EE386 Digital Signal Processing Lab Jul-Dec 2021

4: Experiment

Author: Chandan Kumar *Email:* chandankumar.191ee114@nitk.edu.in

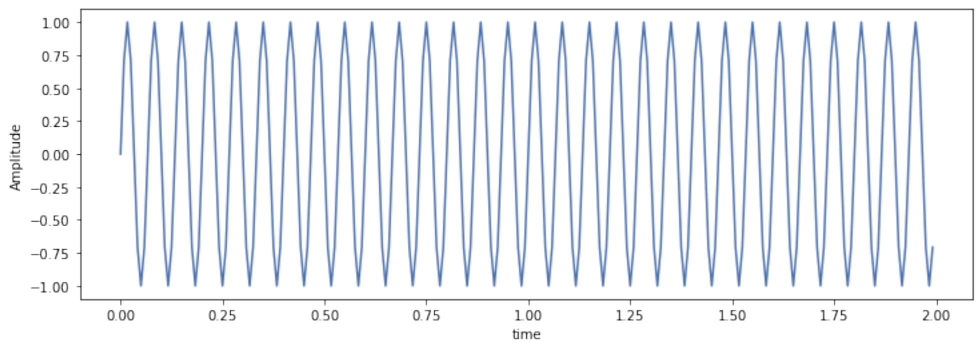
1 Solution

Wherever relevant, $\alpha = 1 + mod(x, 3)$ where x is the last three digits of registration number. Since $x = 114$,

$$\alpha = 1 + mod(114, 3)$$
$$\therefore \alpha = 1$$

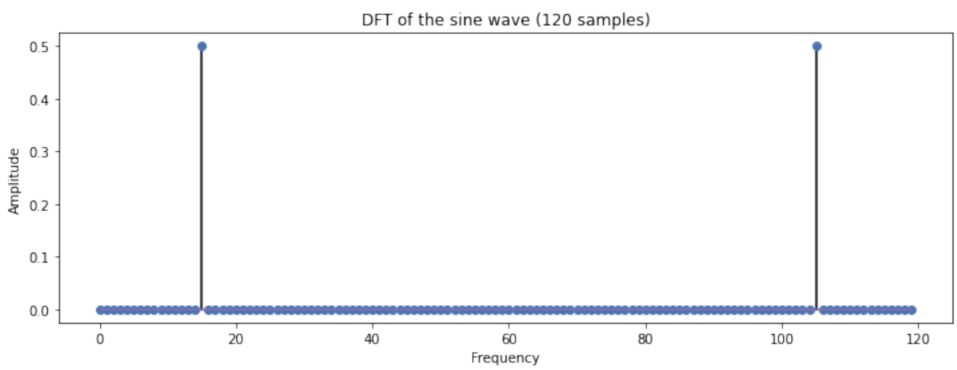
Computing the DFT

According to the problem statement, we are supposed to generate a unit amplitude signal frequency 15Hz (15α) for the duration of 2 seconds with a sampling rate of 120 samples/sec.

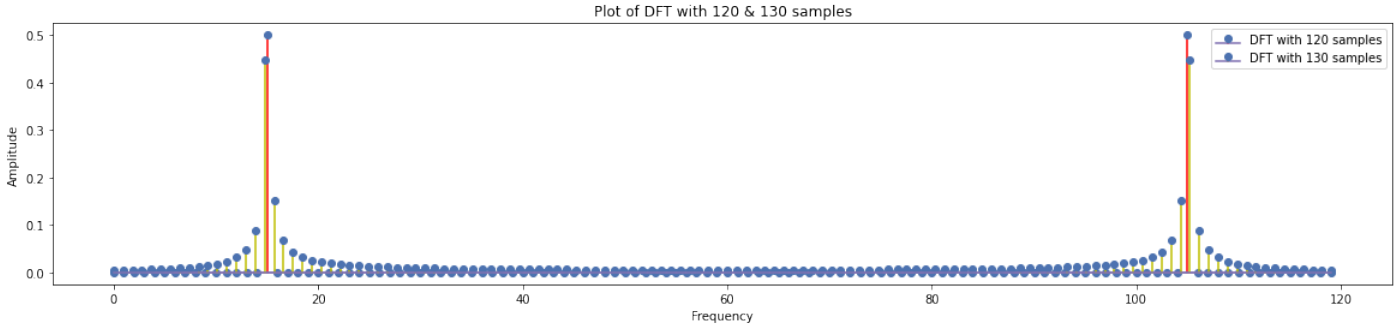


(Subproblem 1) Plot of magnitude of DFT of the first 120 samples of the signal against frequency in Hertz.

