Problem 6

In this problem, we need to decrypt the encrypted voice signals which have been encryted by converting them to frequency domain and divided equally into n parts and then rearrange according to a key.

Approach

- First convert the original signal into frequency domain by taking fft.
- Then break the signal into parts
- Rearrange the parts
- Take the Inverse Fourier transform to convert the signal back to time domain.
- Hear the sound, to check if its decrypted. If not, try rearranging the signal in some other order.

To reduce the number of cases and getting to the key faster, I plotted the graph of the frequency domain of the original signal, so as to quickly reduce to only a fewer number of keys.

Code

1. Reading the audio file and figuring out the sampling frequency and total samples.

```
X = audioread('message1.wav');
p  = audioinfo('message1.wav');
Fs = p.SampleRate;
L = p.TotalSamples;

% Making the time axis
T = 1/Fs;
t = (0:L-1)*T;

% Plot of Original Signal in time domain
figure;
plot(t,X)
title('Original Signal in Time domain')
xlabel('t (seconds)')
ylabel('X(t)')
```

2. Taking the fft and plotting the graph.

```
P1 = fft(X);
% Plot of Original Signal in frequency domain

Y1 = abs(P1);
f = Fs*(1:(L))/L;
figure;plot(f,Y1);
title('Original Signal in Frequency domain')
xlabel('f (Hz)')
ylabel('|P1(f)|')
```

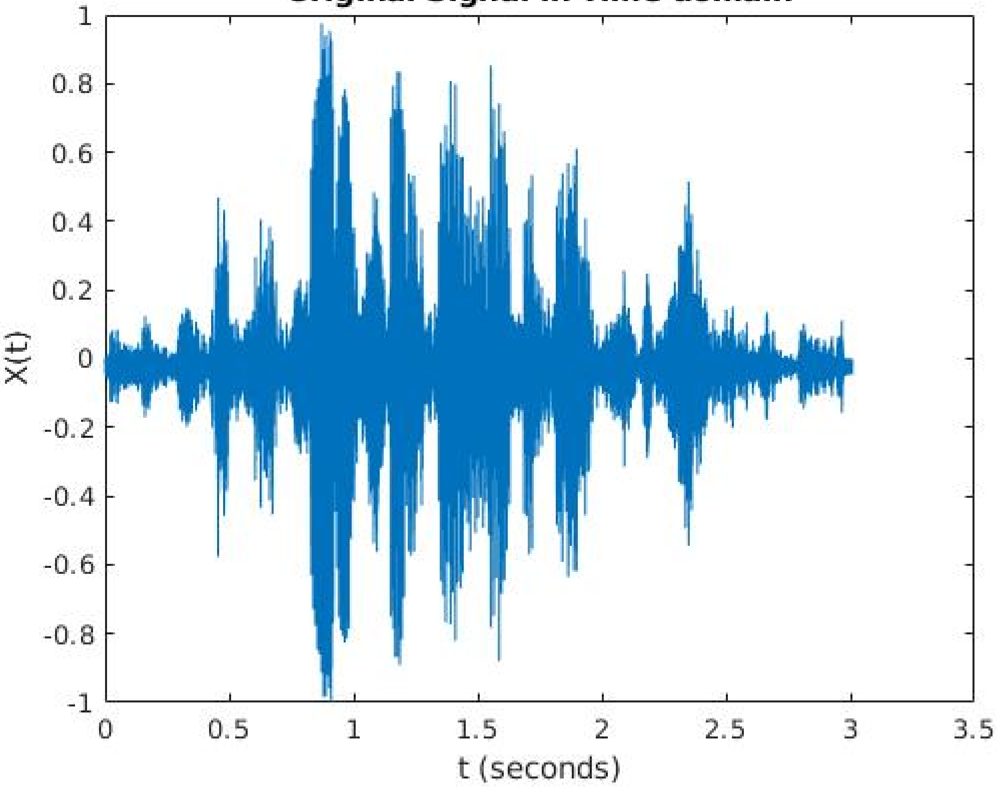
3. Defining domains, reconstructing the signal in frequency domain and plotting fft after rearranging the signal.

```
% Copying the fft of original signal
P2 = P1;

% Reconstructing the signal by changing fft
P2(domain_1) = P1(domain_3);
P2(domain_2) = P1(domain_2);
P2(domain_3) = P1(domain_4);
P2(domain_4) = P1(domain_1);
P2(domain_5) = P1(domain_8);
P2(domain_6) = P1(domain_5);
P2(domain_7) = P1(domain_7);
P2(domain_8) = P1(domain_6);

Y2 = abs(P2);
f = Fs*(1:(L))/L;
figure;plot(f,Y2);

title('Reconstructed Signal in Frequency domain')
xlabel('f(Hz)')
ylabel('|P2(f)|')
```

