EDISP LAB 3 Report: STFT

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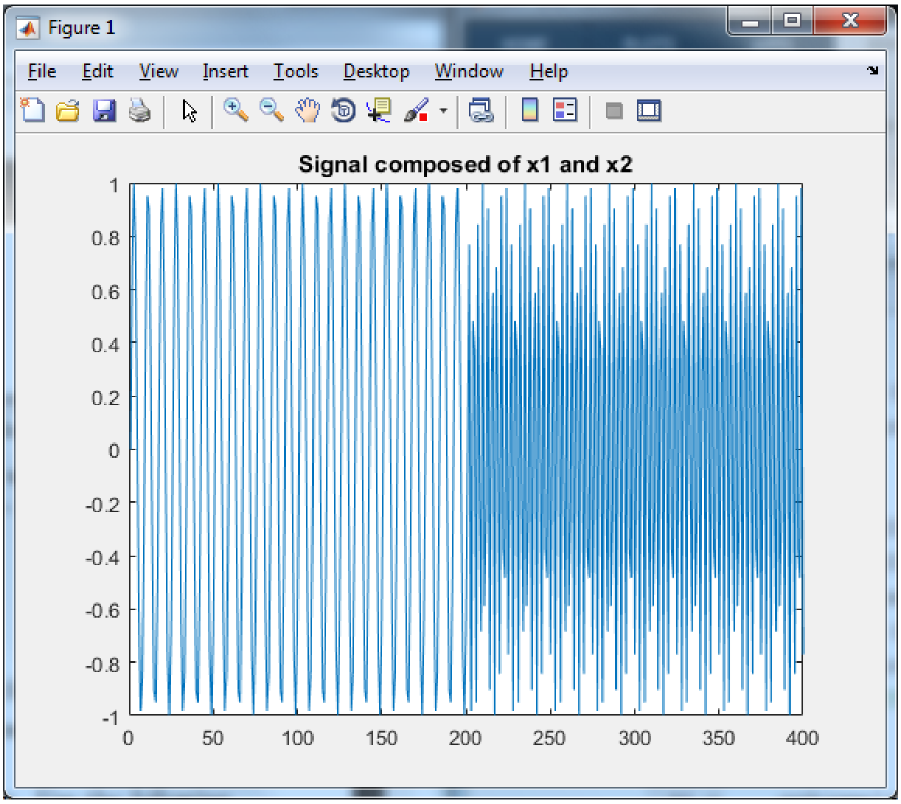
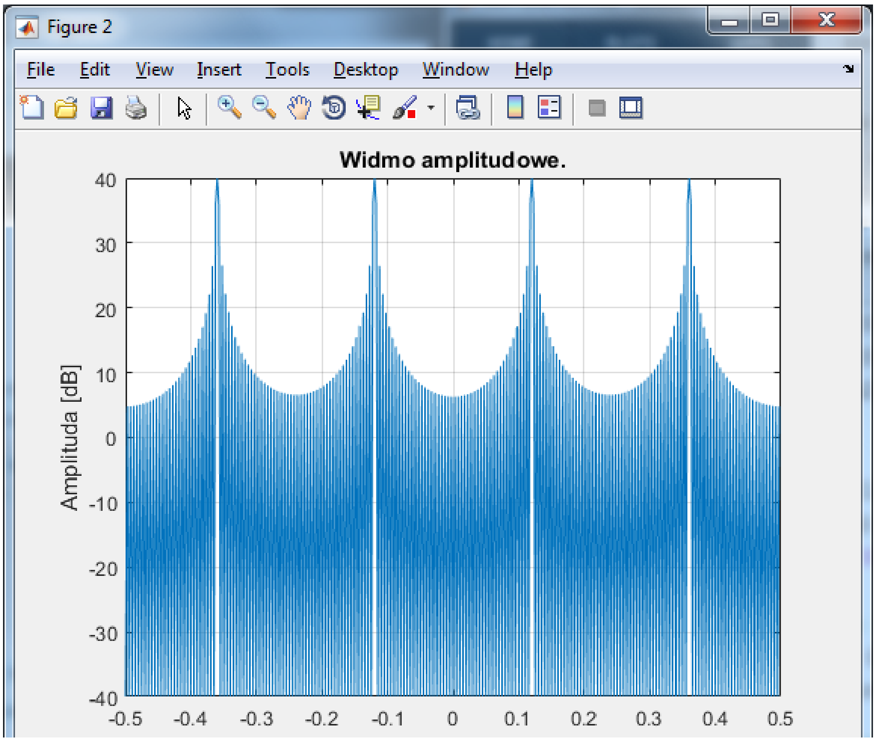
TASK 1

Simulate a signal containing 400 samples: 200 samples of a sinusoid with $\theta_1 = 0.24\pi$ and 200 samples of sinusoid with $\theta_2 = 0.72\pi$

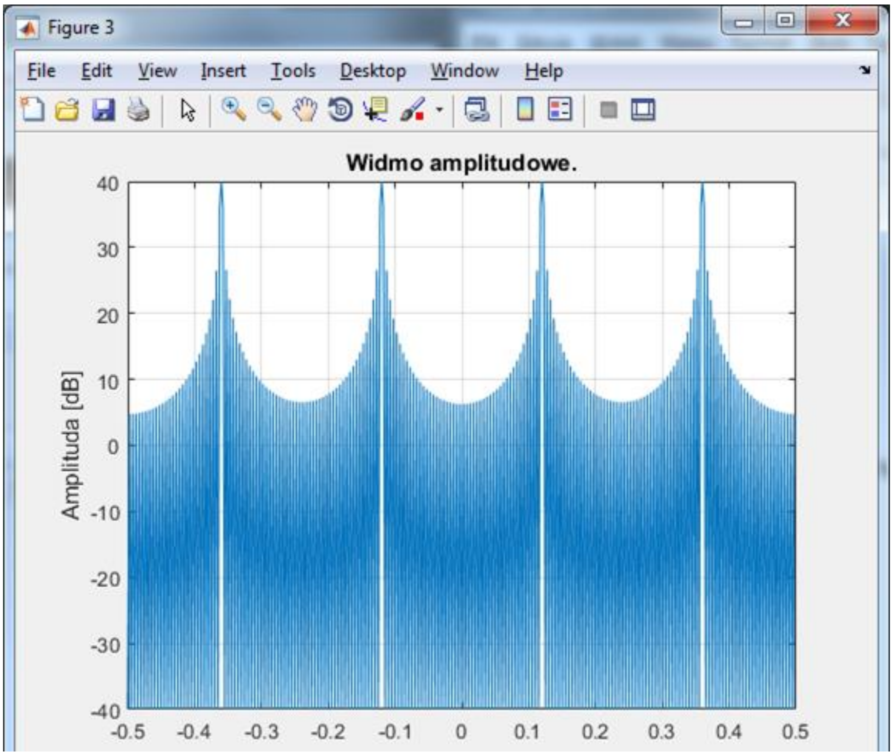
a) Plot the signal x:



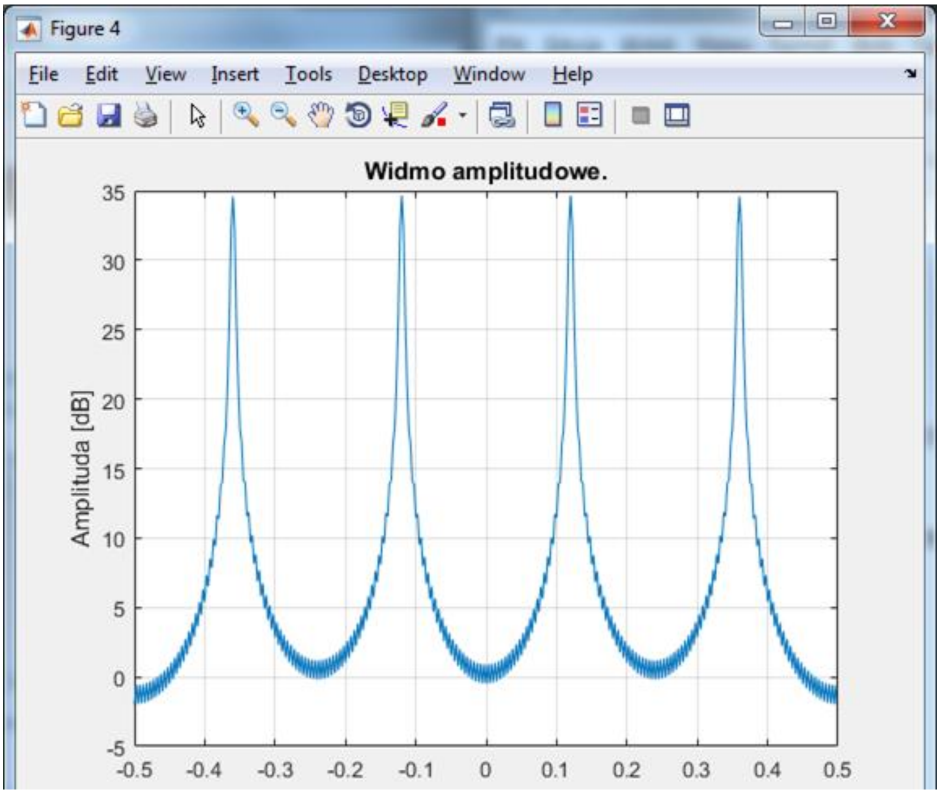
b) Plot its amplitude spectrum:



c) Plot its amplitude spectrum computed with rectangular window

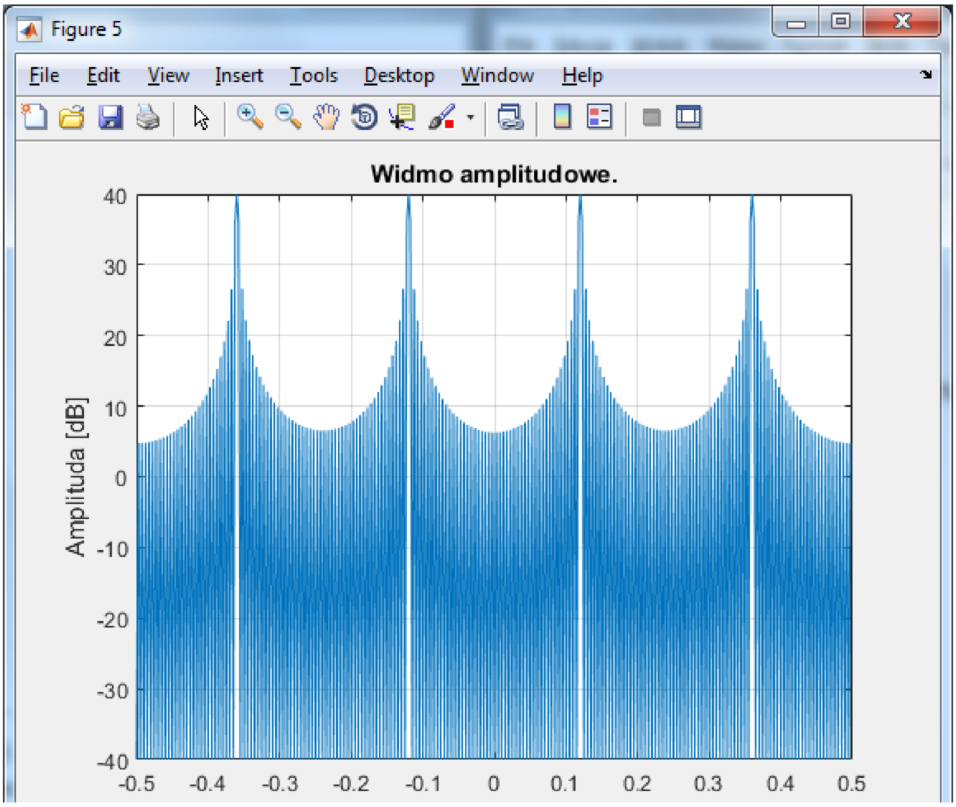


d) Plot the amplitude spectrum computed with Spectrum window:



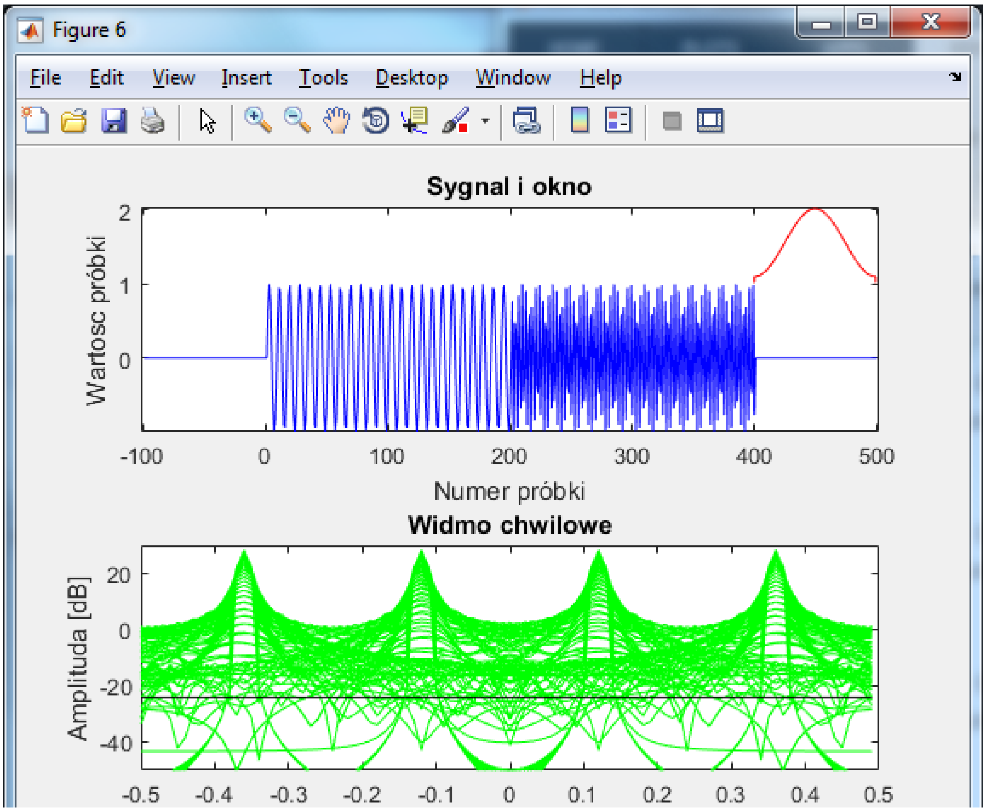
The amplitude window, obtained without the usage of any window (b) represents amplitude vs frequency characteristic of our signal. As it can be observed, the graph obtained with the usage of rectangular window (c), in fact represents identical, to the previously described graph, characteristic. While the amplitude window obtained with the usage of hamming window for the same signal (d), shows a different characteristic, being much more narrow in terms of base. Mainlobes here are much visible. Distance between each is the same as in (b) and (c) cases, however the maximal amplitude is reduced to 35 [dB]. Sidelobes there also much smaller than in two previous cases.