(Solution)

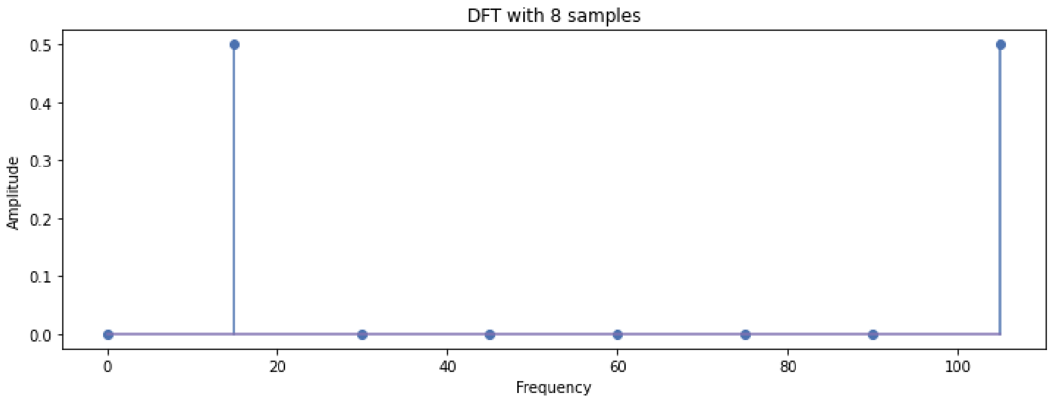


(Subproblem 2) Plot of magnitude of DFT of the first 130 samples of the signal.
(Solution)



As can be seen in the plot above, the spectral leakage is very less in case of 120 samples(stem plot in red color) and is much higher in case of 130 samples(stem plot in yellow color). Therefore, the spectral leakage is observed when the sampling frequency is not the multiple of periodicity.

(Subproblem 3)
In this subproblem, we need to report N($N \neq 120$) such that first N points of the signal matches with the DFT of the first 120 samples of the signal.
(Solution)



