Project Report
EE 210: Signals and Systems

Submitted by: Ram Milan Verma (150010037)
Anuj Agarwal (150110041)

Audio signal (1D) processing:

Brief description of MATLAB Code:

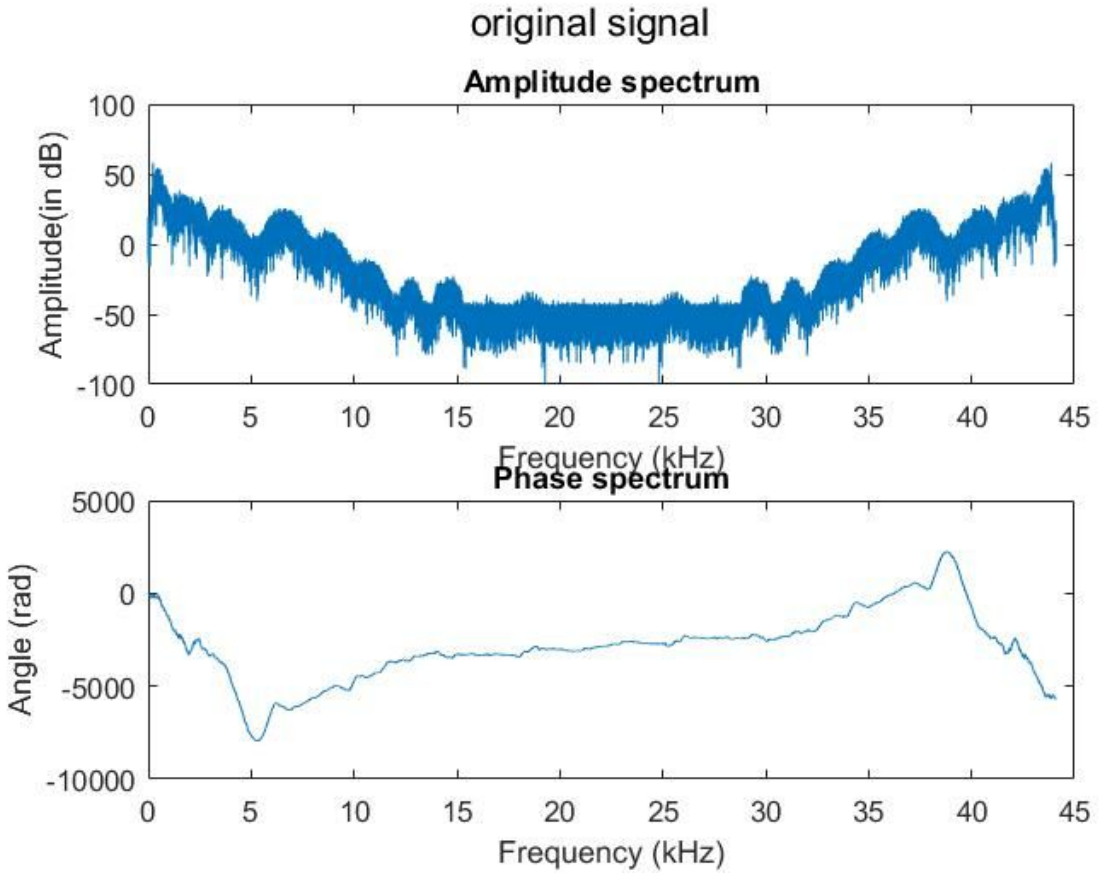
1. 'ft_spect.m' file contains function for plotting phase and amplitude spectrum of the audio signal.
2. 'audioprocess.m' file contains the function to do the processing of audio signal as per the requirement of the question as saves the various processed signals as per the specified format.
3. 'conv1d.m' file contains function for computation of the convolution of 1d signal. Note: using this function was taking time so inbuilt function is used for analysis.
4. 'audioprocessing.m' is the main file which calls all the required functions to do the required job.

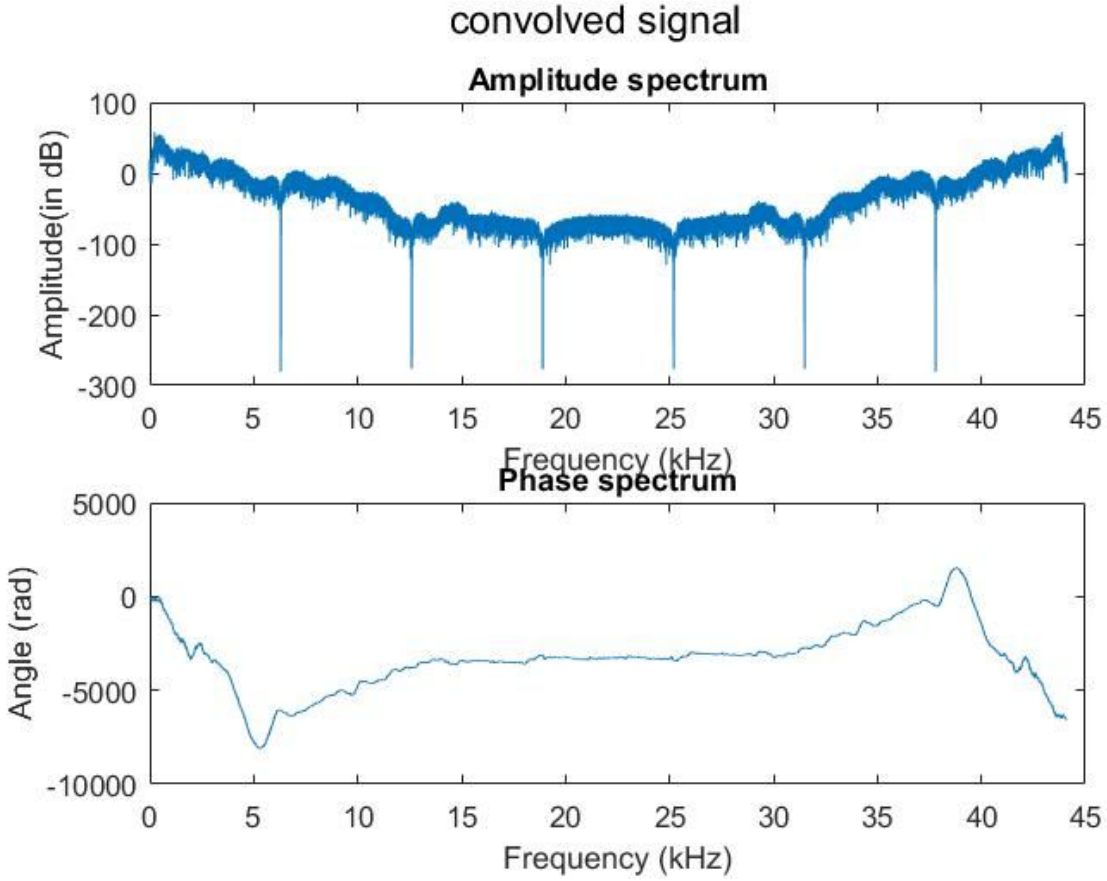
Given filter kernel, h =[1 1 1 1 1 1 1]/7

Q. How is the convolved signal and original signal different?

Ans.: There is difference in amplitude of both the signals while the phase pattern remains the same. Below is the phase and magnitude spectrum of the signal.

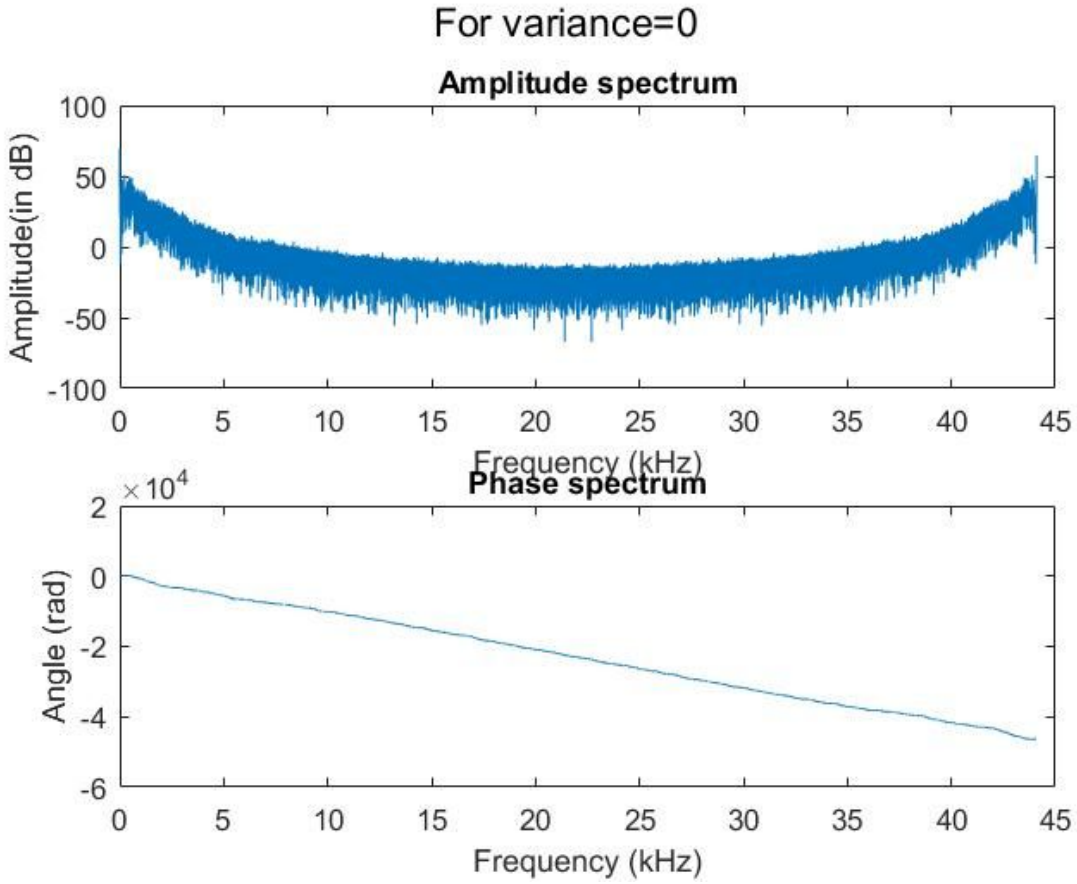
Also when when we listen to the signal by using h=[1 1 1 1 1 1 1]/200 the volume becomes very low. And when we listen to by using h =4*[1 1 1 1 1 1 1], the volume of the signal becomes high along with amplification of noise too.