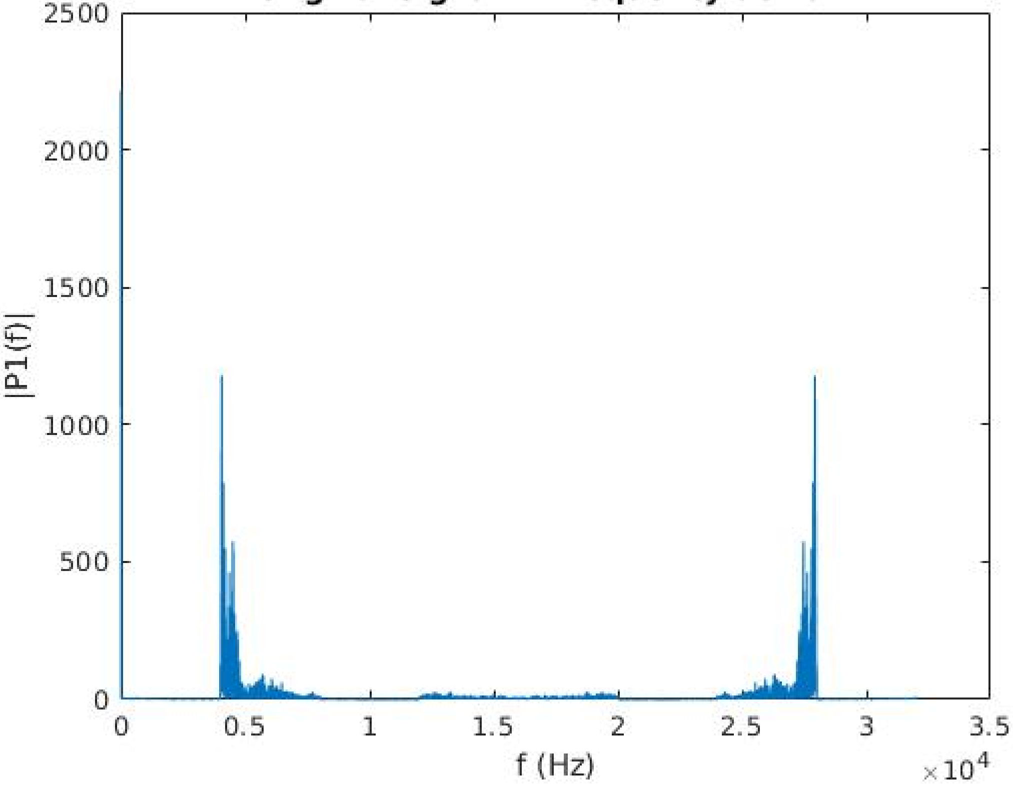
4. Taking inverse fourier transform to take reconstructed signal back into time domain.

```
% Inverting the reconstructed signal back to time domain
m = ifft(P2);
sound(real(m),Fs);
```

