], FT{x1[n]} is a 2pi-shifted version of FT{x2[n]} by time-shifting property. Also, since x3[n] is narrower than x2[n] in time domain, FT{x3[n]} is wider than FT{x2[n]} in frequency domain by inverse time-frequency relationship. The magnitude of FT{x3} is also smaller by equation X(e^jw) = 1/(1-a*e^(jw)). At w=0, X(1) = 1/(1-a). if a decreases, 1-a increases and 1/(1-a) decreases. So the max value of FT{x3} decreases.




magnitude of $X2_f$ft
10
5
0
-4
-3
-2
-1
0
1
2
3
4
Frequency
phase of $X2_f$ft
2
1
0
-1
-2
-4
-3
-2
-1
0
1
2
3
4
Frequency

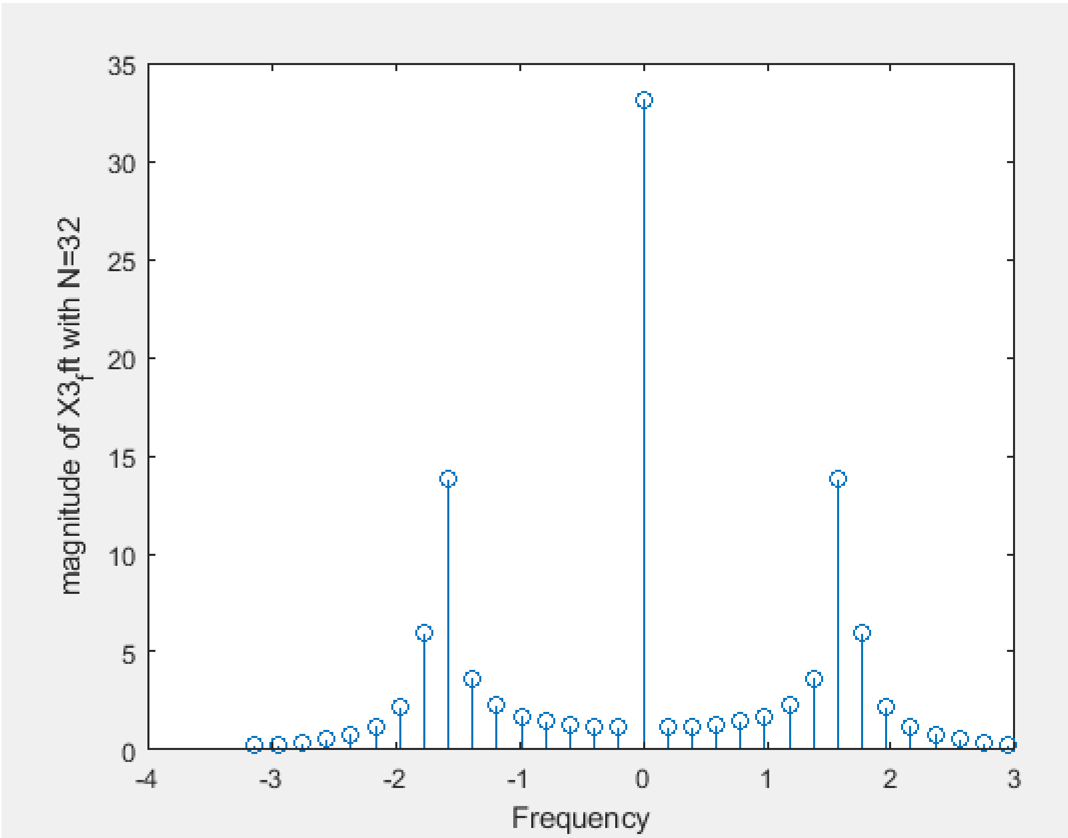

magnitude of $X3_f$ft
2
1.5
1
0.5
-4
-3
-2
-1
0
1
2
3
4
Frequency
phase of $X3_f$ft
1
0.5
0
-0.5
-1
-4
-3
-2
-1
0
1
2
3
4
Frequency