original signal
Amplitude spectrum
Amplitude(in dB)
100
50
0
-50
-100
0
5
10
15
20
25
30
35
40
45
Frequency (kHz)
Phase spectrum
Angle (rad)
5000
0
-5000
-10000
0
5
10
15
20
25
30
35
40
45
Frequency (kHz)

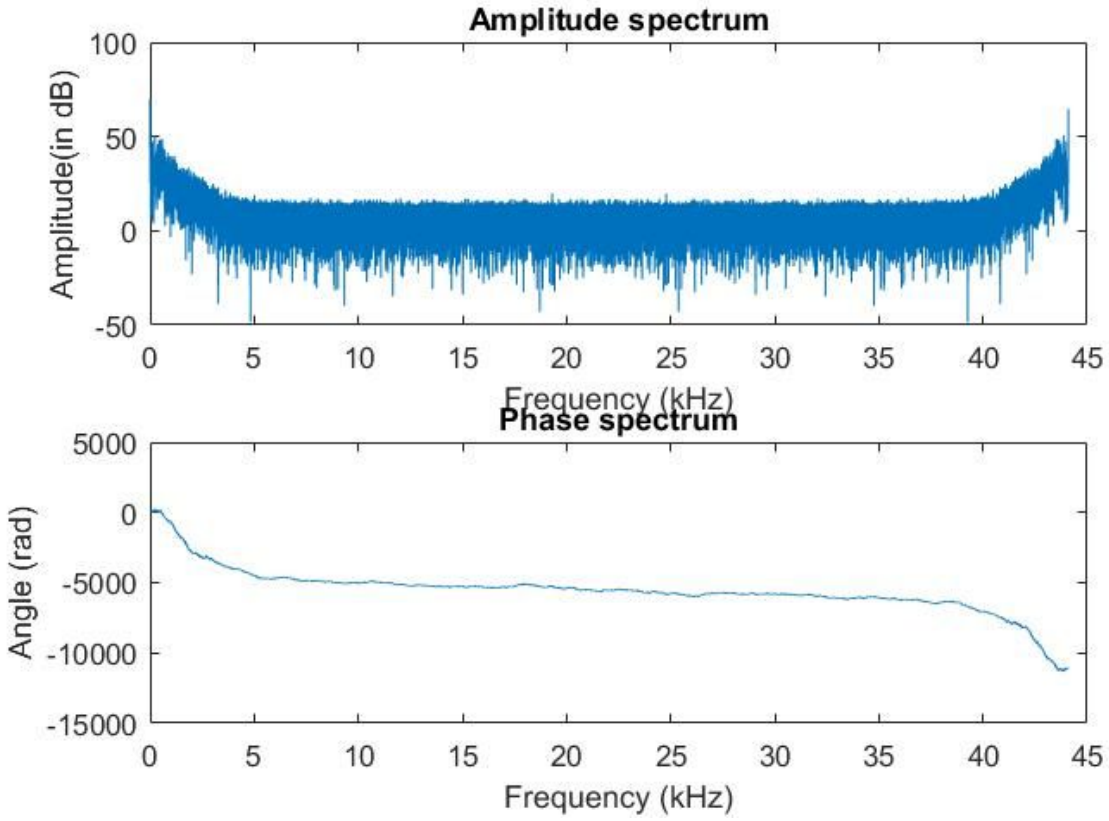

convolved signal
Amplitude spectrum
Amplitude(in dB)
100
0
-100
-200
-300
0
5
10
15
20
25
30
35
40
45
Frequency (kHz)
Phase spectrum
Angle (rad)
5000
0
-5000
-10000
0
5
10
15
20
25
30
35
40
45
Frequency (kHz)

Q. Now add a random noise of variance \sigma^2 to the filtered output g(x), and call it y(x). Vary \sigma and listen to the signal.

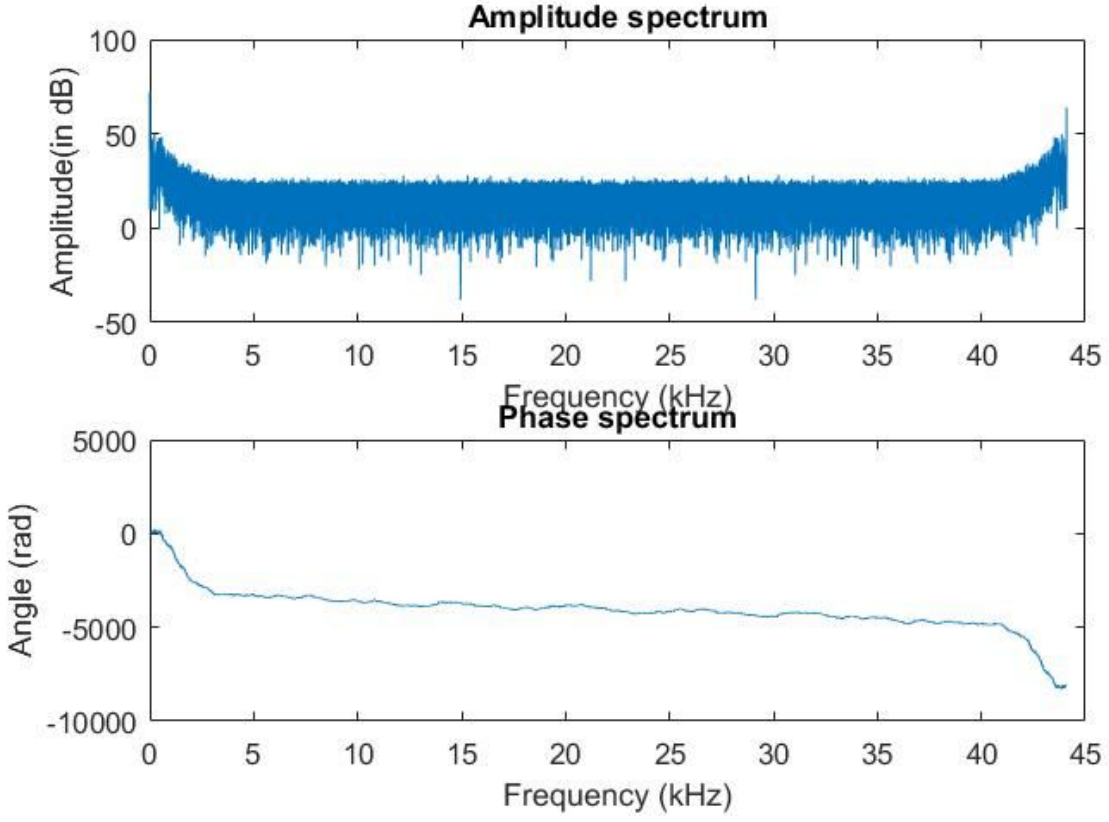
Observation: With the increase in sigma the signal becomes more and more noisy. Below is the spectrum plots for various sigmas.