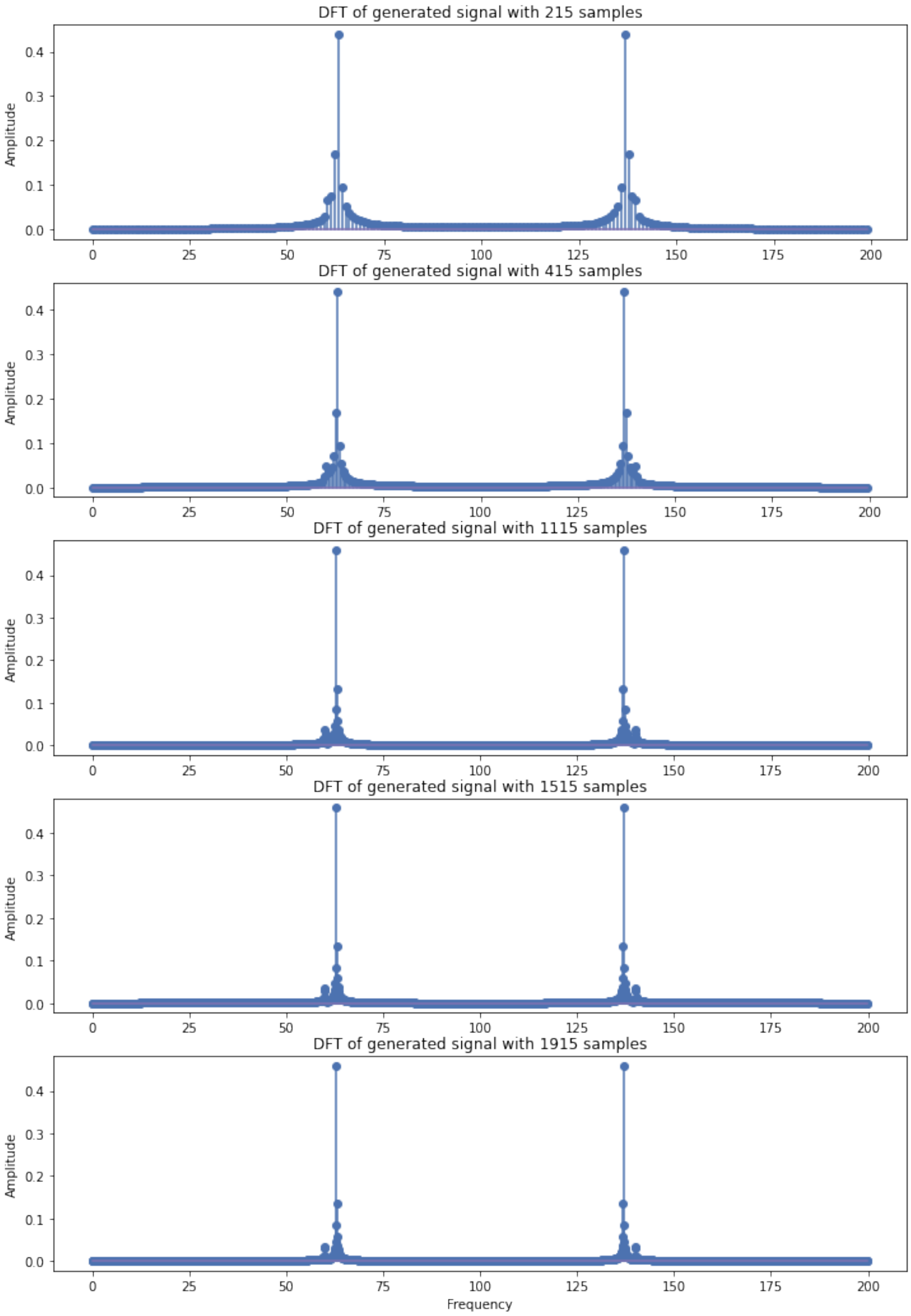
$$\frac{f}{Fs} = \frac{k}{N}$$
$$N = k\frac{Fs}{f}$$
$$N = 8k(Fs = 200, f = 15)$$

Here periodicity comes out to be 8. Therefore, we would not find spectral leakage for all the values of N where N is multiple of 8.

Resolution of DFT

Plot of the DFT of signal for 1. 215 samples, 2. 415 samples, 3. 1115 samples, 4. 1515 samples, 5. 1915 samples in 5 separate figures.

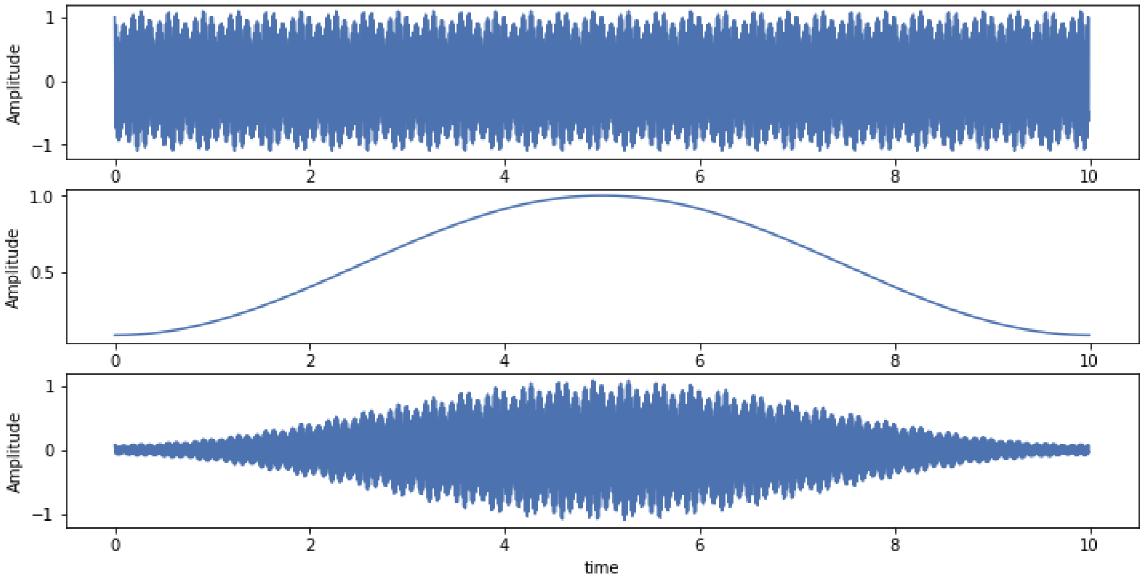
$$\alpha = 1$$
$$\therefore A = 120, B = 126$$
$$x(a) = 0.1 \sin 120\pi t + \cos 126\pi t$$