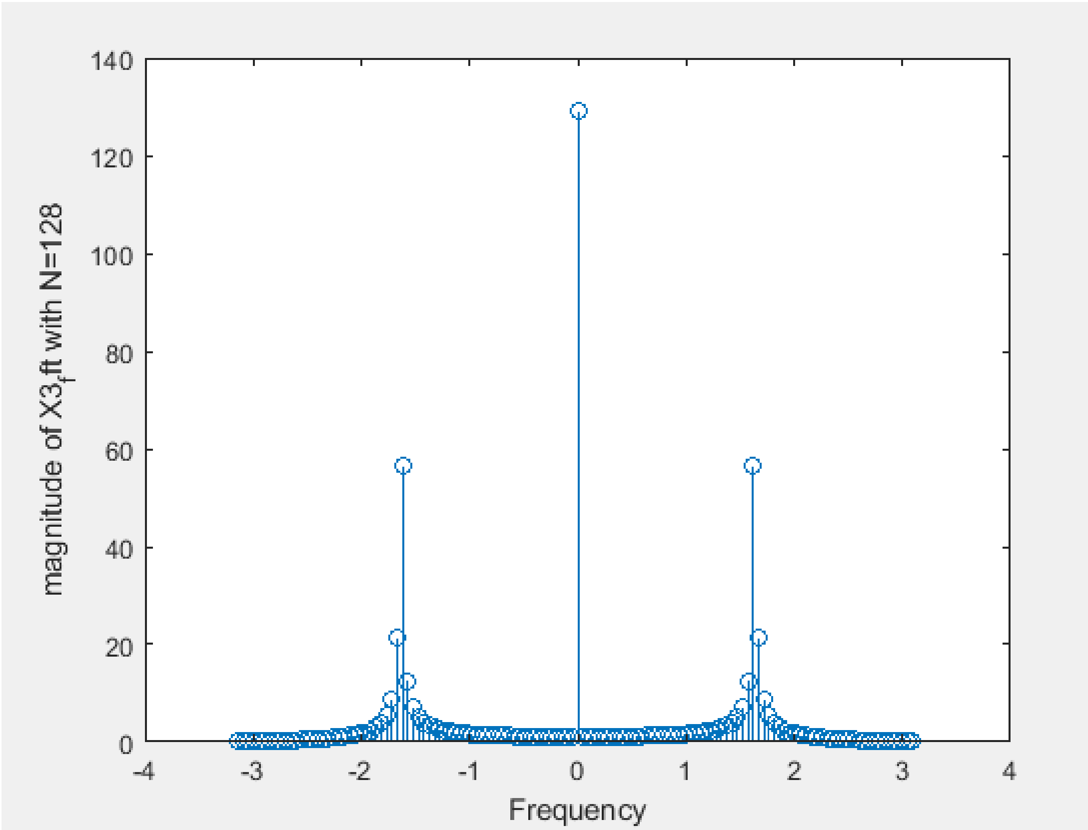
2 ASSIGNMENT II

Q2: Turn in the plots for the cosine with frequency f=0.26 for the 3 window lengths and explain why the DFTs look different. Include the flute DFT plot, specify what length FFT you used and why, and explain how you determined the note that is being played.

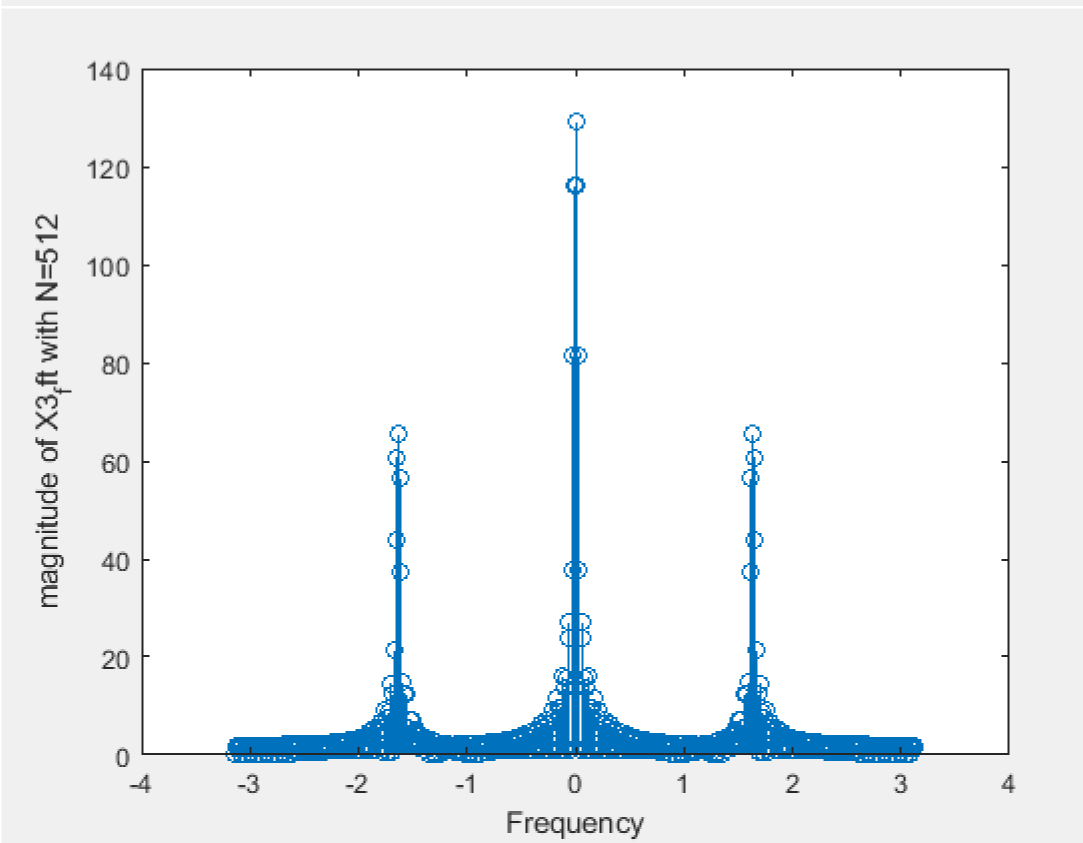
A2: The plots in frequency domain are different because the sampling frequency (N) is different.