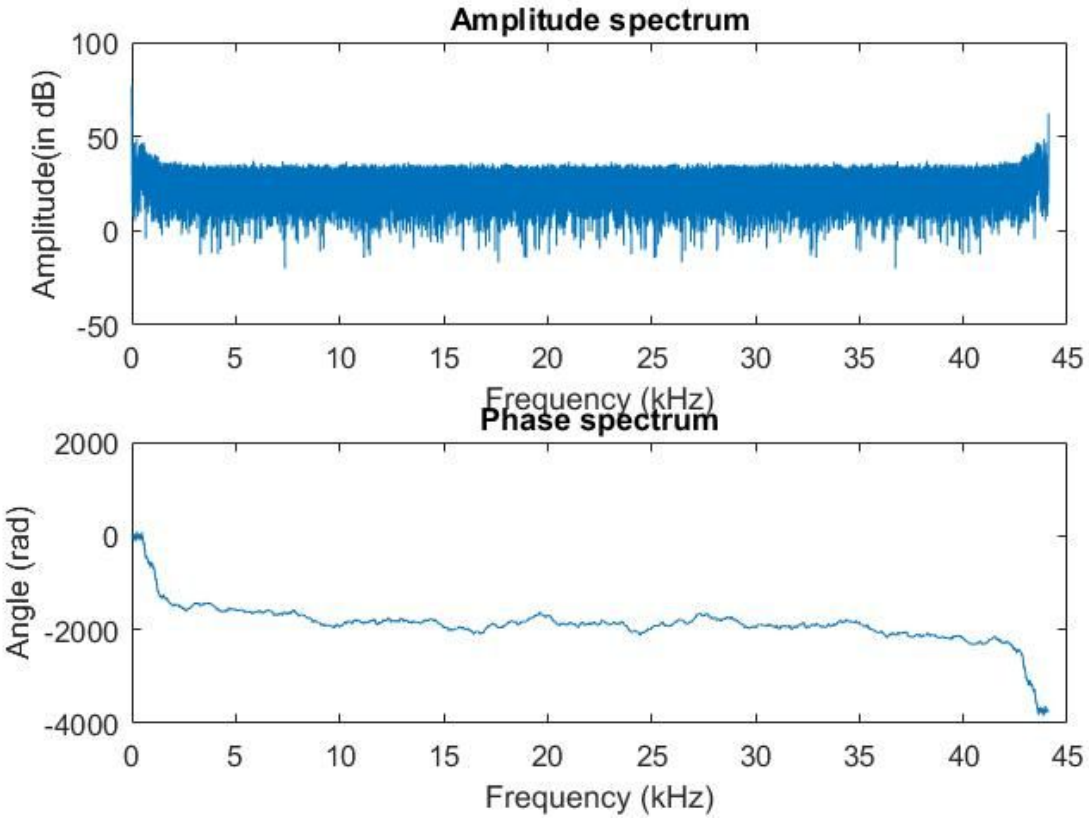
For variance=0.0001



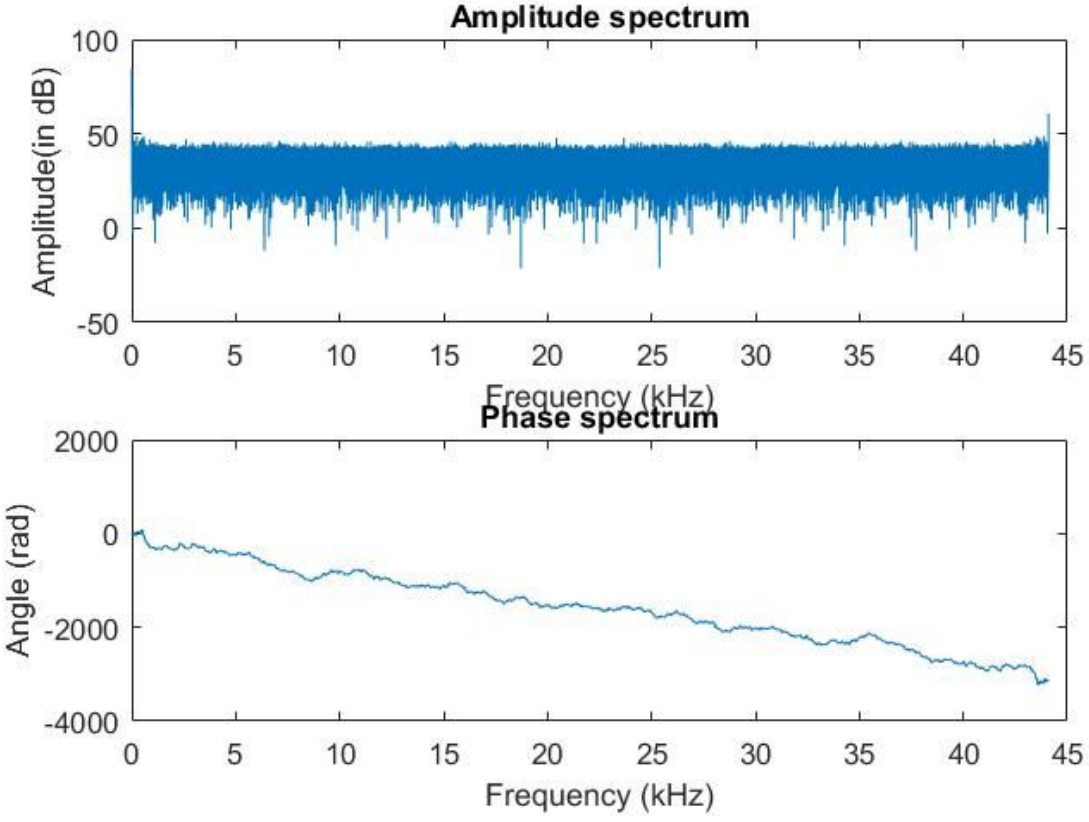
For variance=0.001

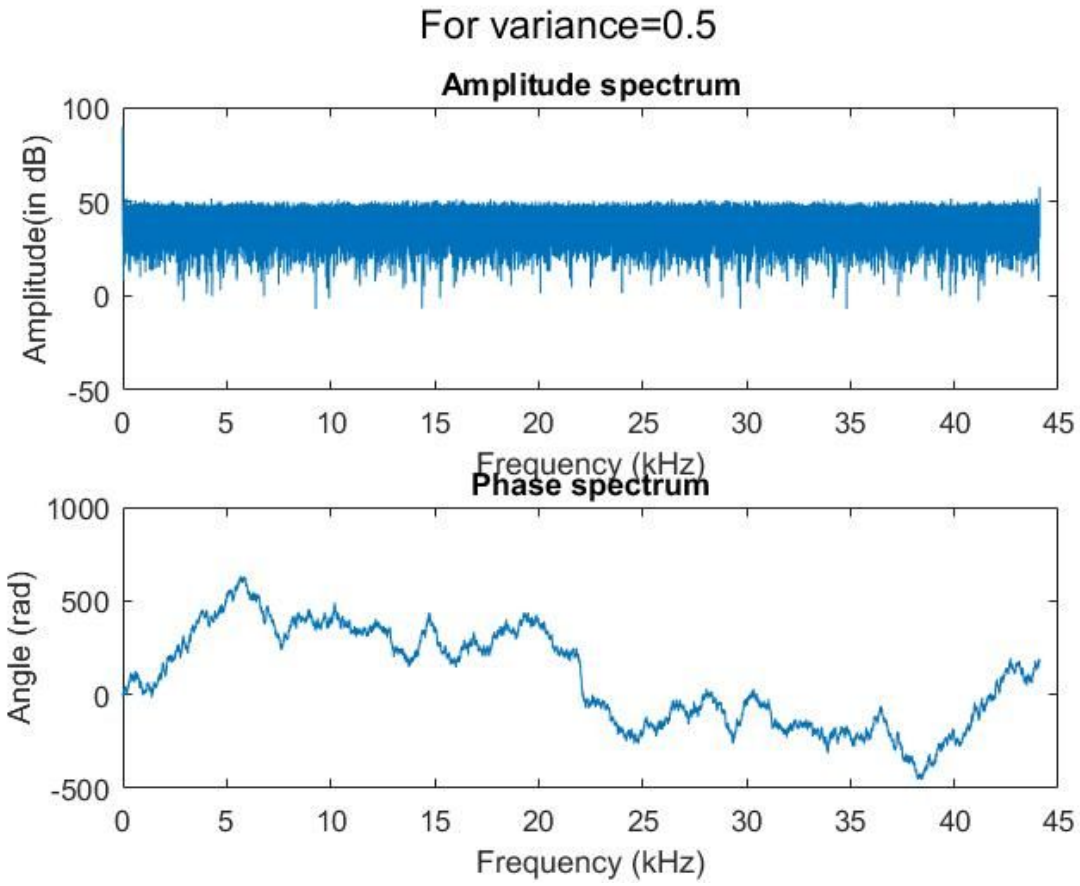


For variance=0.01



For variance=0.1



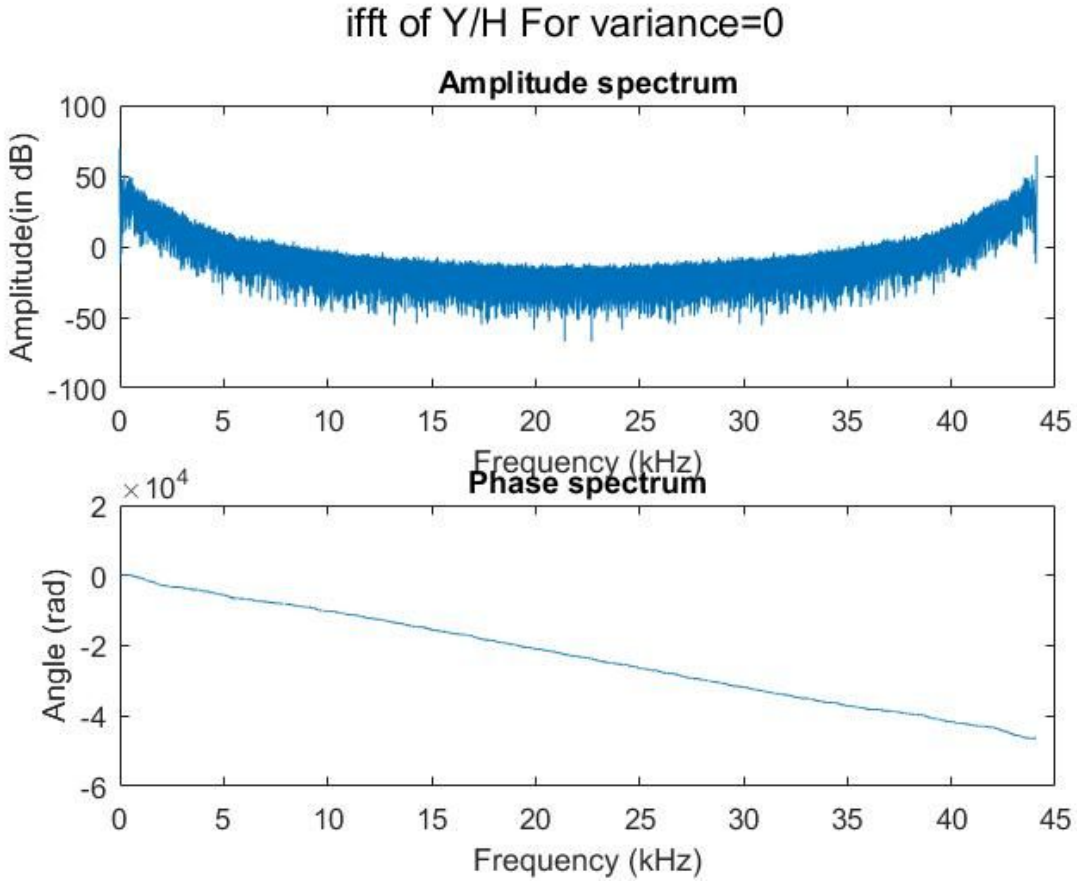


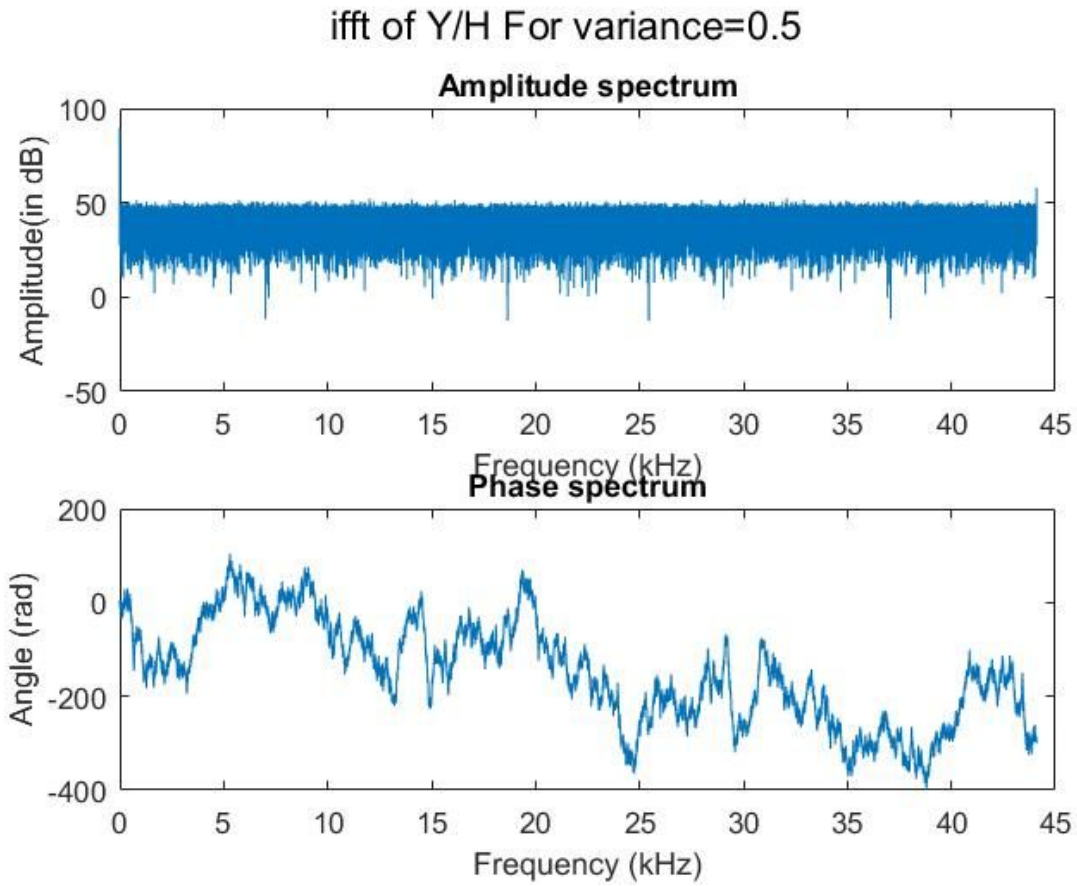
From the plots we can see that there is not much difference in the pattern and magnitude of the amplitude spectrum but the phase spectrum pattern and magnitude changes noticeably. With the increase of sigma the phase spectrum magnitude decreases.

Q. Obtain Y(w)/H(w) and then the inverse DFT. Compare this to the original signal for different values of \sigma (including \sigma=0). Explain why there is a difference.

Ans.: With the increase of variance the noise is increasing. We are not getting the original signal back. The reason is we added noise to the convolved function and then deconvolved or divided with the convolution function back expecting to get back the same signal but it's not.