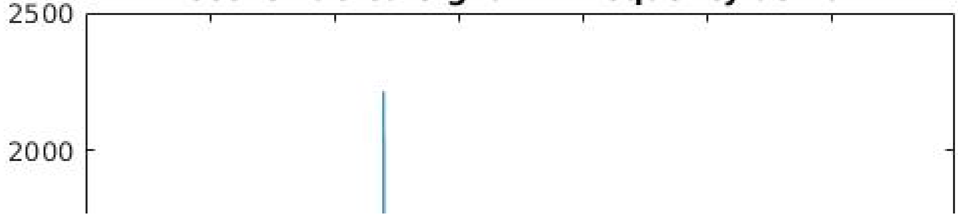
Message1.wav



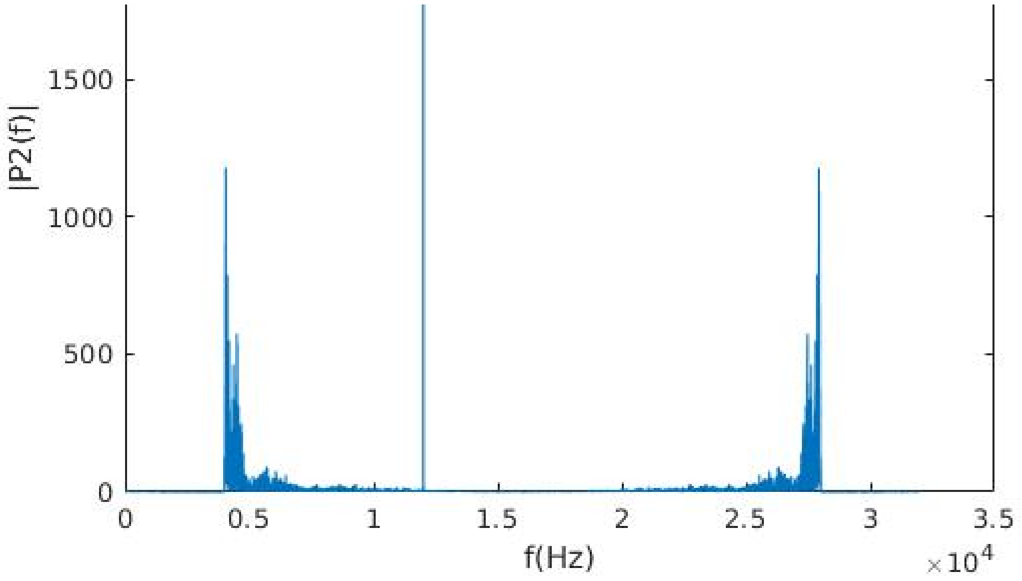
Original Signal in Time domain

