EE123 Spring 2019 Miki Lustig
Digital Signal Processing

Assignment 4

Due February 25^{th} 2018

1. Self-grade Homework 3.
2. Read Chapter 10.1-10.2 Oppenheim and Schafer, 3rd ed.
3. Problem 9.47, parts a,b,c,d Oppenheim and Schafer, 3rd ed.
4. Consider the time-frequency tiling of the DFT. Draw qualitatively what happens to the Heisenberg boxes when you window the signal in time domain.
5. *Adapted From Final, fall'11*

   An N-sample possibly complex signal $x[n]$ is bounded, so that $|x[n]| \leq 1$ for all n.

   a) What is the largest value possible for $|X[k]|$, the magnitude of the DFT of $x[n]$?

   b) Find an expression for all of the $x[n]$ sequences which achieve this maximum.

6. *Adapted From Midterm I, sp'13*

Consider the sequence $h[n] = \{1, -1\}$

a) Compute $H_4[k]$, the 4-point DFT of $h[n]$ and sketch its magnitude.
Is $H_4[k]$ even, odd, conjugate symmetric, or none of the above? Is it low pass, high pass, or neither?

b) We are given that $y[n]$ is the circular convolution of $h[n]$ with an unknown length-4 **real** sequence $x[n]$

$$y[n] = x[n] \textcircled{4} h[n]$$

Given $y[n]$ can you uniquely determine $X[k]$ (and hence $x[n]$)?
Write an expression for $X[k]$ or for the class of signals $X[k]$ could be.

Example of a possible answer for a class of signals: $X[k] = C \cdot (-1)^k Y[k]$, where C is unknown.

c) Now, in addition to $y[n]$, you are given that $\sum_{n=0}^{3} |x[n]|^2 = D$, with the same unknown **real** sequence $x[n]$
Is it true that we can now uniquely determine $x[n]$?
Write an expression for $X[k]$ or for the class of signals $X[k]$ could be.

d) For this part, consider a complex modulated version of $h[n]$,

$$\tilde{h}[n] = e^{-j\frac{2\pi}{4}n} h[n]$$

We are given that $\tilde{y}[n]$ is the circular convolution of $\tilde{h}[n]$ with the same unknown **real** sequence $x[n]$

$$\tilde{y}[n] = x[n] \textcircled{4} \tilde{h}[n]$$

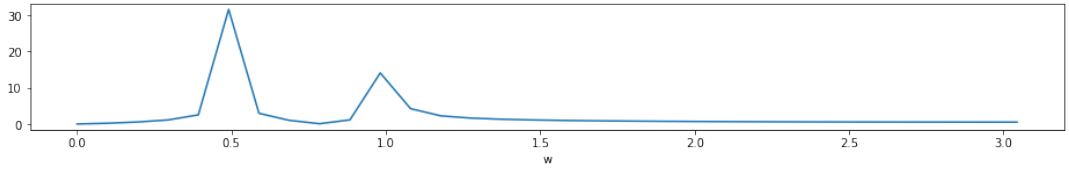
Is it possible to uniquely determine $x[n]$ from $\tilde{y}[n]$?

7. *Adapted From Midterm I, sp'18*

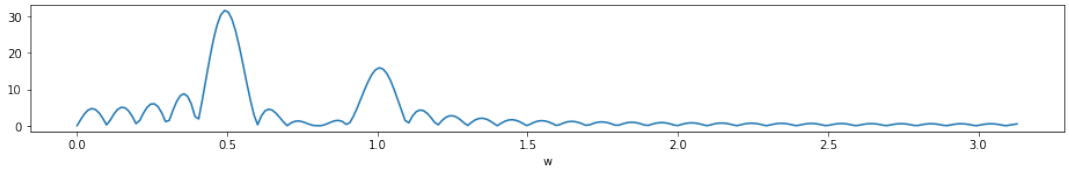
You perform a spectral analysis of a sequence. Let L be the length of the sequence, and N be the length of the DFT (zero-padded).

a) What is the source for the differences between the following two spectrum plots? Explain your choice!!! (Choose only the most likely cause – 1 choice)

(1)



(2)



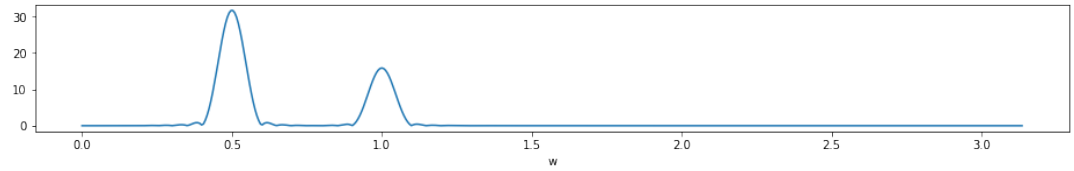
(i) L increased in (2)
(ii) N increased in (2)
(iii) The windows in (1) and (2) are different
(iv) Both L and N increased in (2)