Now plots of the spectrum for various sigma. We're not putting all the plots because all of them looks similar to previous case plots.


ifft of Y/H For variance=0
Amplitude spectrum
Amplitude(in dB)
100
50
0
-50
-100
0
5
10
15
20
25
30
35
40
45
Frequency (kHz)
Phase spectrum
×10^4
2
0
-2
-4
-6
Angle (rad)
Frequency (kHz)

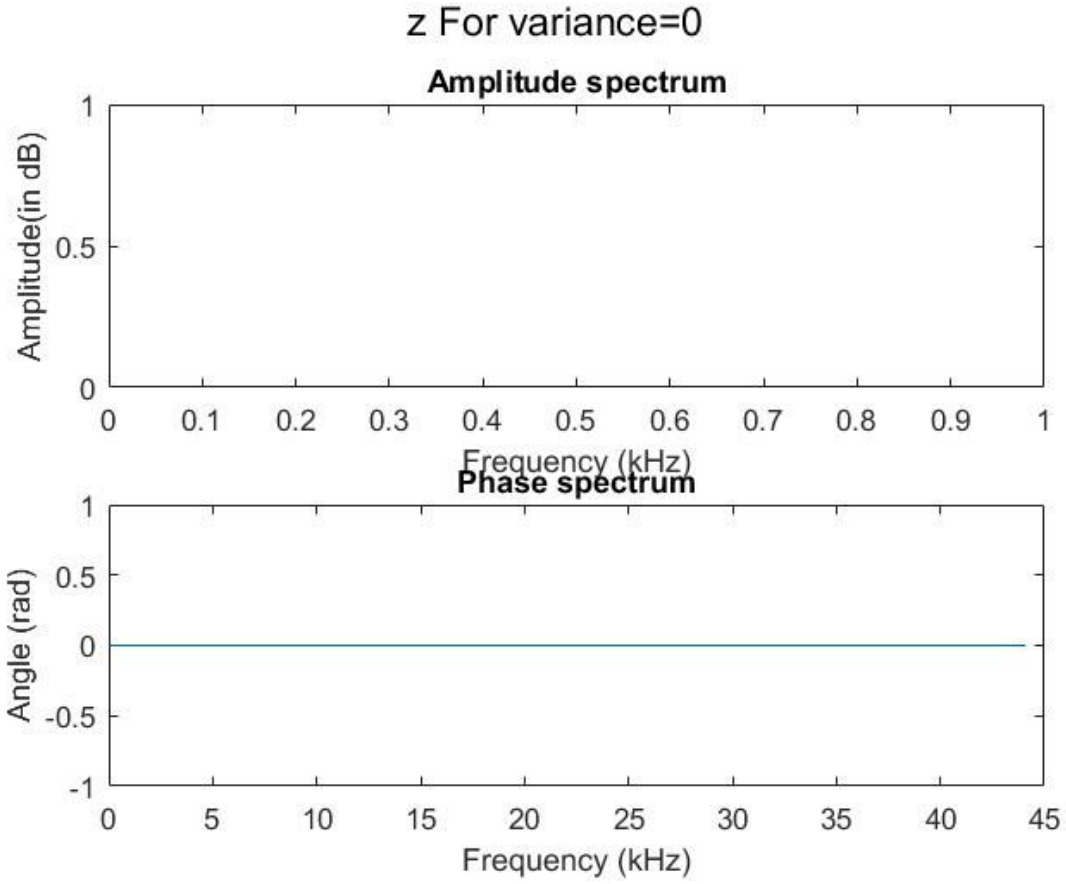

ifft of Y/H For variance=0.5
Amplitude spectrum
Amplitude(in dB)
100
50
0
-50
0
5
10
15
20
25
30
35
40
45
Frequency (kHz)
Phase spectrum
200
0
-200
-400
Angle (rad)
Frequency (kHz)

Q. Now, instead, multiply Y(w)/H(w) with a Gaussian Gs(w) with mean w=0 and variance v^2. Take the inverse DFT of Gs(w)Y(w)/H(w), call it z(x), and listen to the signal z(x) for various values of v.