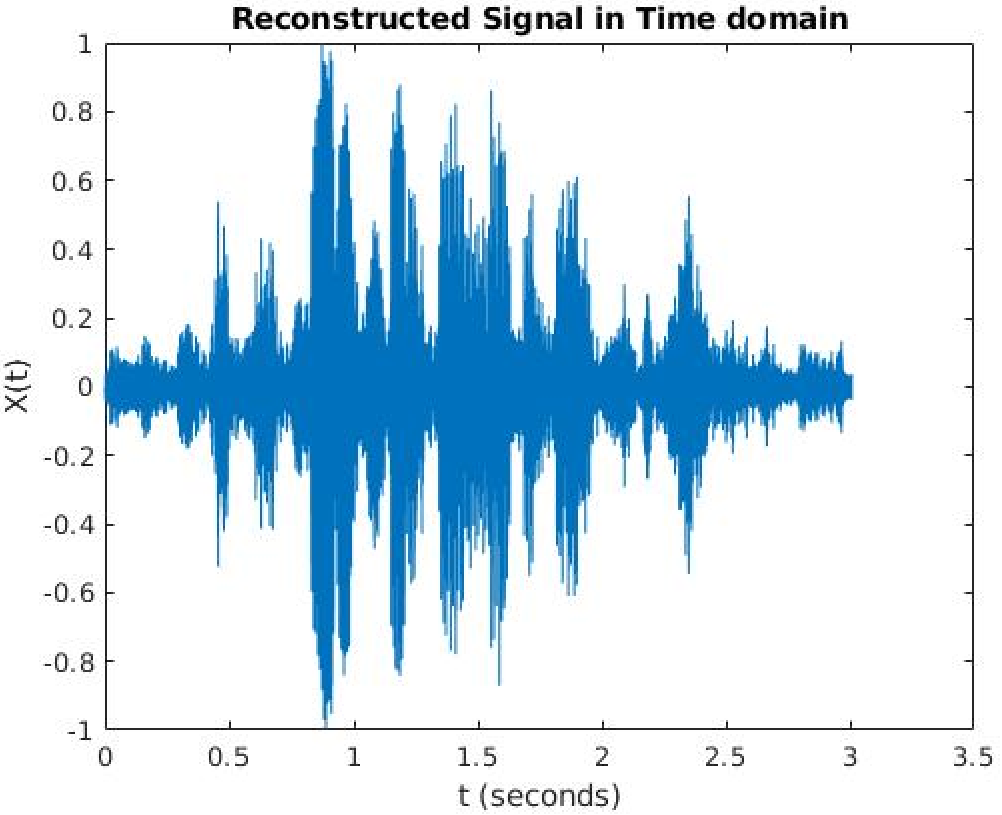


Original Signal in Frequency domain



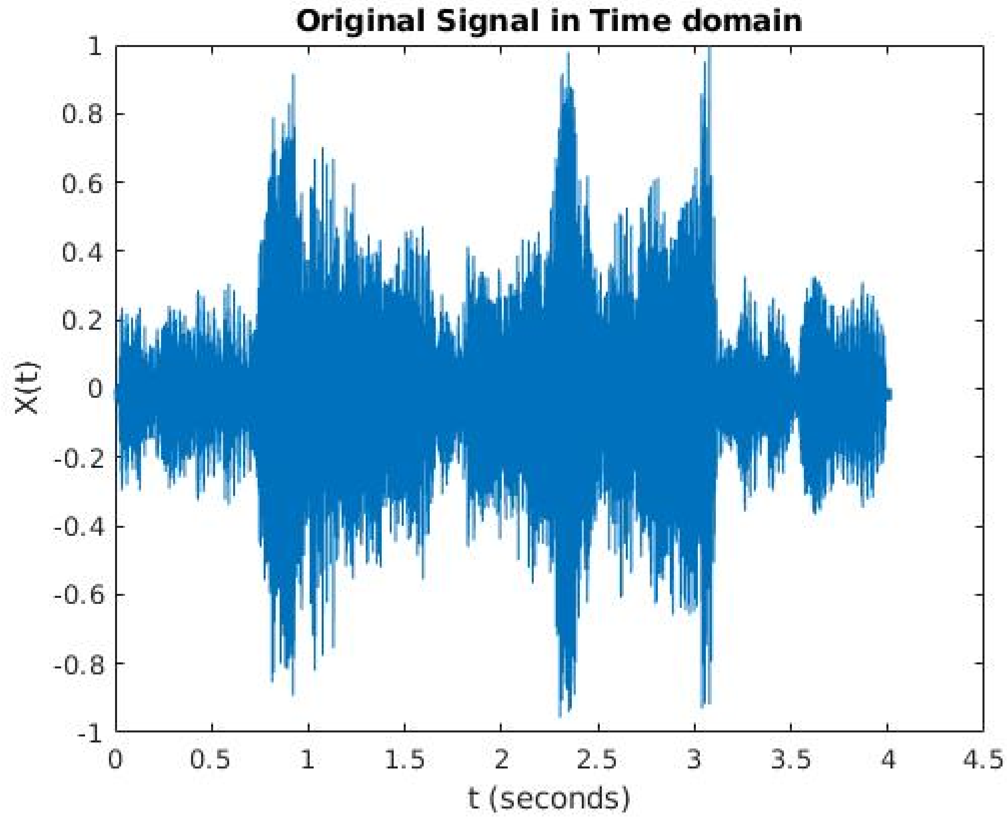
Reconstructed Signal in Frequency domain