Evidence:

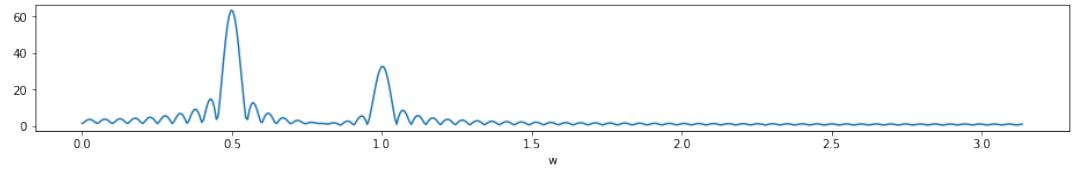
(i)	(ii)	(iii)	(iv)

b) What is the source for the differences between the following two spectrum plots? Explain your choice!!! (Choose only the most likely cause – 1 choice)

(1)



(2)

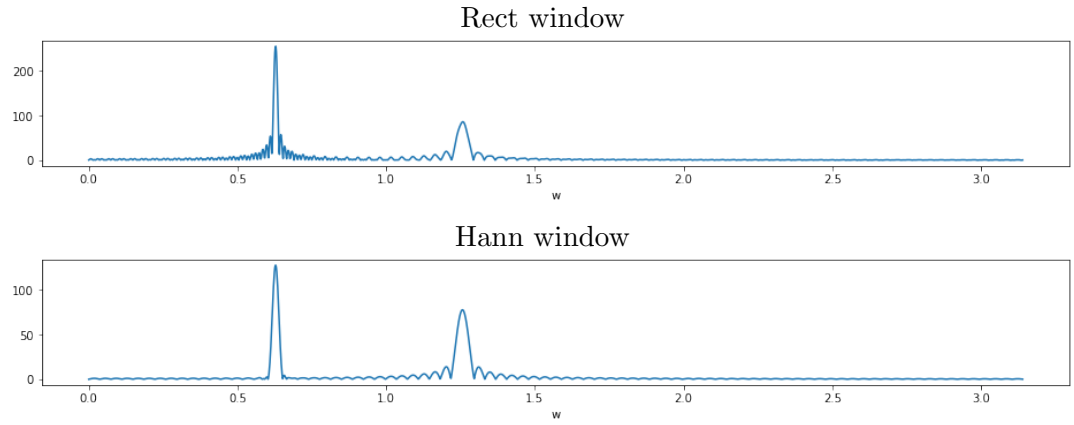


(i) L increased in (2)
(ii) N increased in (2)
(iii) The windows in (1) and (2) are different
(iv) Both L and N increased in (2)

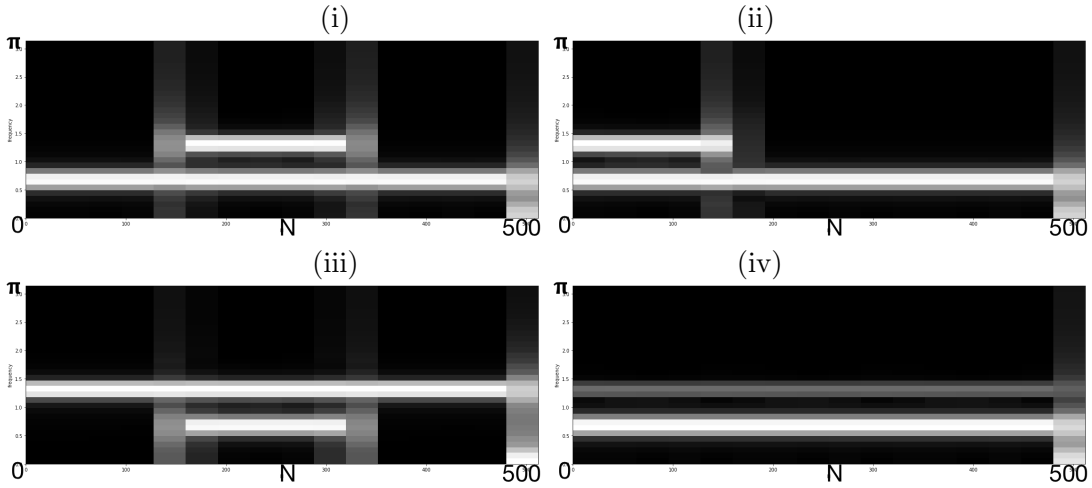
Evidence:

(i)	(ii)	(iii)	(iv)

c) You perform a spectral analysis of a <u>new</u> 512-length sequence using rectangular and Hann windows of the same length. The results are shown below:



Which of the following would fit as the best spectrogram for the above spectral plots? Explain!!!



Evidence:

(i)	(ii)	(iii)	(iv)