Here, it is observed that with increase in the number of samples, the resolution of the DFT increases and spectral leakage decreases.

Resolution of DFT with windowing

Plot of the DFT signal by windowing the time domain signal using Hamming window, since $\alpha = 1$.

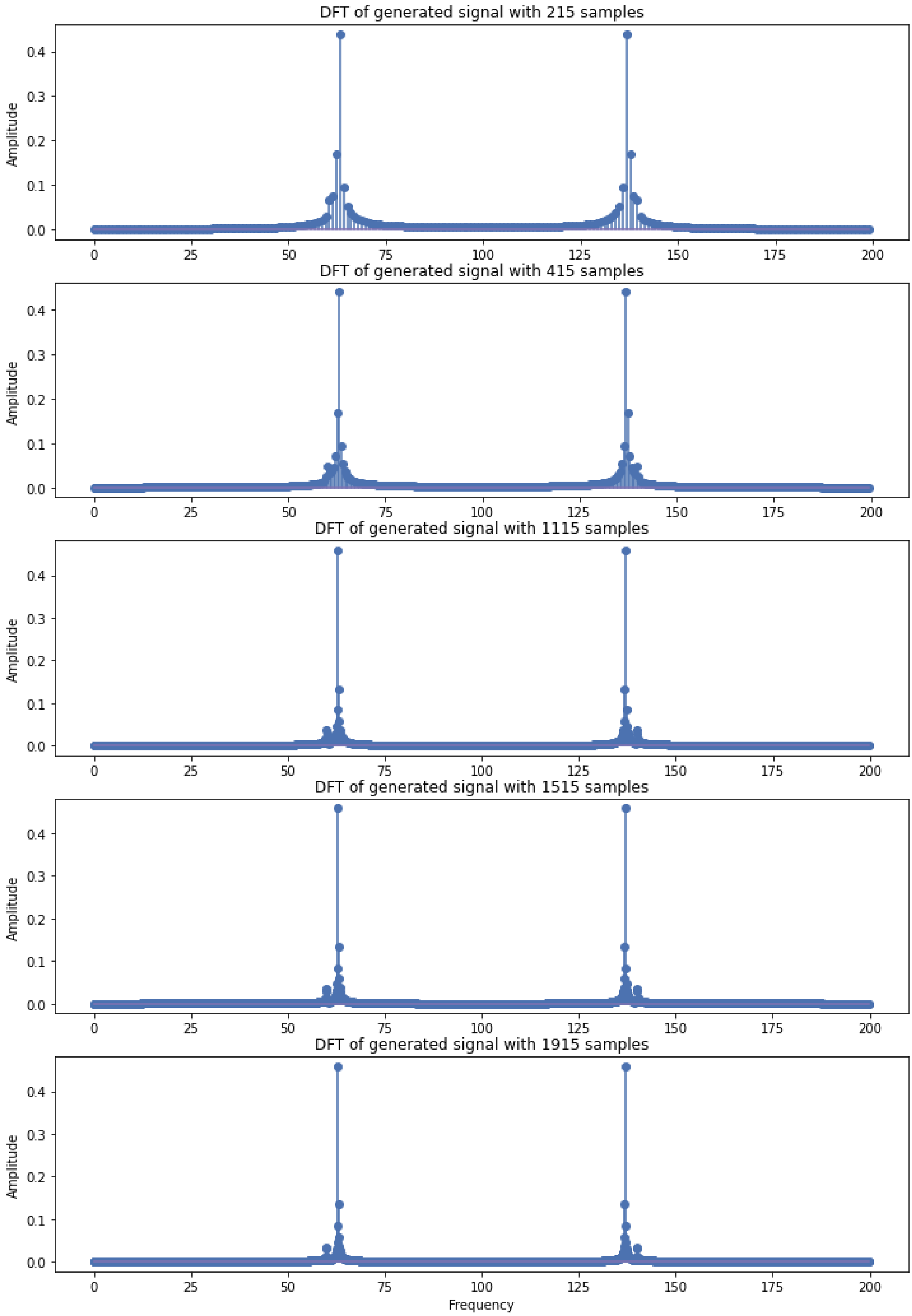


Here the signal is windowed using hamming window technique.