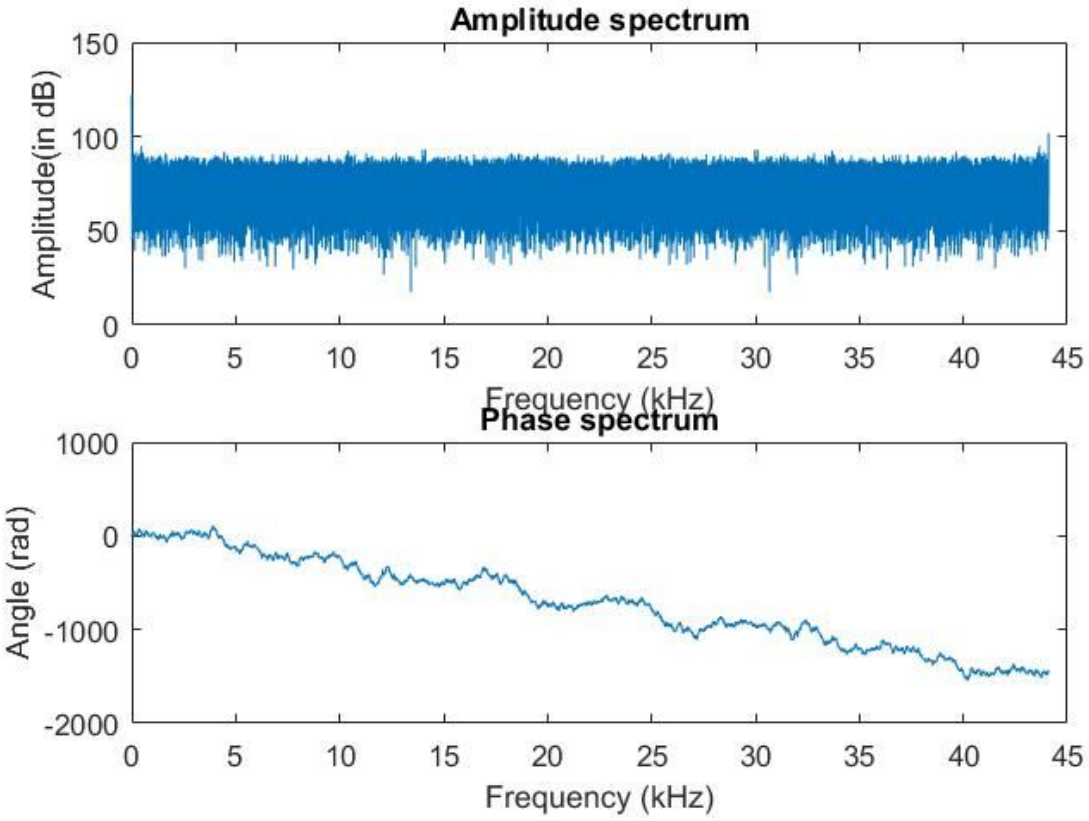
Observation:

For zero sigma it was silent. And for other sigma we're unable to listen to the voice. It sounded too noisy to be able to identify the human voice in the signal. However with the increase of the value of the sigma the noise magnitude increased.

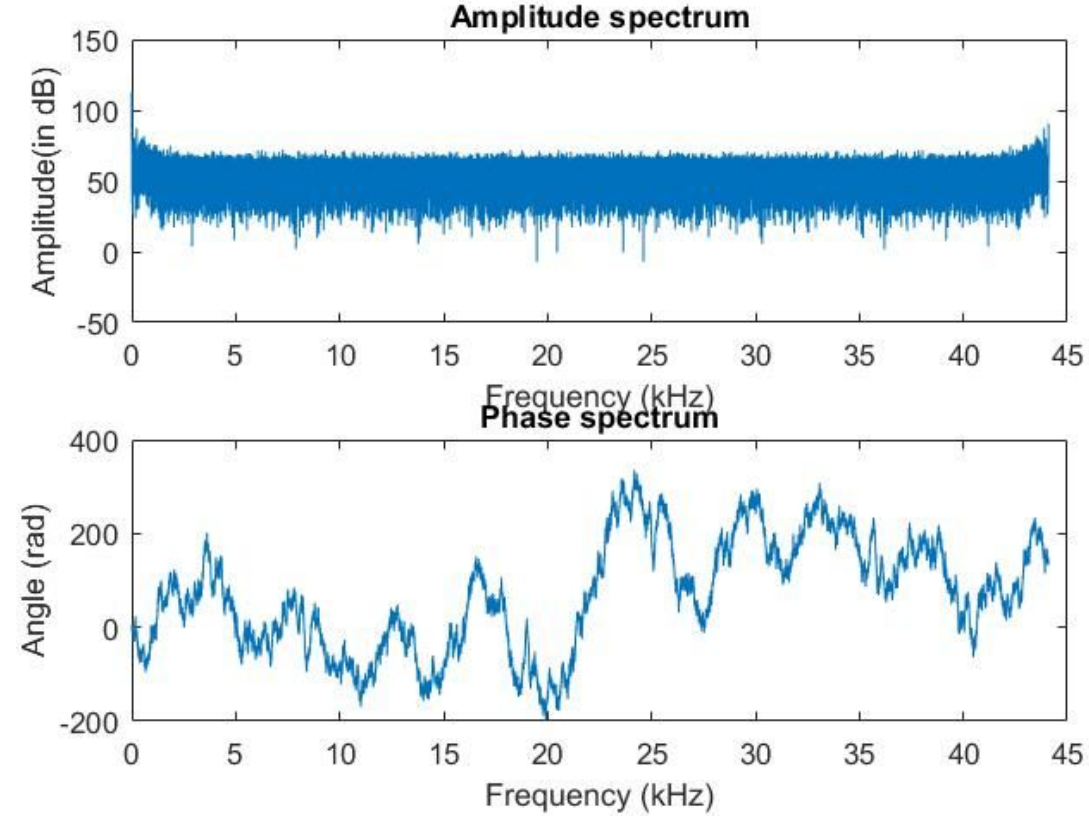
Plot for the same are :



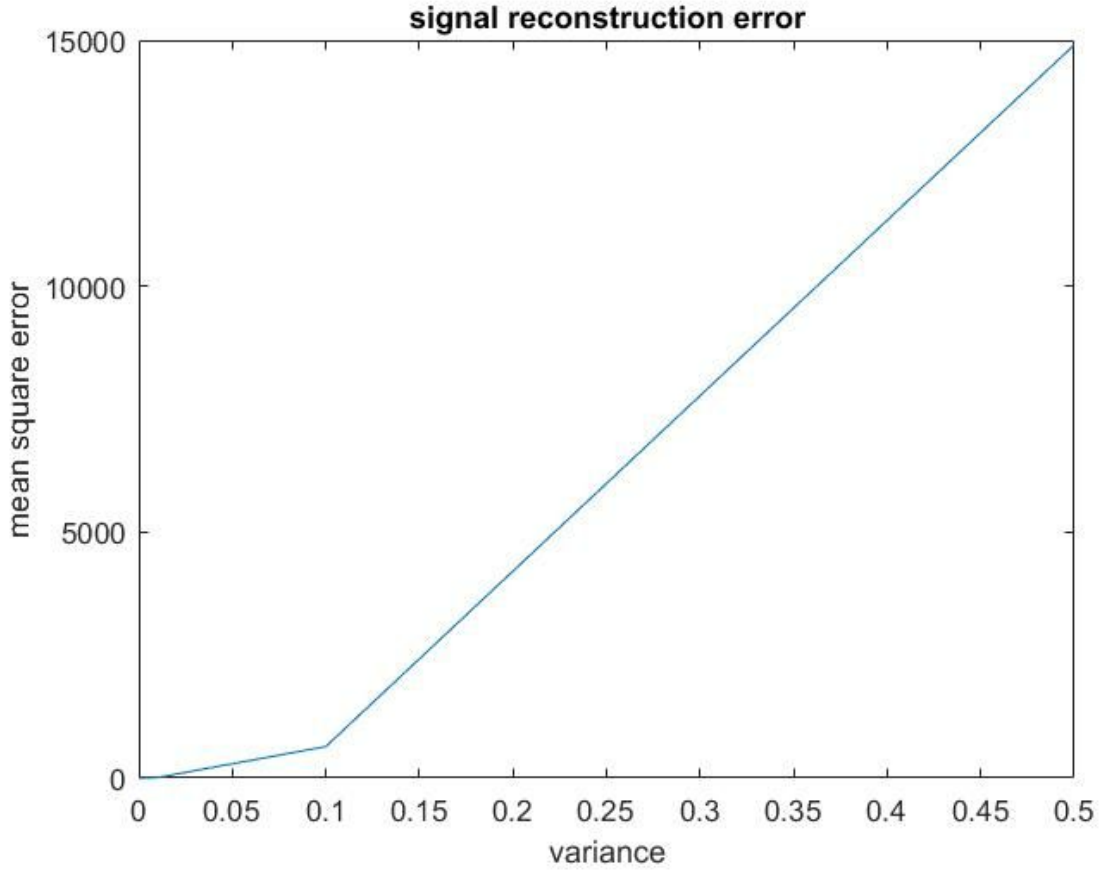
z For variance=0.1



z For variance=0.01



Q. Plot Signal reconstruction error.



With the increase in variance the signal reconstruction error increases.