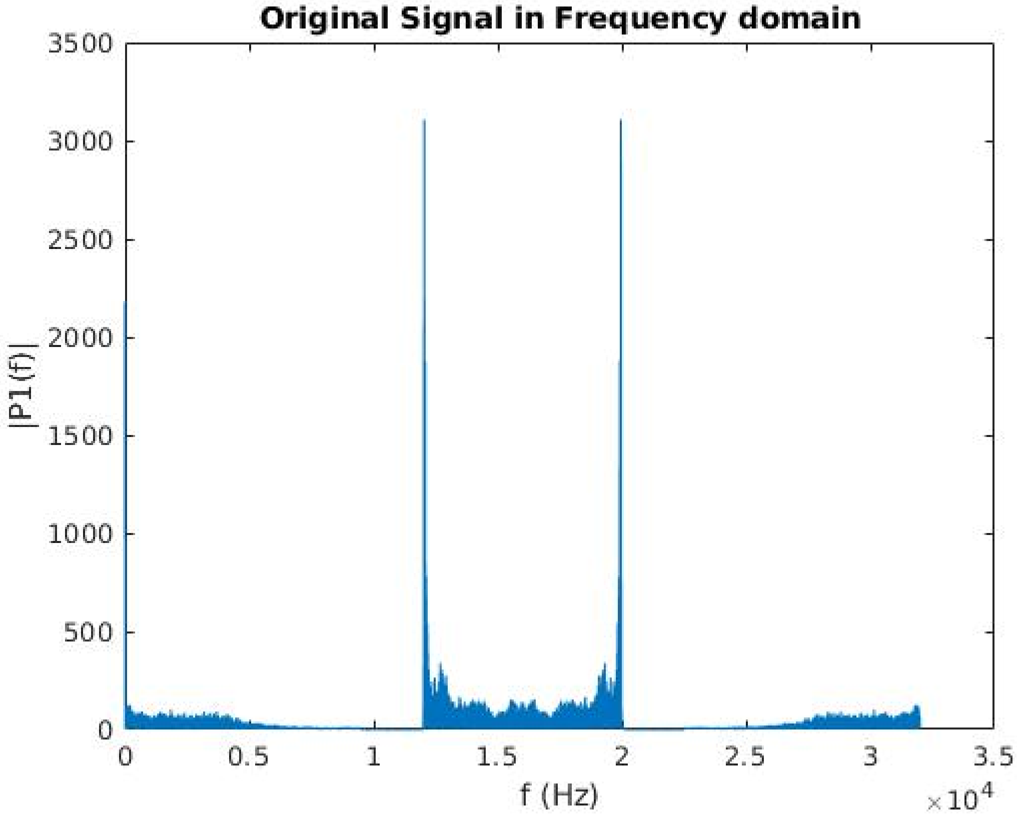


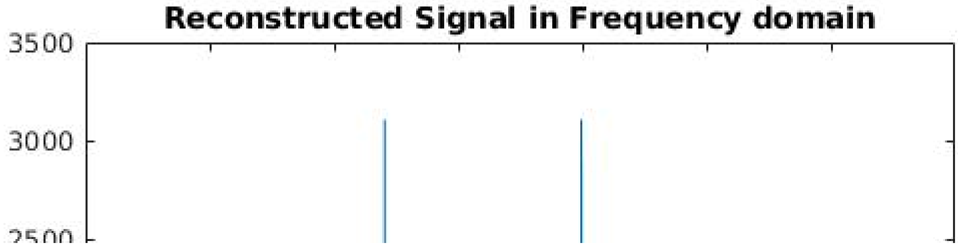


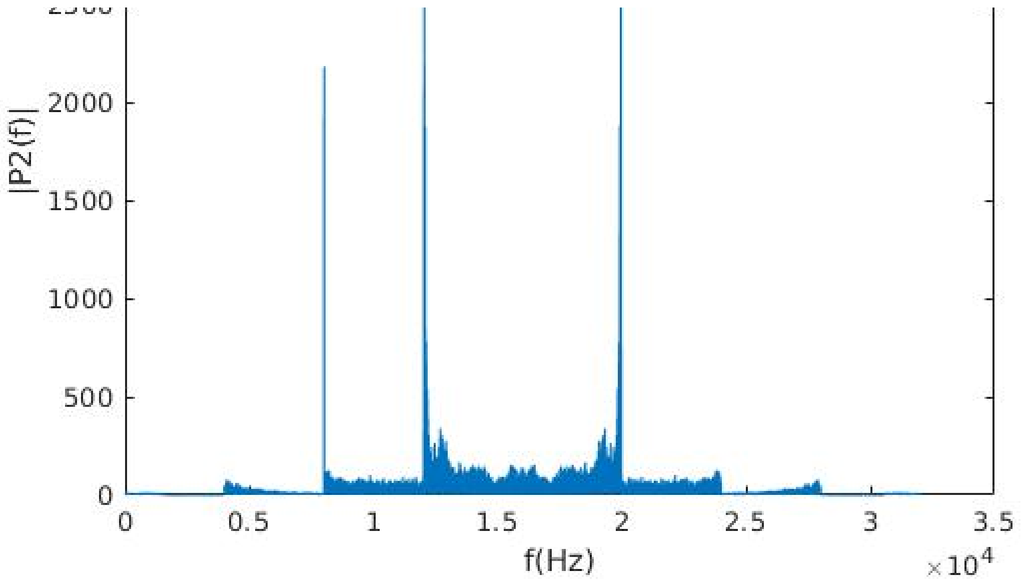
The decrypted message of message1.wav is "**If you are good at something never do it for free**". The audio output is decrypted_message1.wav