e) Reverse the order of frequencies in your signal, and the plot spectrum:

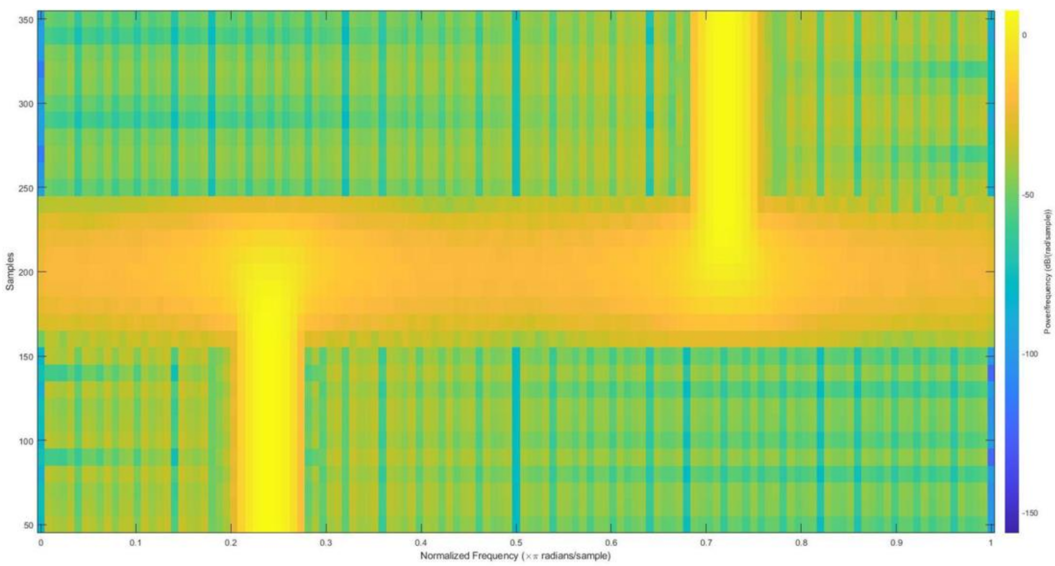


<u>As the graph above proves it – there is no difference produced for the amplitude spectrum, by changes in the order of signals. Namely, it doesn't matter which signal is the leading one, and which it the next one.</u>

f) Compute FFT with sliding window:



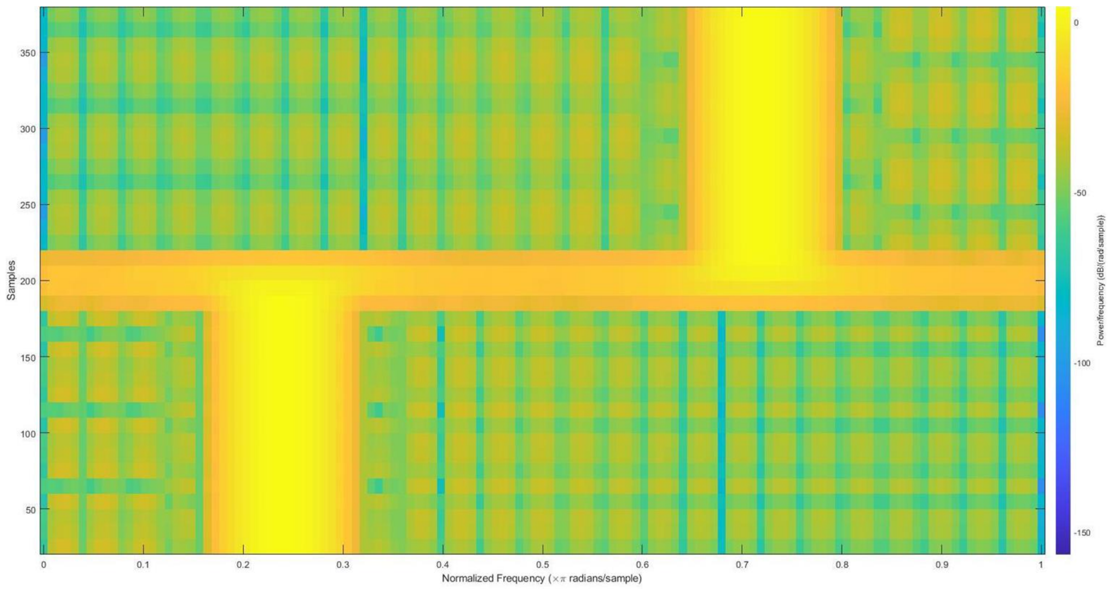
g) Plot the spectogram. Note the transitions between segments with different frequencies.



On the graph we can distinctly observe how frequency changed during the time. First, starting off with the first signal (0 to 199 samples) we see that frequency (theta) preserves the initial value of 0.24π. Then, at the sample 200 another signal begins, this short transition is represented by the horizontal orange line which surrounds the mark of 200 samples. We can observe that another signal starts at the 200 sample, at the value of 0.72π and then preserves this value until the end.