var=0	var=0.0001	var=0.001	var=0.01	var=0.1	var=0.5
0.009521643	0.067365317	0.509789911	9.154029312	639.8150553	14905.83703

Image(2D signal) processing:

Brief description of the MATLAB Code:

1. ‘conv2d.m’ this function for computing the 2D convolution.
   Note: This function was taking time so we used the inbuilt function for the sake of analysis.

Given Kernel : h=(1/49)*ones(7,7); A 7X7 matrix

Original image, s(x,y)

Fig: s.jpg

Image after convolution:

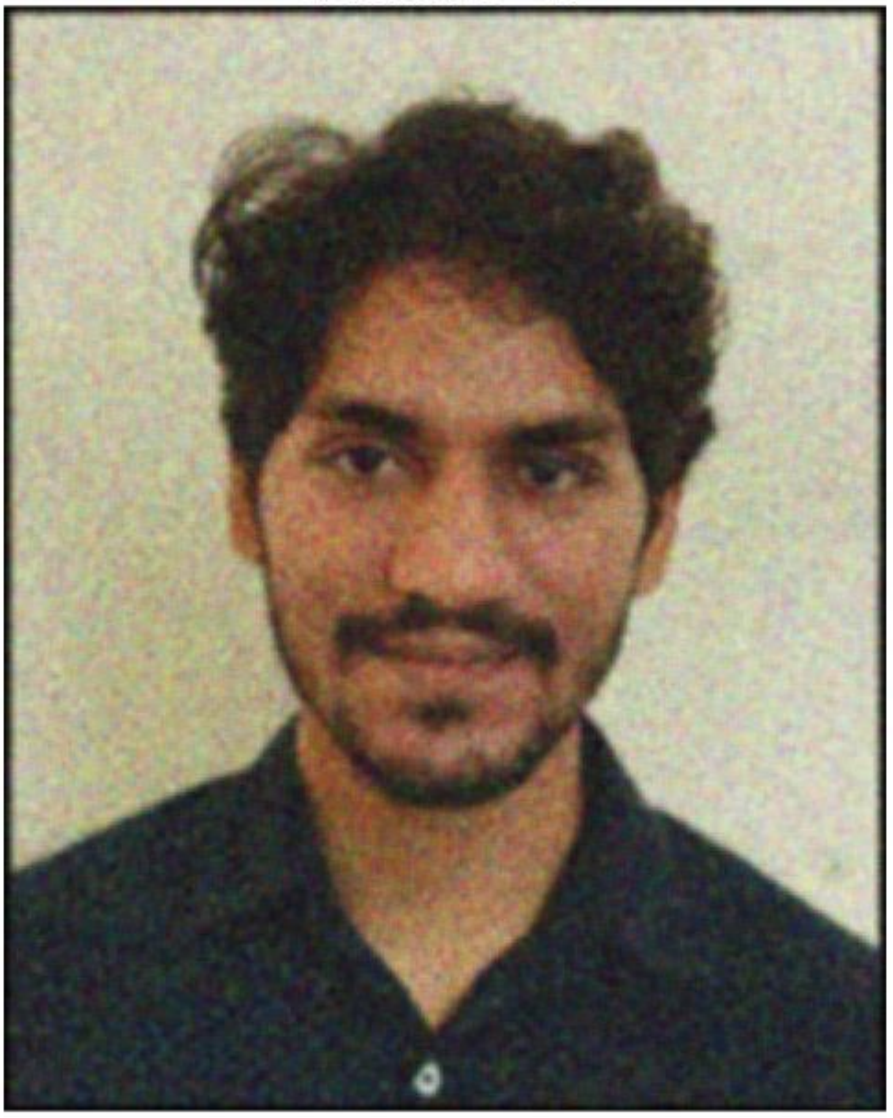
Fig.: g.jpg

Observation: The image's sharpness has been lost after the convolution with the kernel given. It looks like the mean filter. That means each pixel has been replaced by the mean of the neighbouring pixels.

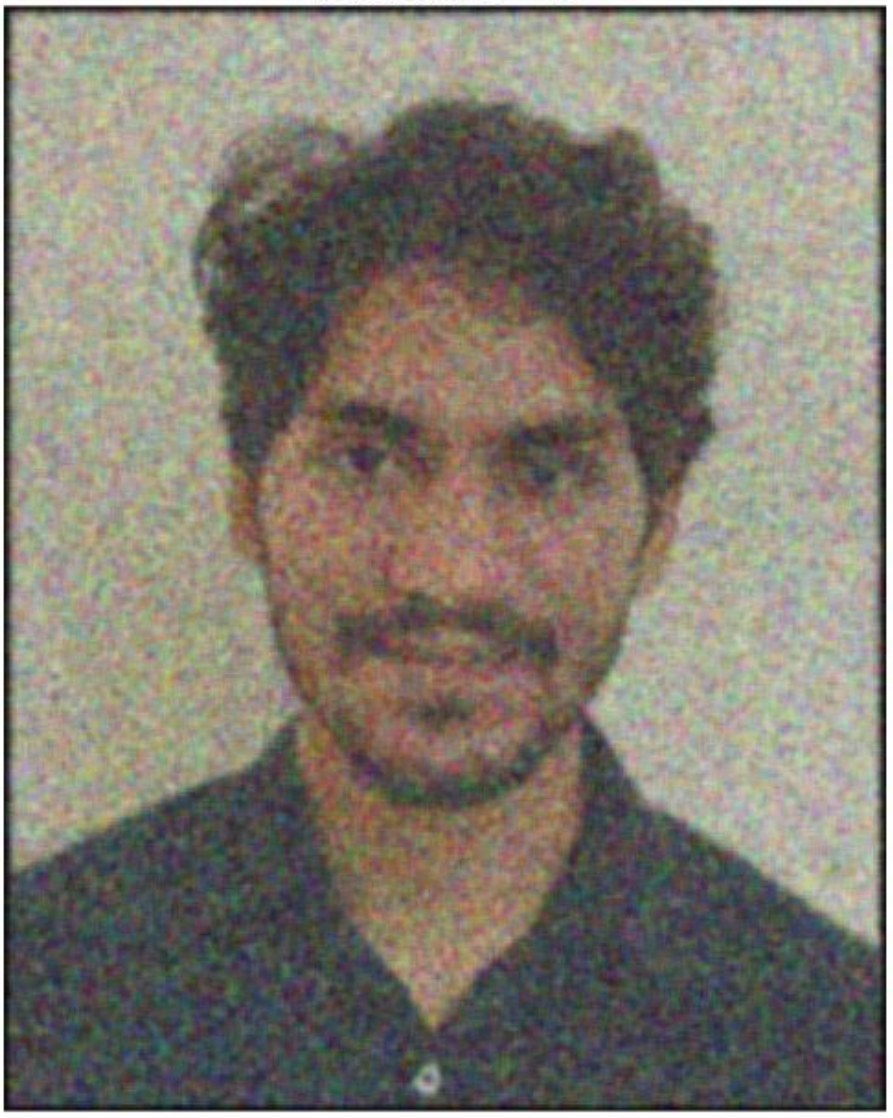
Q. Addition of noise with different sigmas