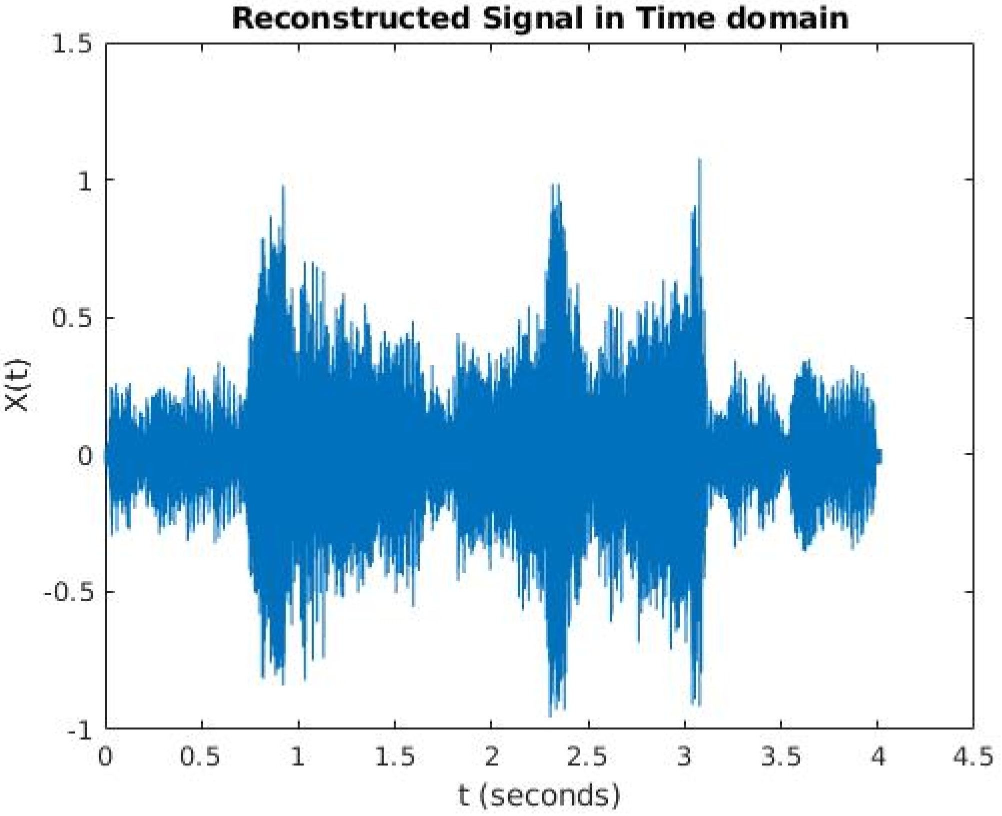
Message2.wav


Original Signal in Time domain
X(t)
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
3
3.5
4
4.5
t (seconds)


Original Signal in Frequency domain
|P1(f)|
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
f (Hz)
$\times 10^4$