TASK 2

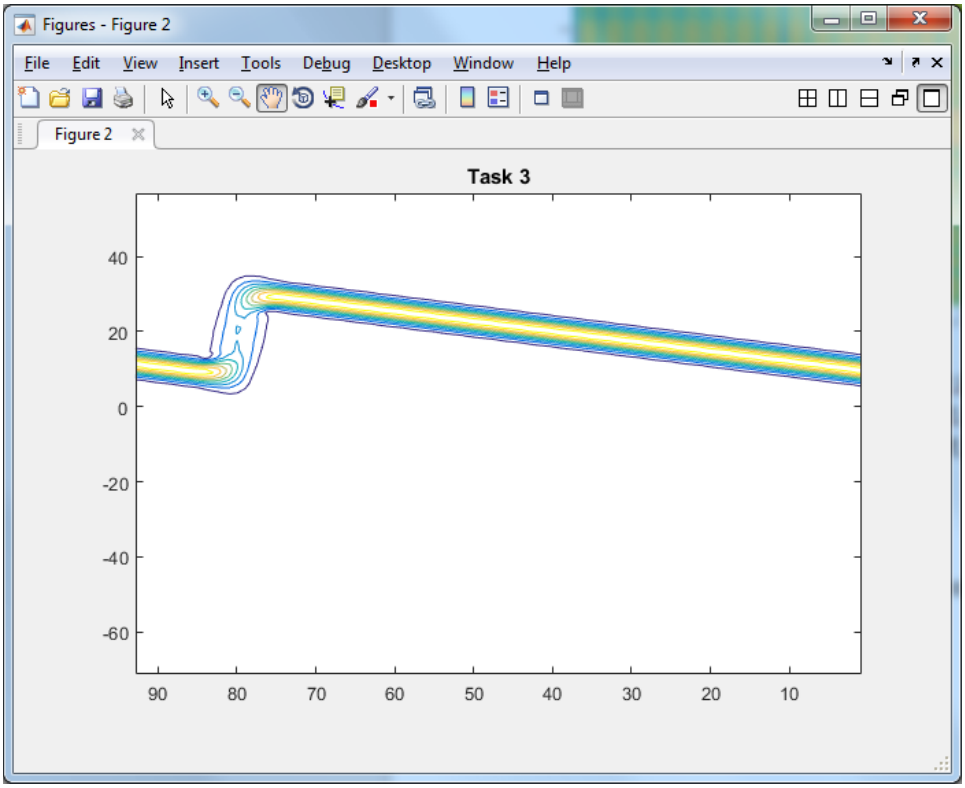
Repeat 1g) for shorter window:



As the window became shorter it is harder now to observe the correct frequencies of signals. But, now we can more precisely confirm that the moment of the end of the first signal and beginning of another was at 200 samples mark. Thus, we get a better precision in time with the shorter window, but pay for it with the loss of frequency precision.

TASK 3

Plot the spectogram of an LFM signal from the generator:



TASK 4

Experiment to see the properties of different window lengths (at least 2 lenghts) and window types (2-4 types, maybe including Kaiser with different β:

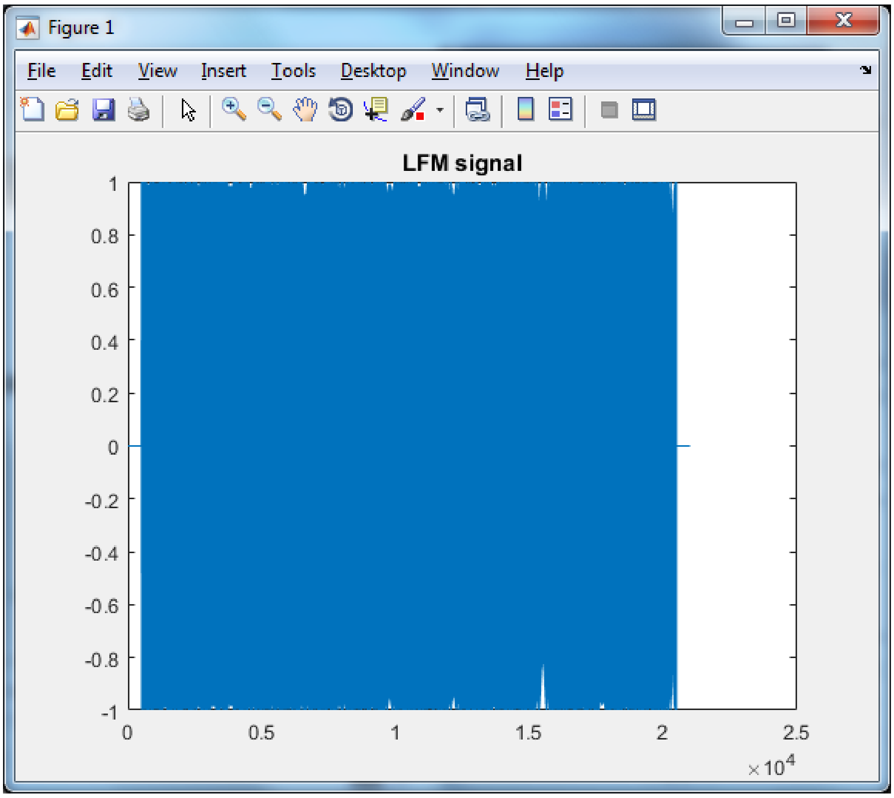


Figure 1
File Edit View Insert Tools Desktop Window Help
LFM signal
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.5
1
1.5
2
2.5
× 10^4

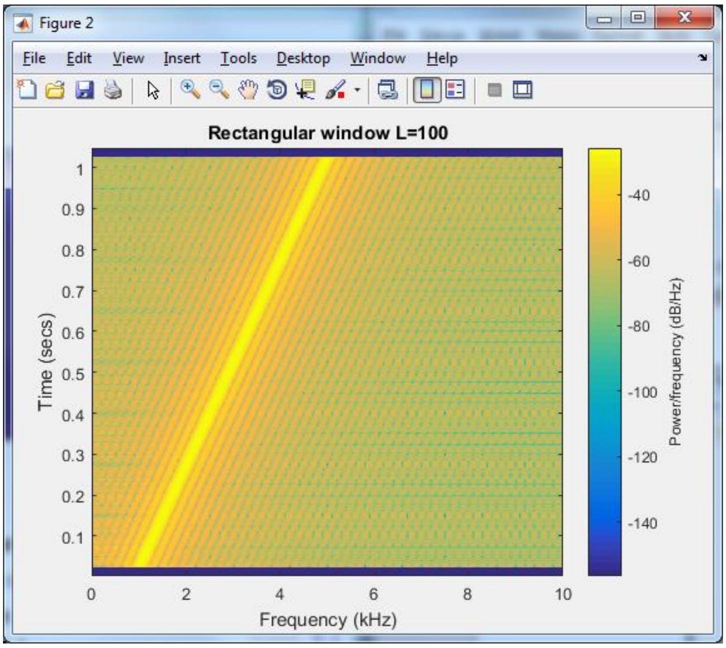


Figure 2
File Edit View Insert Tools Desktop Window Help
Rectangular window L=100
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)
0
2
4
6
8
10
-40
-60
-80
-100
-120
-140