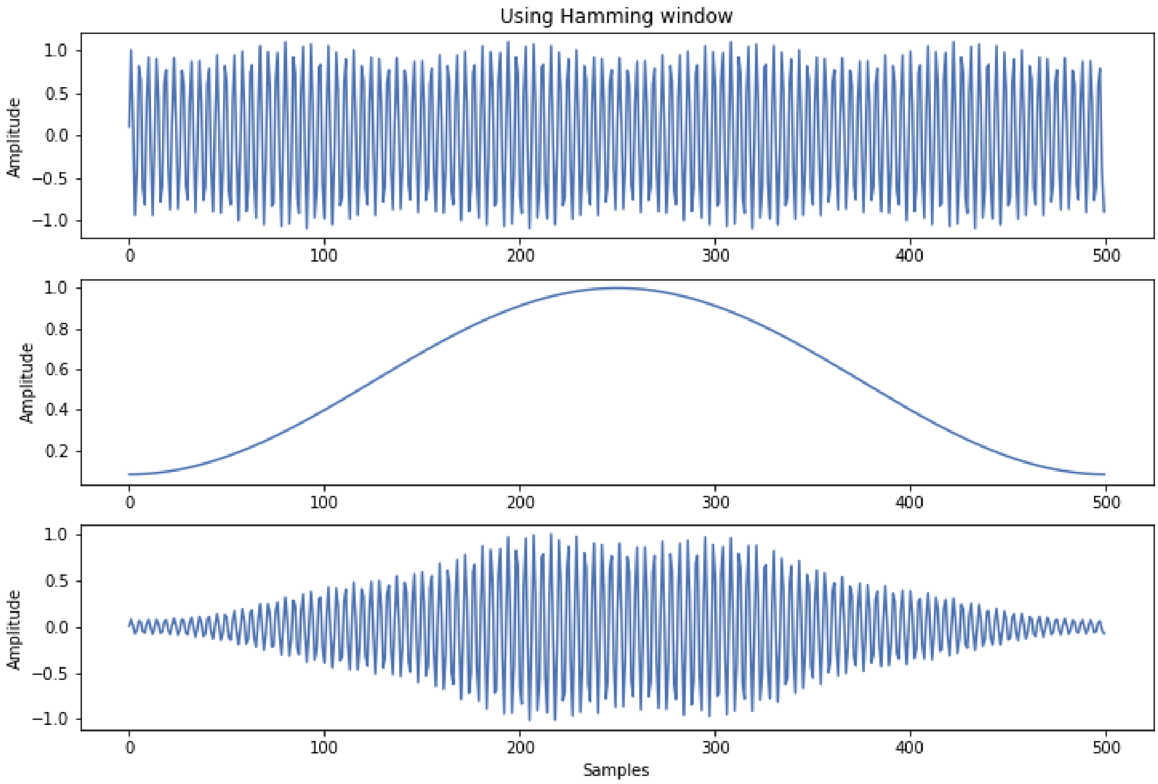
$$h(n) = 0.54 - 0.46 * \cos \frac{2\pi}{N} n$$

Below is the plot of DFT of signal windowed using Hamming Window technique with signals given in problem 2.

From the figure below, it is observed that in the DFT windowed using hamming window, the spectral leakage and the resolution is also less when compared to that of rectangular window as shown in the problem 2.