Reconstructed Signal in Frequency domain
3500
3000
2500

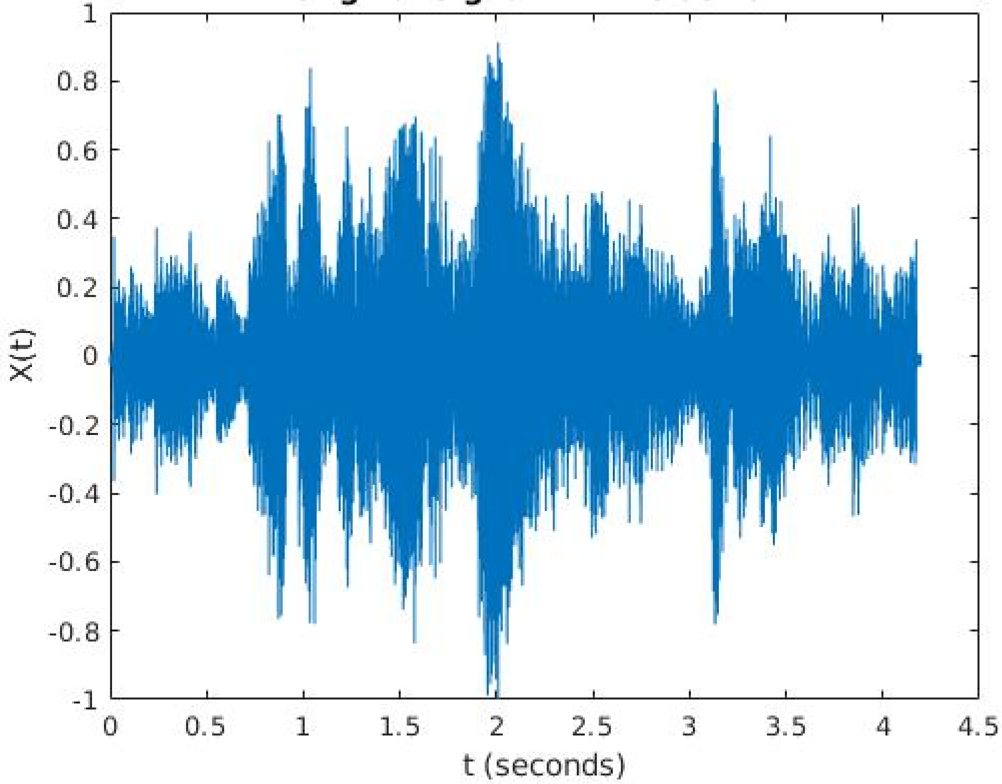




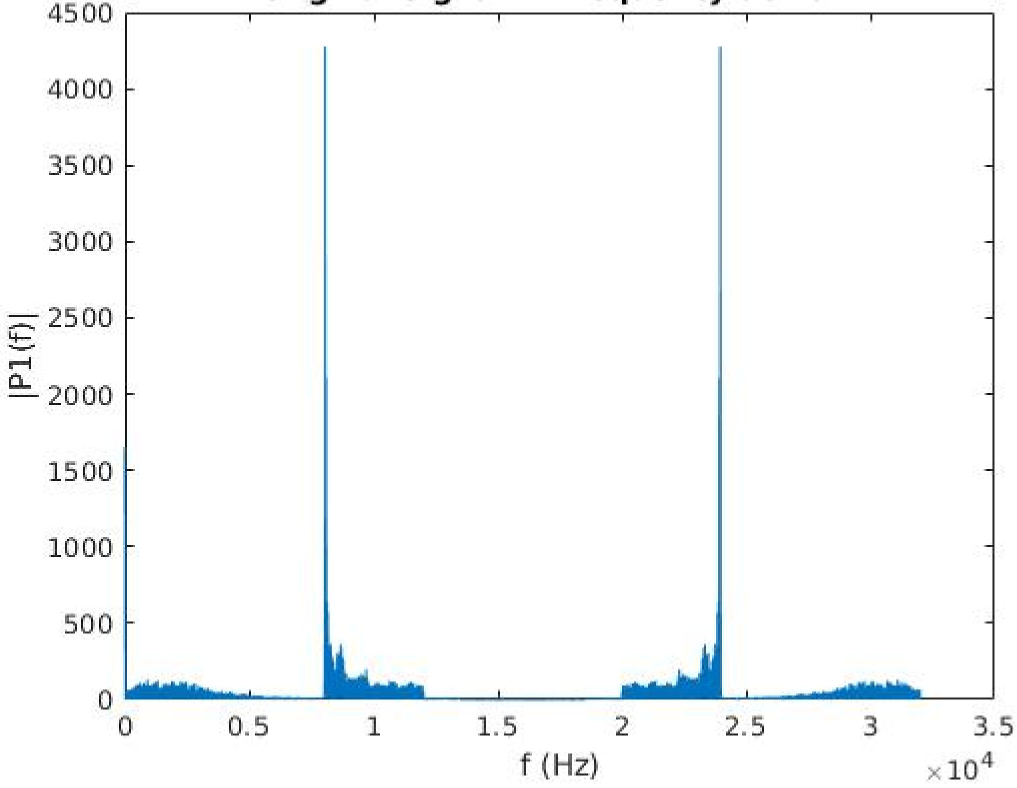
The decrypted message of message2.wav is "**Why so serious?**". The audio output is decrypted_message2.wav