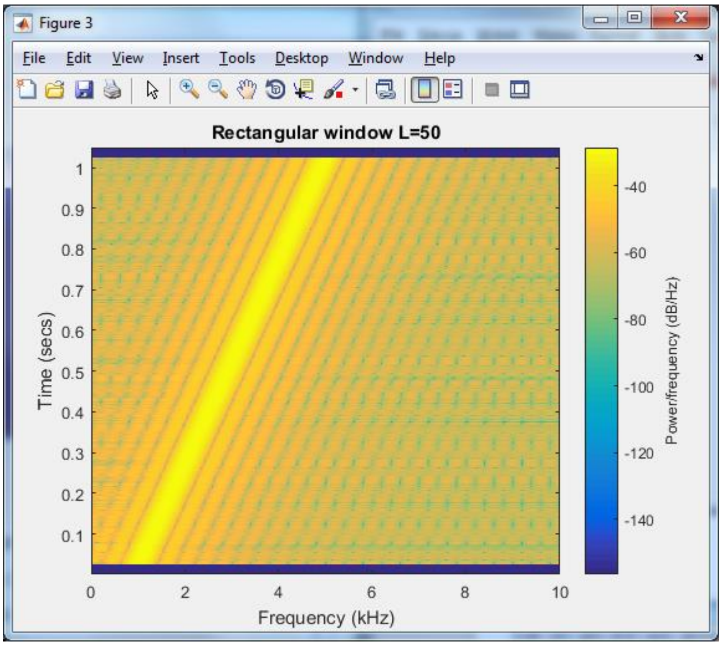


Figure 3
File Edit View Insert Tools Desktop Window Help
Rectangular window L=50
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)
0
2
4
6
8
10
-40
-60
-80
-100
-120
-140

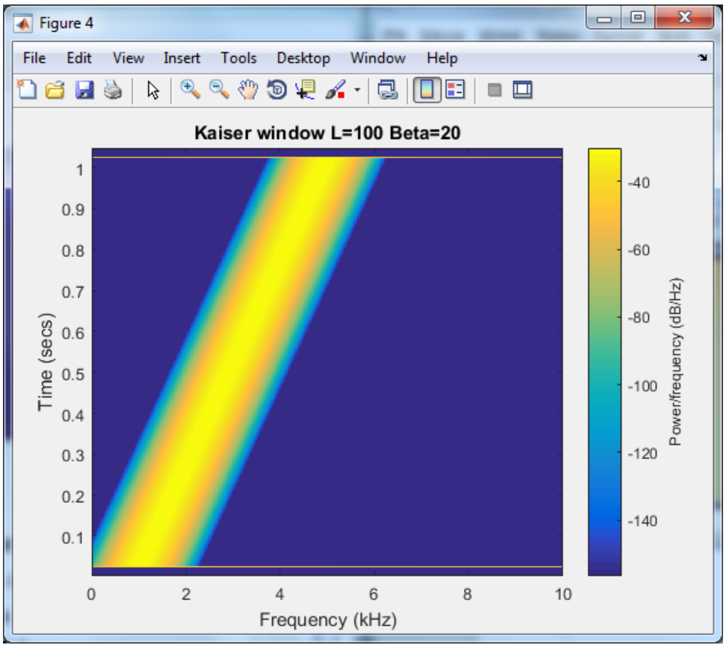


Figure 4
File Edit View Insert Tools Desktop Window Help
Kaiser window L=100 Beta=20
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)

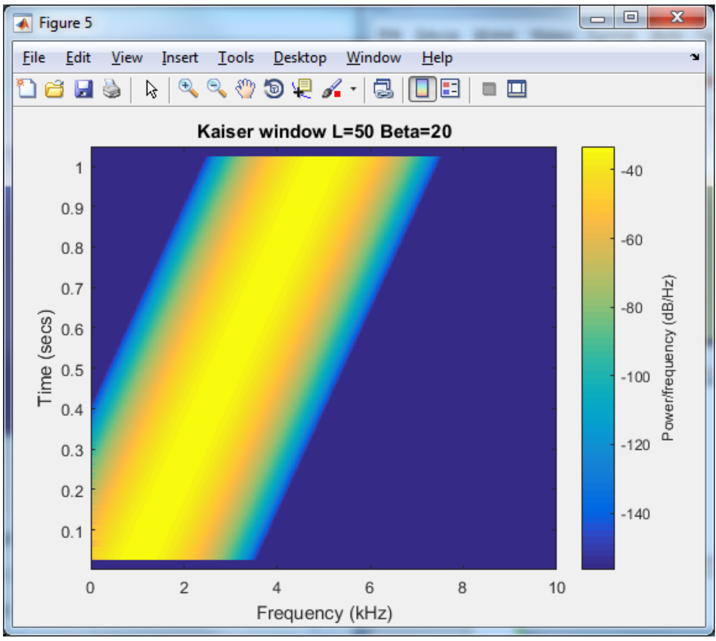
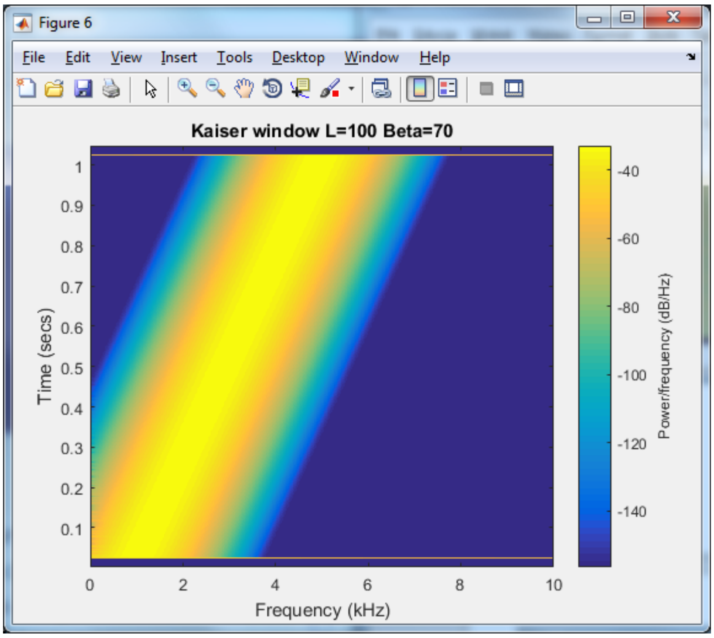
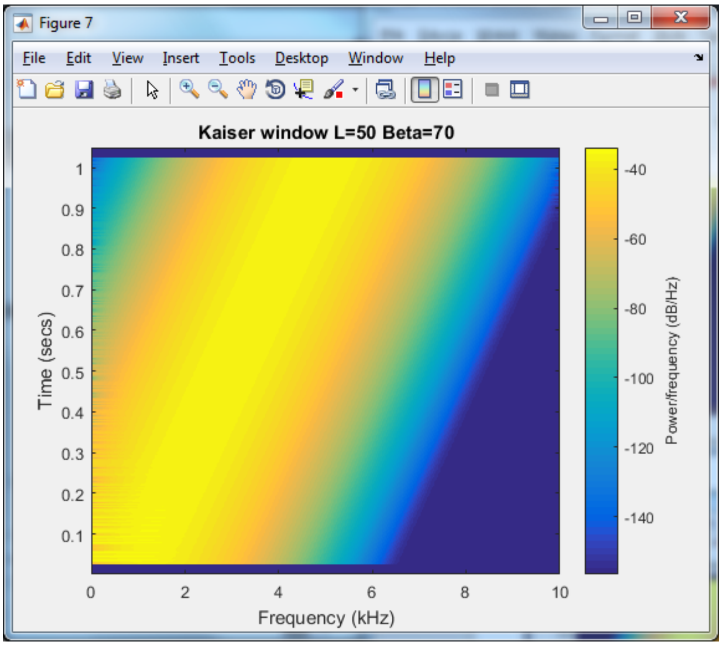