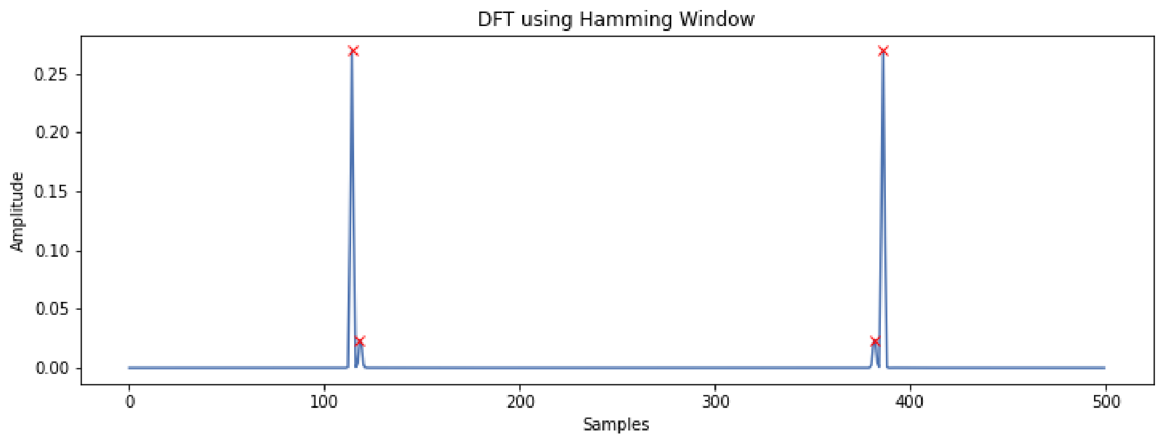


Frequency Estimation using windowing There are 500 samples in the data from Exp4Data1.txt. The signal is loaded and multiplied by a hammer window. The process's plot is presented below:



(Subproblem 1)

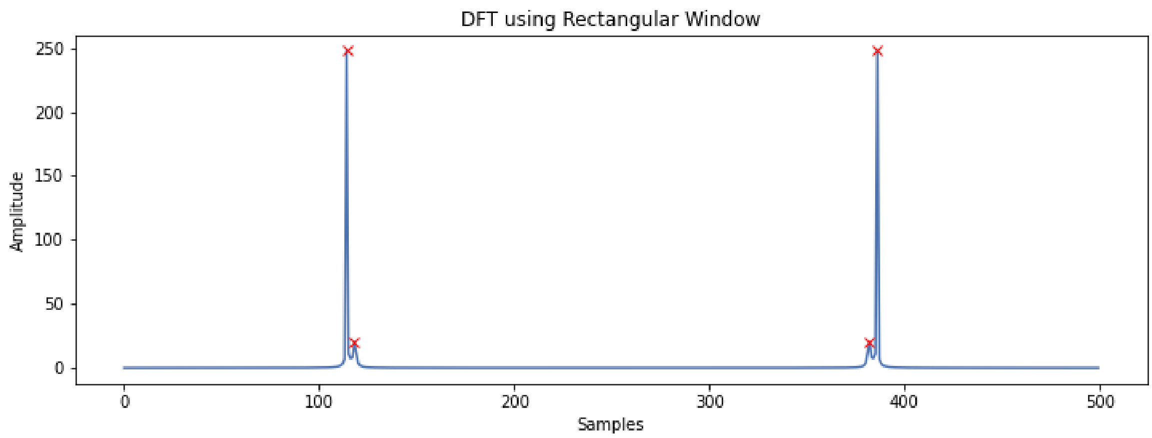
After that, the windowed signal is translated to frequency domain and plotted as seen below. $scipy.signal.find_peaks$ is used to detect the peaks in the DFT.



The marked peaks correspond to the following samples: 114,118,382,386. The latter two peaks are caused by the symmetry characteristic of the actual signal. As a result, because samples 114 and 118 correspond to two frequency components of the dual tone out of a total of 500 samples, the dual tone frequencies in terms of sampling frequency are:

$$F1 = \frac{114}{500} * Fs = 0.228 * Fs$$
$$F2 = \frac{118}{500} * Fs = 0.236 * Fs$$

Using a rectangular window, similar conclusions are achieved with better resolution but with blurred second peaks.



A Code Repositories

Refrain from including any or all code in this document. Upload codes to your repository and include the links to executed nbviewer files here as – The codes to reproduce the results can be found in the GitHub repository `https://github.com/predator4hack/EE386_Digital_signal_processing`.