Message3.wav

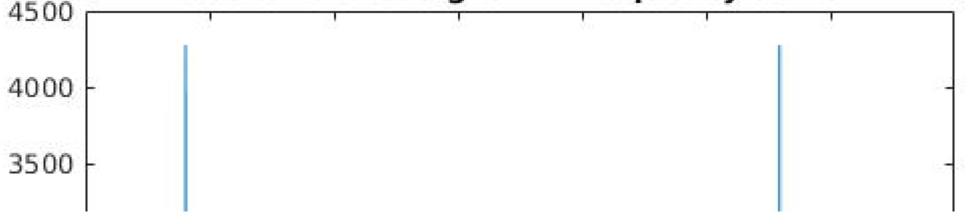
Original Signal in Time domain

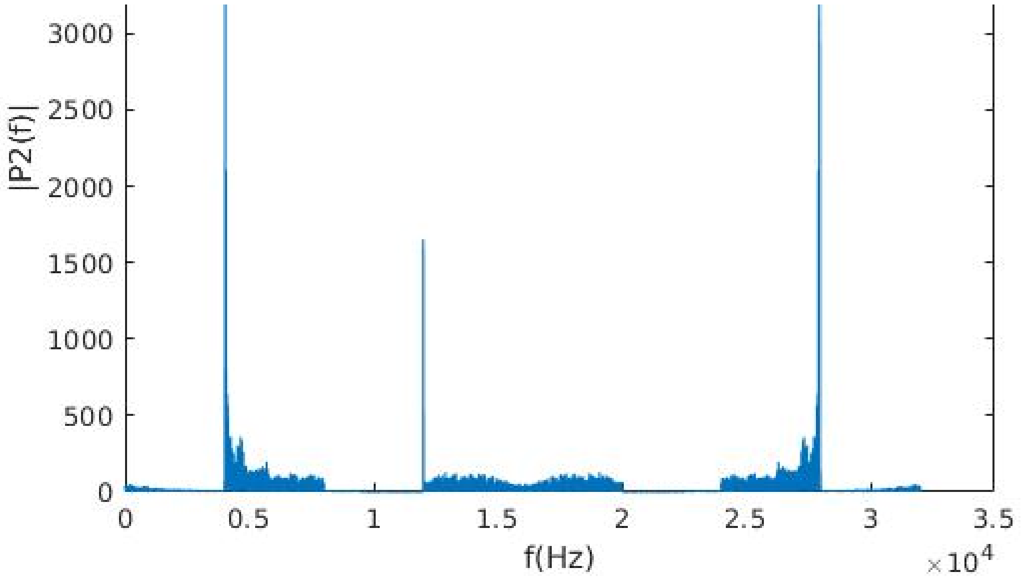


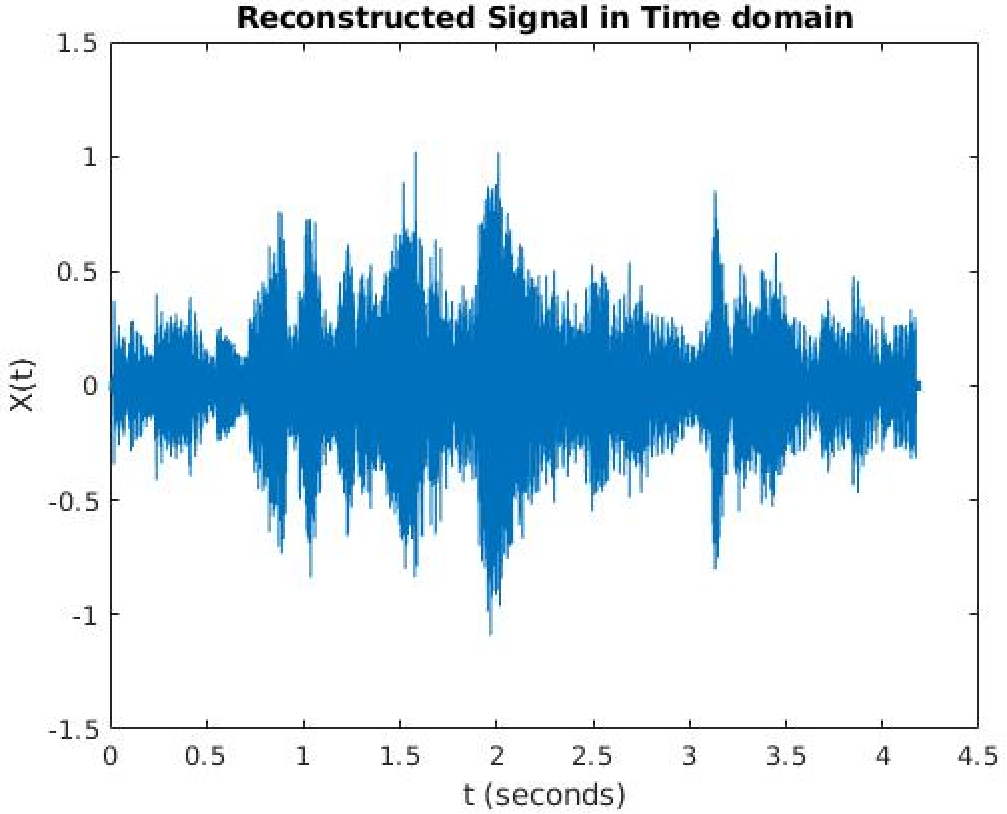
Original Signal in Frequency domain



Reconstructed Signal in Frequency domain







The decrypted message of message3.wav is "**Let's put a smile on that face**". The audio output is decrypted_message3.wav