Figure 5
File Edit View Insert Tools Desktop Window Help
Kaiser window L=50 Beta=20
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)



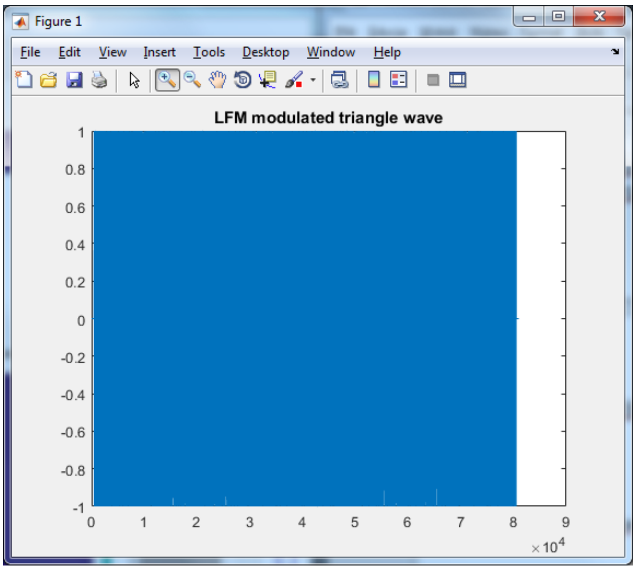


The windows used for our signal in that case were Rectangular and Kaiser ones. Rectangular window with the length 100 gives a clear insight on the nature of signal – a sound, which grew fast, like a high-pitched note. We can clearly observe the change from 1 [kHz] frequency to the 5 [kHz]. Duration of the signal is one second, which is also visible.
Next, using the wider rectangular window (length 50) allows us to better see the time changes, while the correct initial frequency is more difficult to determine.

The Kaiser window clears the graph from the other distortions (as those other lines we could see in case of rectangular window, near the main characterstic). In the case of Kaiser windows with length equal to 100 and beta equal to 20 we can deduce the similar signal characteristics as in case of rectangular window. Changes of length (to 50) and beta (to 20) in two consequently following graphs lead to the obtaining of two quite identical characteristics, where the signal frequency pattern is still possible to determine, but may be more difficult. Duration of the signal is easier to observe in this case.
On the last graph (Kaiser, length=50, beta=70) it is quite difficult to determine precisely the frequency values of the signal, however the general look is still close to those described before. Closer to the time-scale we can see small lines, which prove the wave shape of the signal and show that in some short time instant signal didn't preserve precisely same value of the Power/frequency ratio.

TASK 5

Repeat the experiments with LFM modulated triangular wave.



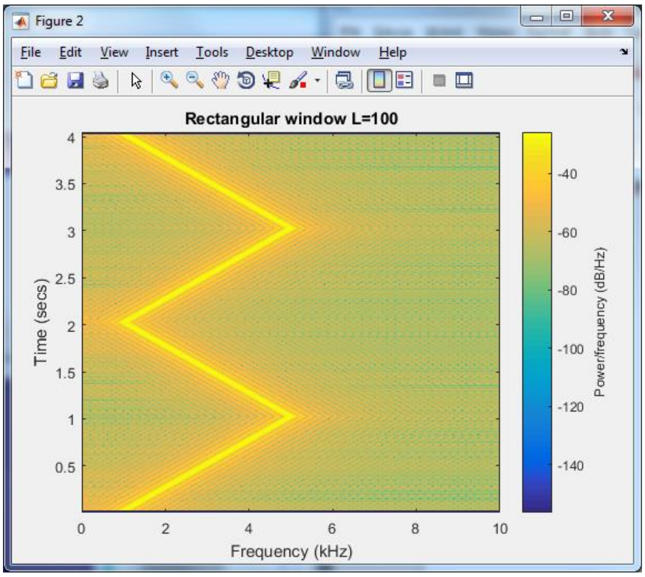


Figure 2
File Edit View Insert Tools Desktop Window Help
Rectangular window L=100
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)

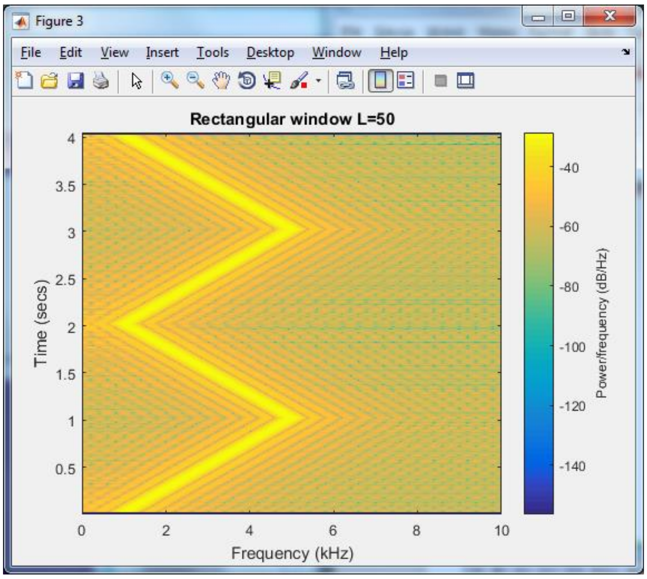


Figure 3
File Edit View Insert Tools Desktop Window Help
Rectangular window L=50
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)

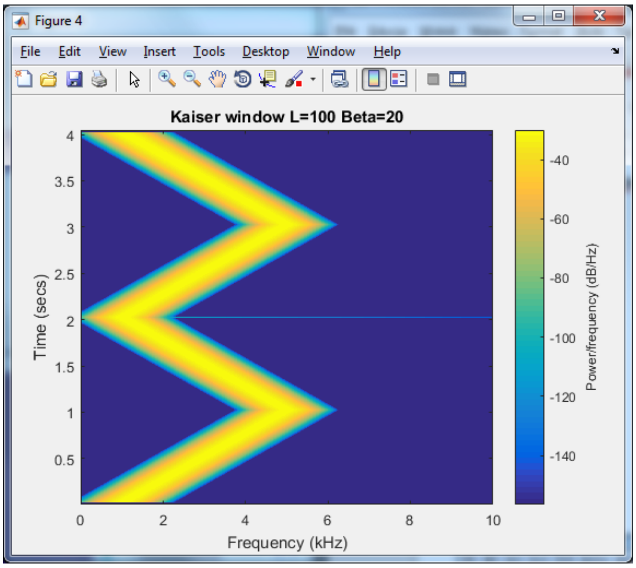


Figure 4
File Edit View Insert Tools Desktop Window Help
Kaiser window L=100 Beta=20
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)