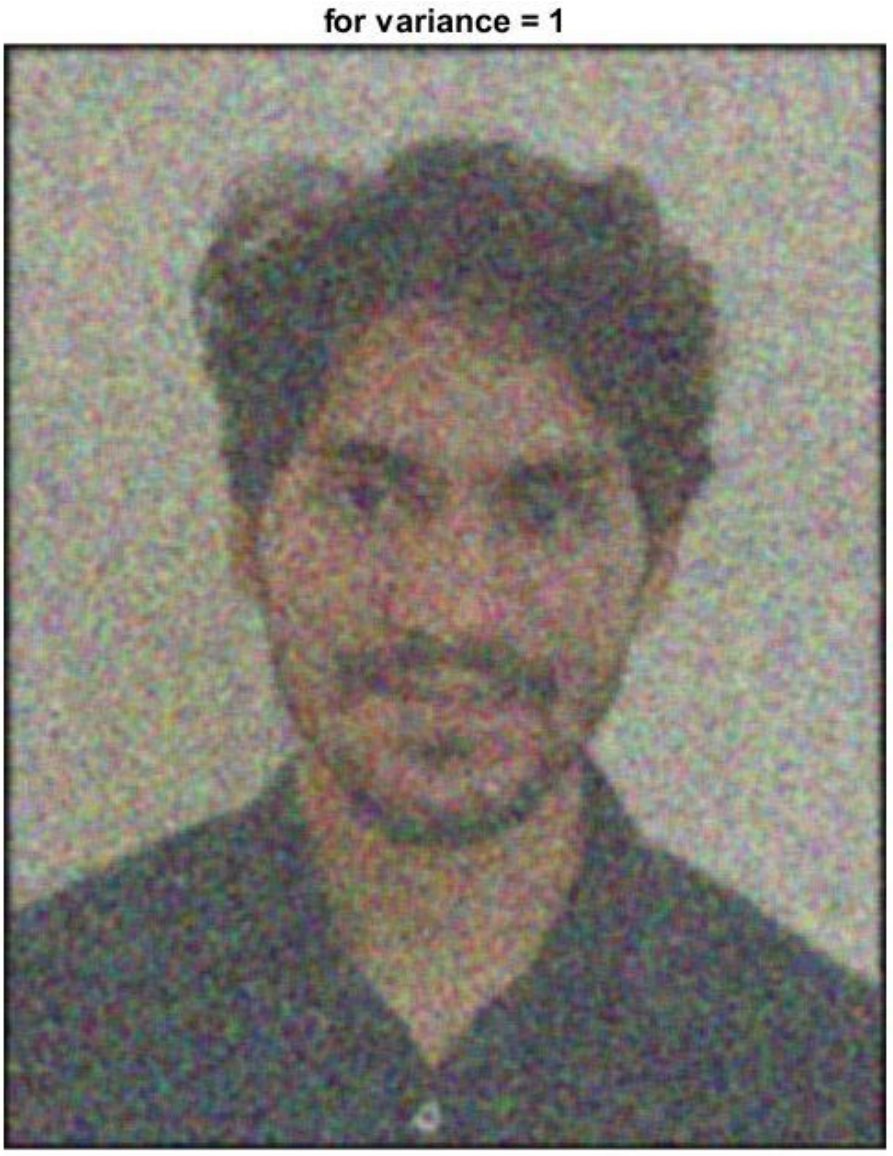
for variance = 0

for variance = 0.1



for variance = 0.5

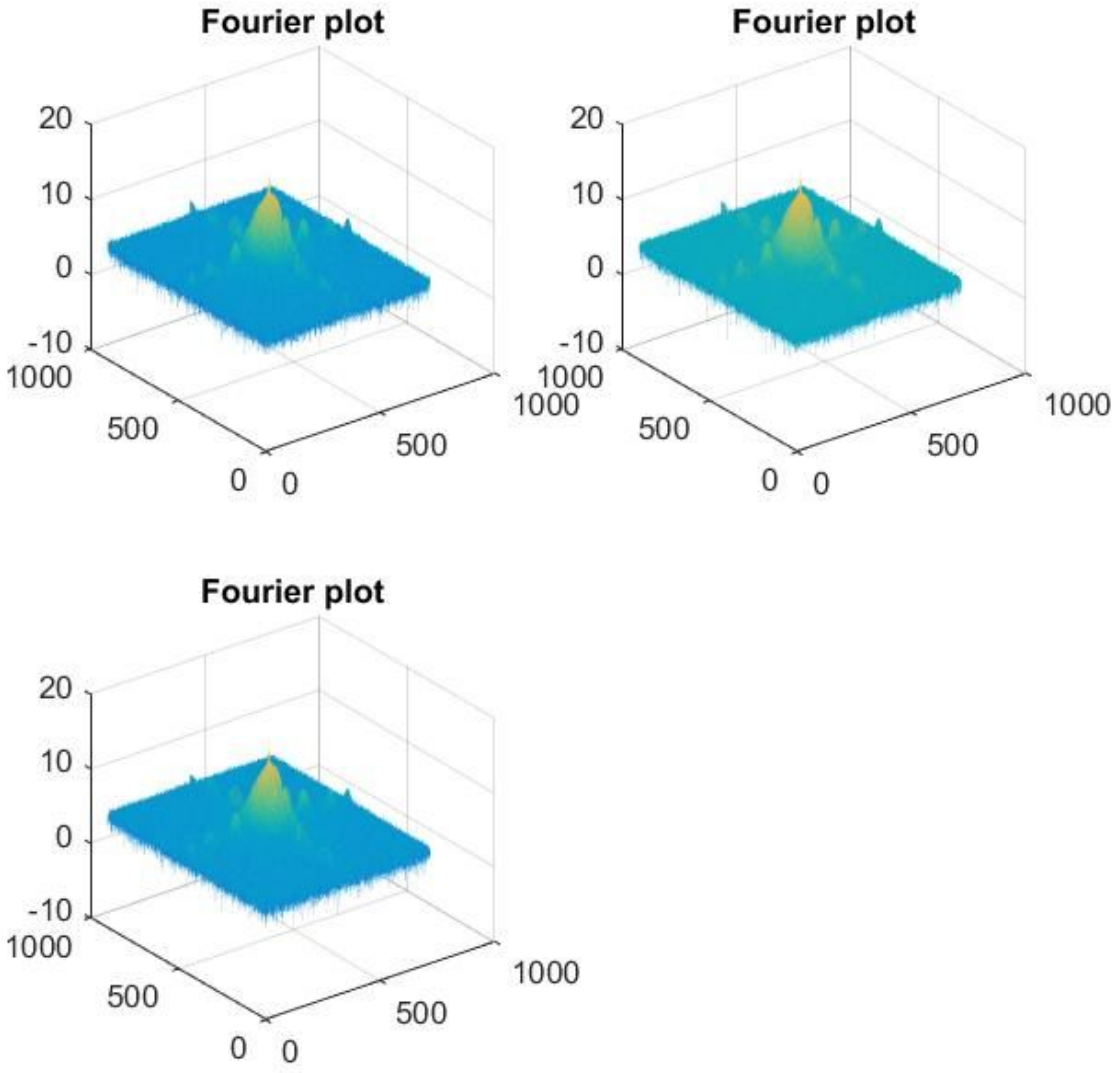




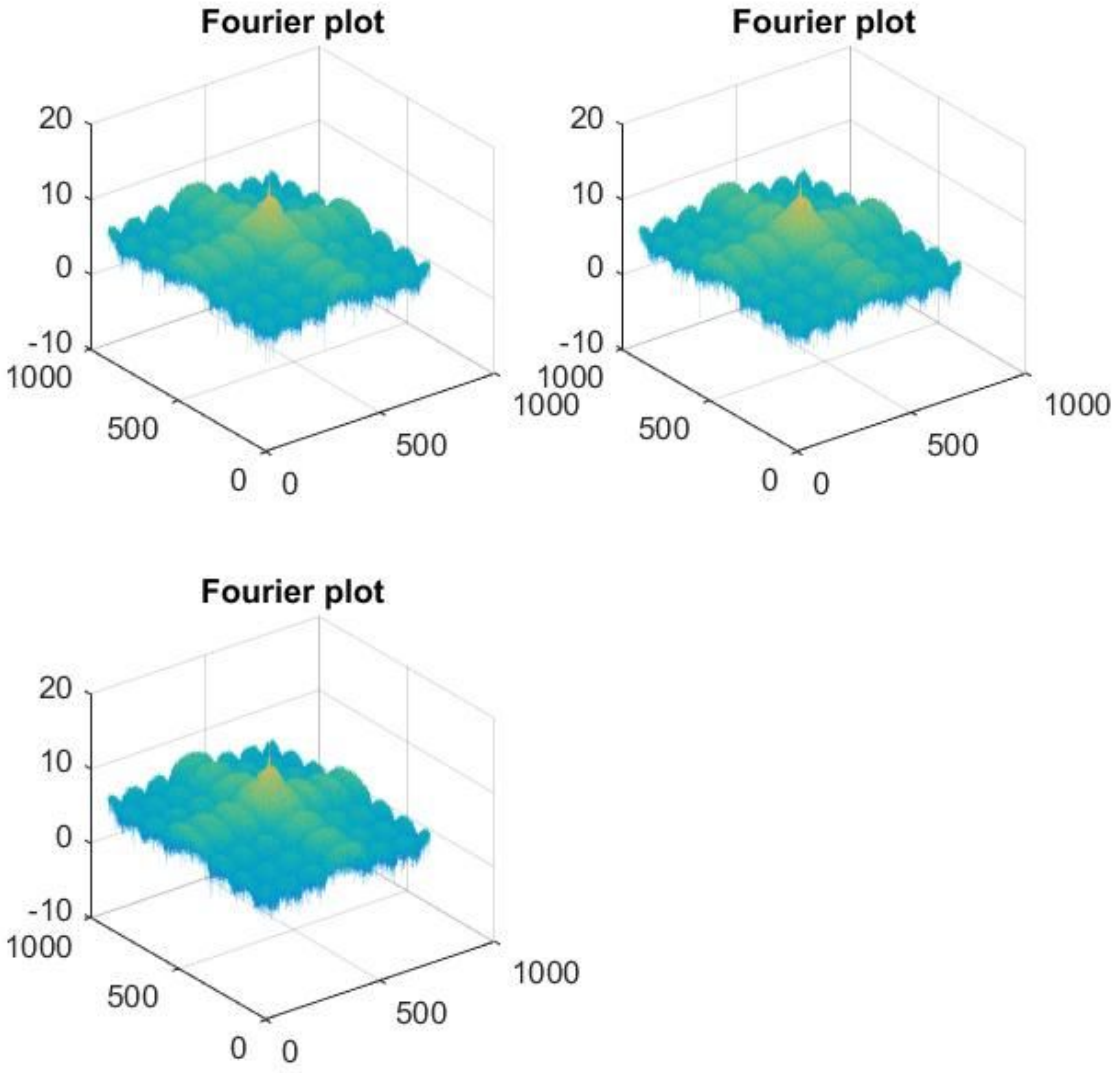
As we can see increase in variance is leading to more noisy image. The clarity of the image is being lost. Contrast, colour and sharpness all gone.