I used a N = 512 to cover all significant frequency content. According to the plot, the highest peaks that are not at w=0 are at +/- 861.3 Hz, which is close to A5 (880Hz). So the note in the flute-short.wav is close to note A.

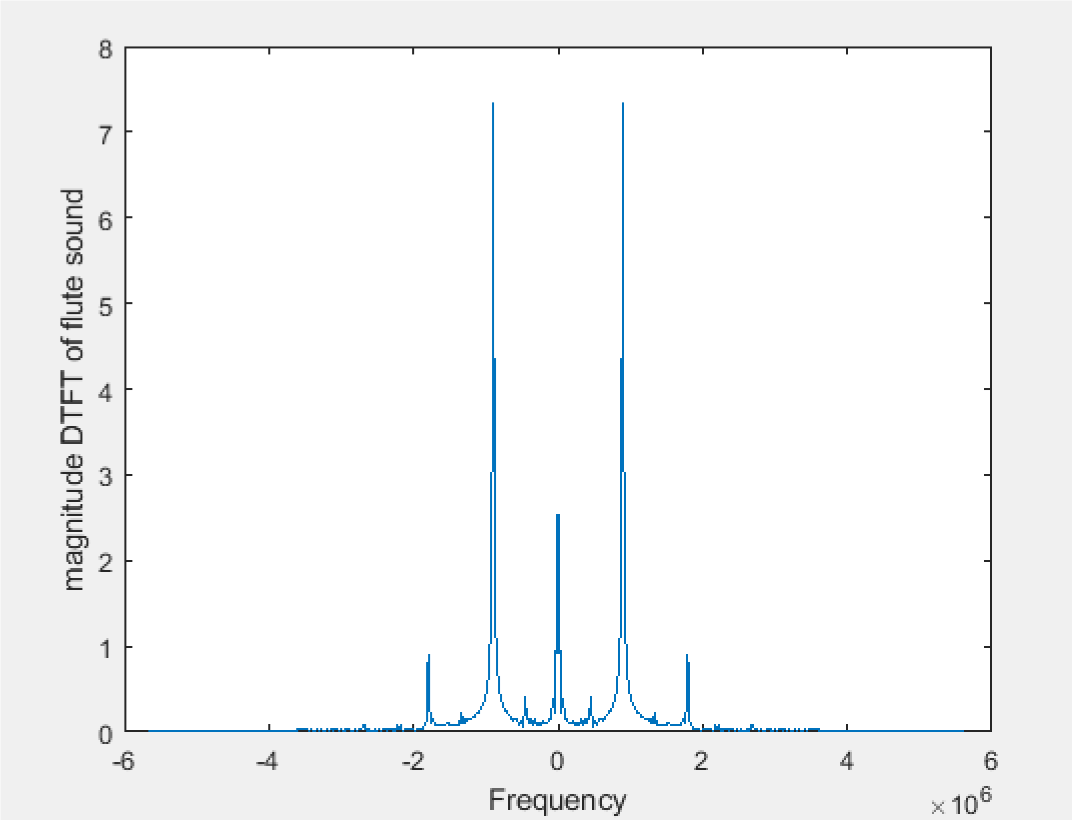




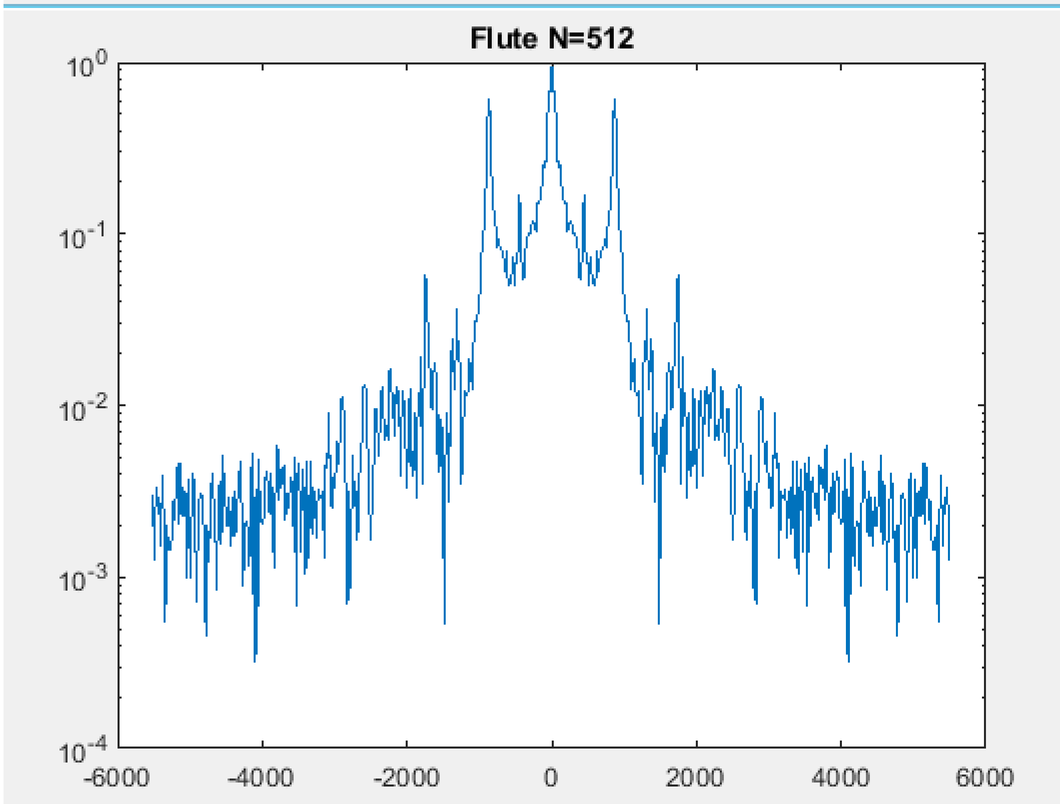
140
120
100
80
60
40
20
0
-4
-3
-2
-1
0
1
2
3
4
Frequency
magnitude of $X3_f$ft with N=128



140
120
100
80
60
40
20
0
-4
-3
-2
-1
0
1
2
3
4
Frequency
magnitude of $X3_f$ft with N=512



magnitude DTFT of flute sound
Frequency
$\times 10^6$
8
7
6
5
4
3
2
1
0
-6
-4
-2
0
2
4
6



Flute N=512
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
-6000
-4000
-2000
0
2000
4000
6000