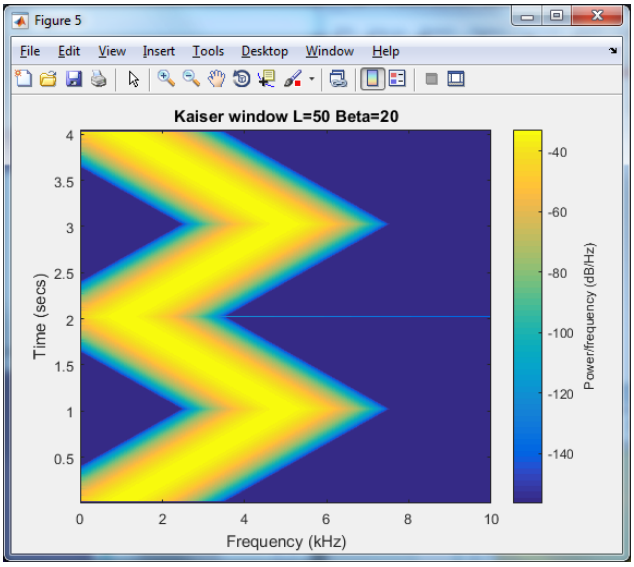


Figure 5
File Edit View Insert Tools Desktop Window Help
Kaiser window L=50 Beta=20
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)

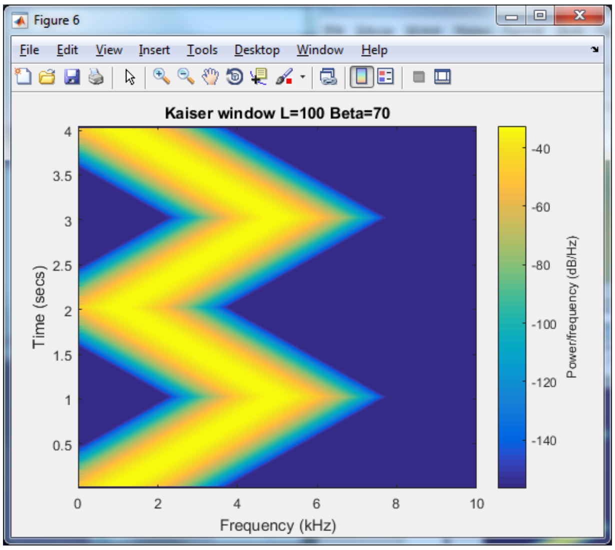


Figure 6
File Edit View Insert Tools Desktop Window Help
Kaiser window L=100 Beta=70
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)

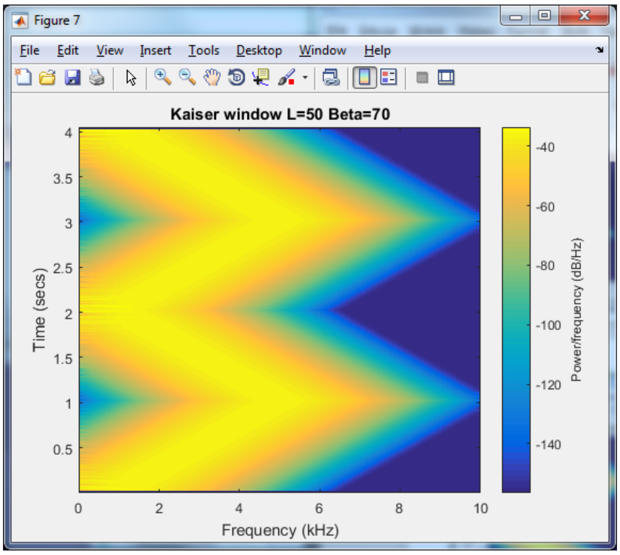
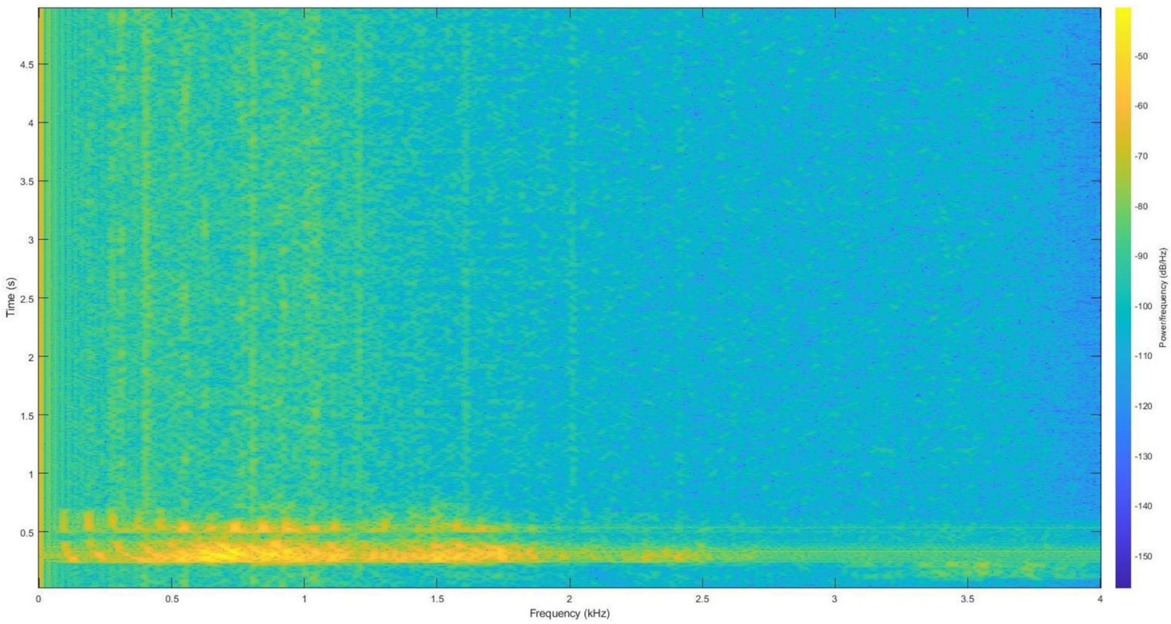


Figure 7
File Edit View Insert Tools Desktop Window Help
Kaiser window L=50 Beta=70
Time (secs)
Frequency (kHz)
Power/frequency (dB/Hz)