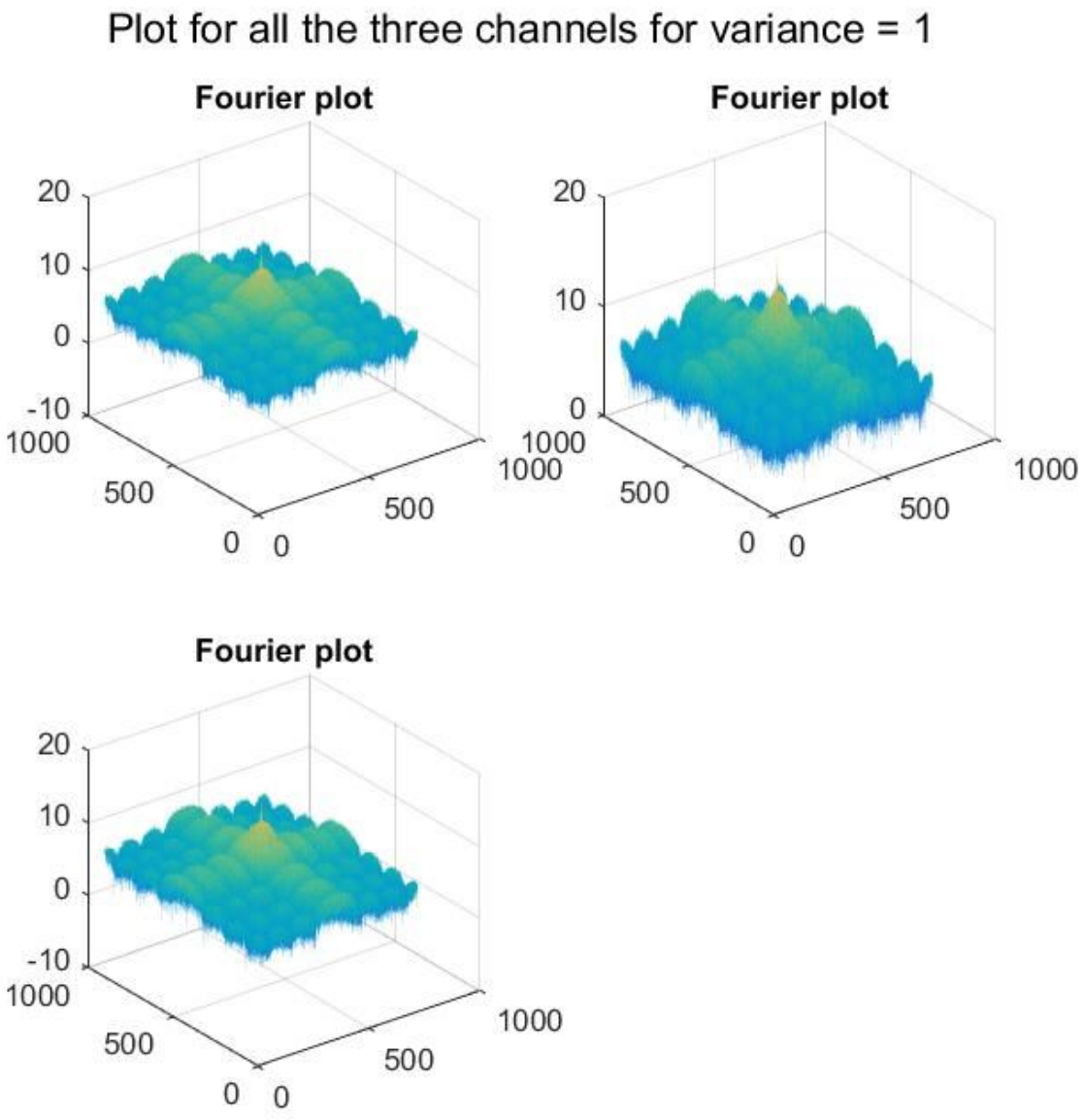
Now let’s look at the Fourier plots of the image for various sigma for all channels 1,2 and 3 respectively.

Plot for all the three channels for variance = 0



Plot for all the three channels for variance = 0.5





As the noise's variance being increased the peak is getting flattened or smooth.

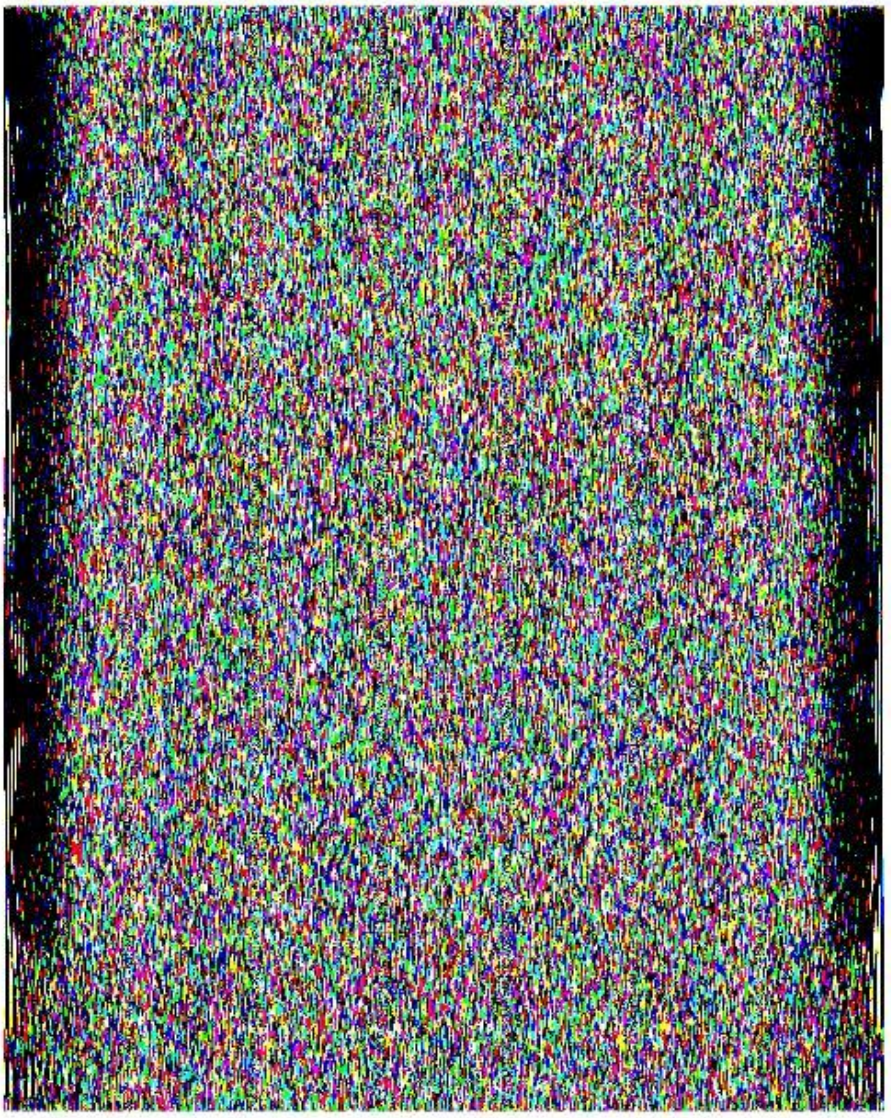


Fig.: ifft of Y after noise of variance of 0.2

Q. What is the learning experience?

Ans.: This was our first experience working with signals and processing. It was very interesting to see actually modifying the original voice and listening to it. This was a great learning experience and intrigued us to delve deeper into this field of signal processing field later. The image processing was much more interesting. We got to explore how a simple mathematics makes the things easier. This exposure will surely help me dig deeper in the field of computer vision.

References:

1. Resources on official mathworks website
2. https://in.mathworks.com/help/matlab/ref/conv2.html
3. https://in.mathworks.com/help/images/ref/imnoise.html