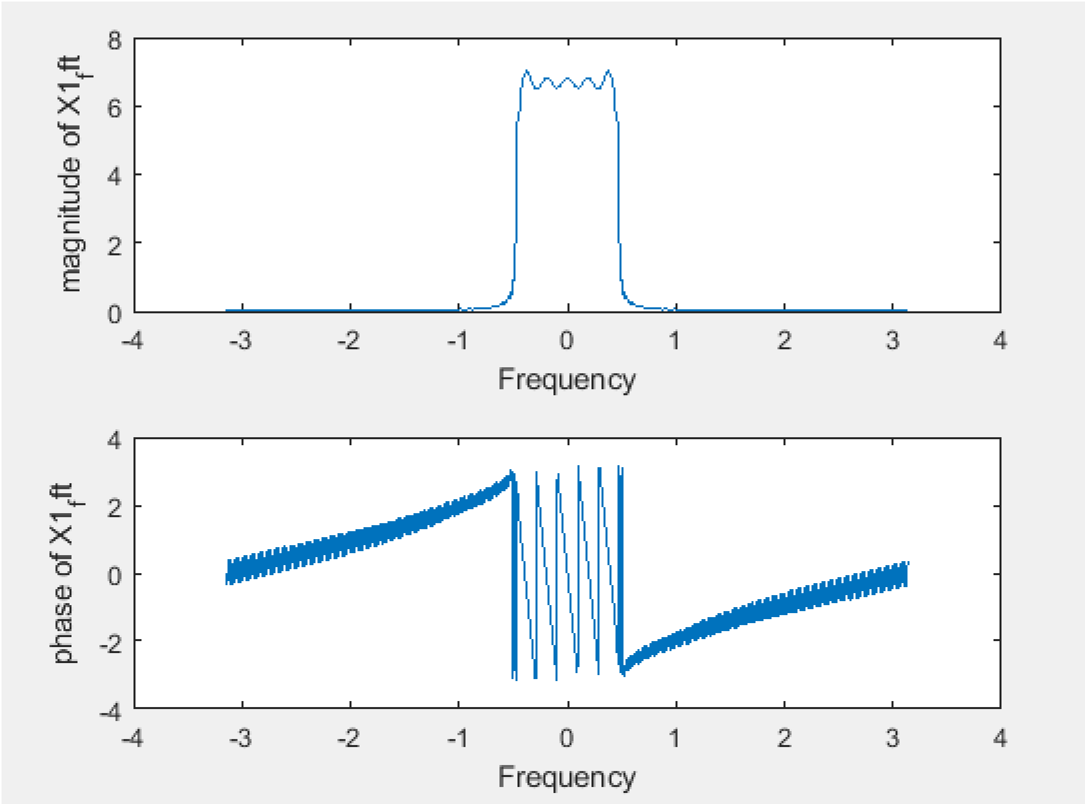
3 ASSIGNMENT III

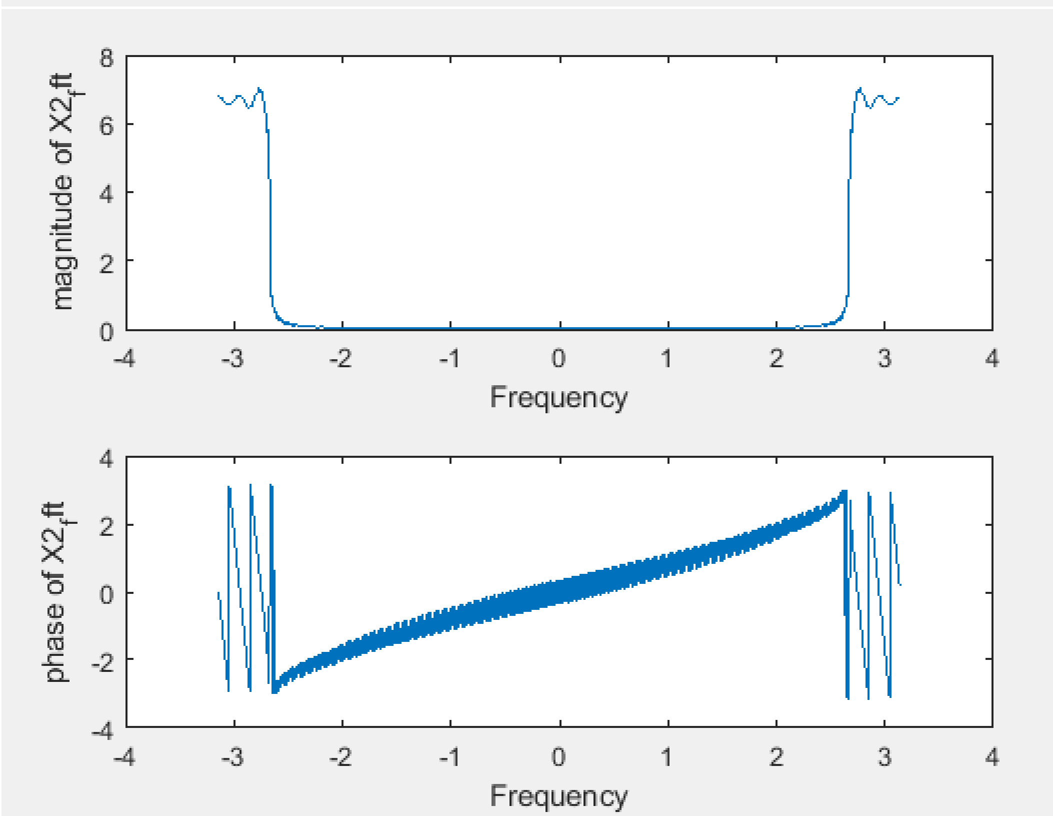
Q3 Turn in plots of the magnitude and plots for (a)-(c). State what type of signals each corresponds to (low pass, high pass, etc.) and what the (normalized) cut-off frequencies are for each. Explain why the DTFTs do not have a flat frequency response in the passband.