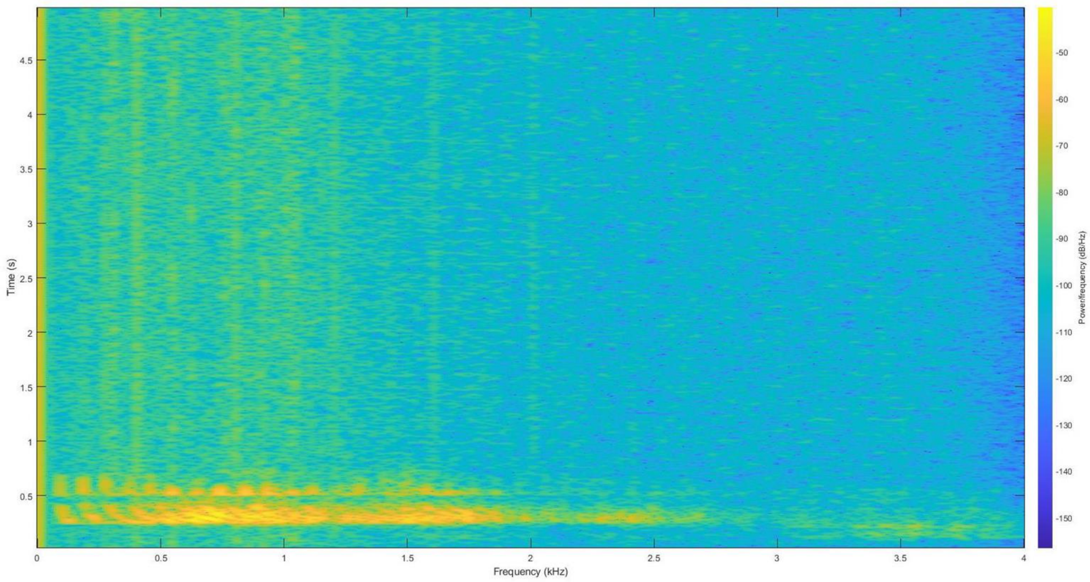
TASK 6

Plot the spectrogram of a voice signal from the microphone:

Word SEVEN

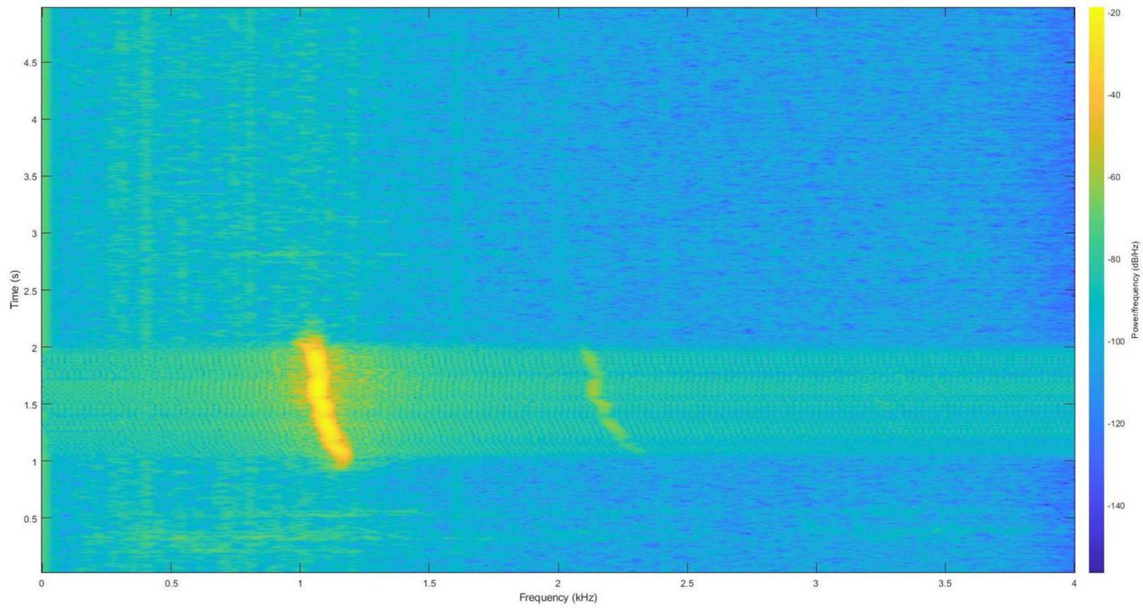


Hamming window

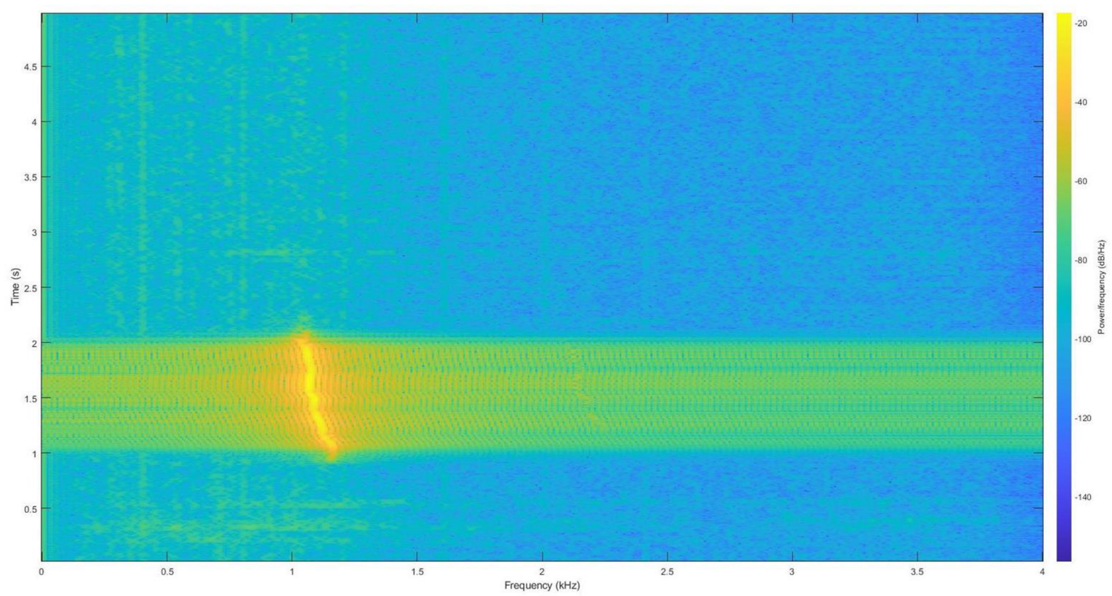


Rectangular window

My signal was generated by me, saying the word “seven” at the very beginning. Nature of the signal can be observed with the help of first graph. The beginning of the signal, where I start with the sound “s” is about 0.25 of a second and is followed by the sound “e” as we can see consequently. Then there is a small gap at about 0.5 second, which correspond to the “v” sound, which is pronounced rather less distinctly than other sounds in this word



Hamming window



Rectangular window

This time I made a short whistle as input sound. This time it is much more denser that previous sound. We observe its frequency and duration clearly. In addition, Hamming window has taken into account more higher frequencies of background noise and some echo is present.