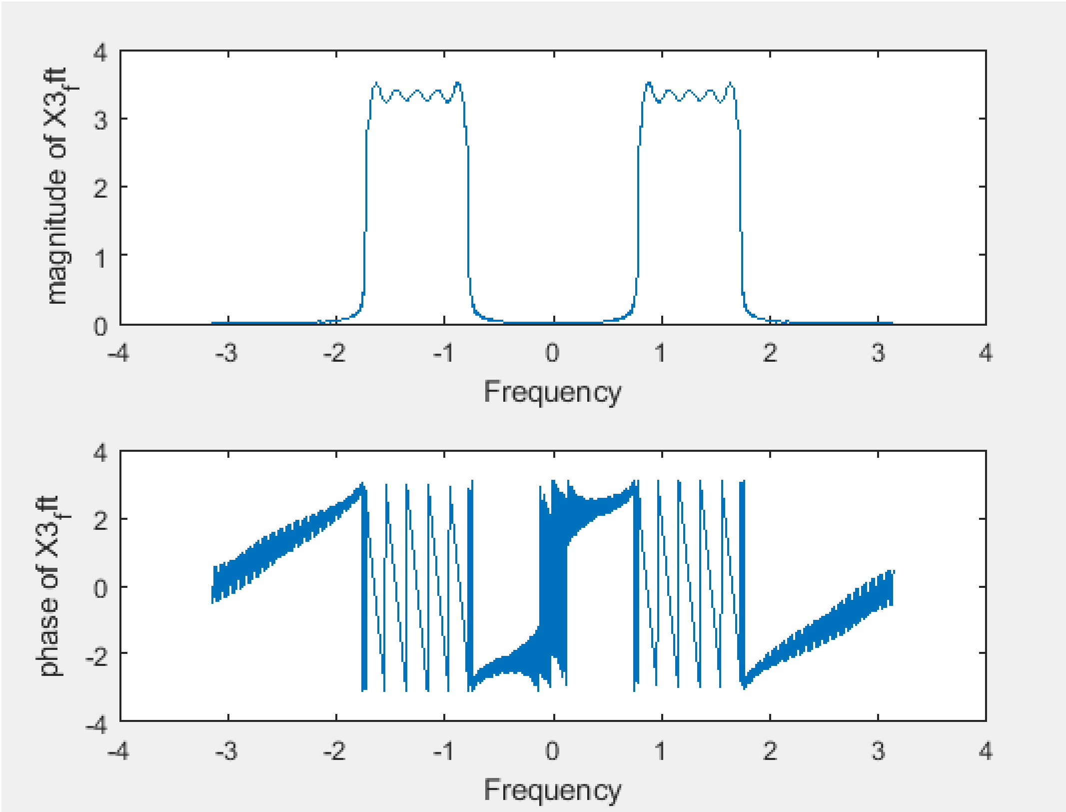
A3: x1 is a low-pass filter. X2 is a high-pass filter. X3 is a band-pass filter.

Cut-off frequencies: x1 (0.47), x2(2.7), x3(0.79 – 1.72)

Since x1[t], x2[t] and x3[t] are defined in the range(0, 255), which doesn't cover the whole positive x-axis to +infinity, the Fourier transforms of the signals are not perfect boxes.


magnitude of $X1_f$ft
Frequency
phase of $X1_f$ft
Frequency


magnitude of $X2_f$ft
Frequency
phase of $X2_f$ft
Frequency


magnitude of X3_f ft
Frequency
phase of X3_f ft
Frequency