EE386 Digital Signal Processing Lab Jul-Dec 2021

Experiment 1 Report

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The calculated value of α for the roll number : 191EE126 is

$$\alpha = 1 + mod(126, 4) = 3$$

Problem 1

(Decaying Exponential Signal)

(Solution)

The Decaying Exponential Signal x(t) with α as time constant is defined as $x(t) = e^{-t/a}$.
x(t) is plotted for the following function :

1. x(t)
2. x($t - 1.5\alpha$)
3. x(2t)

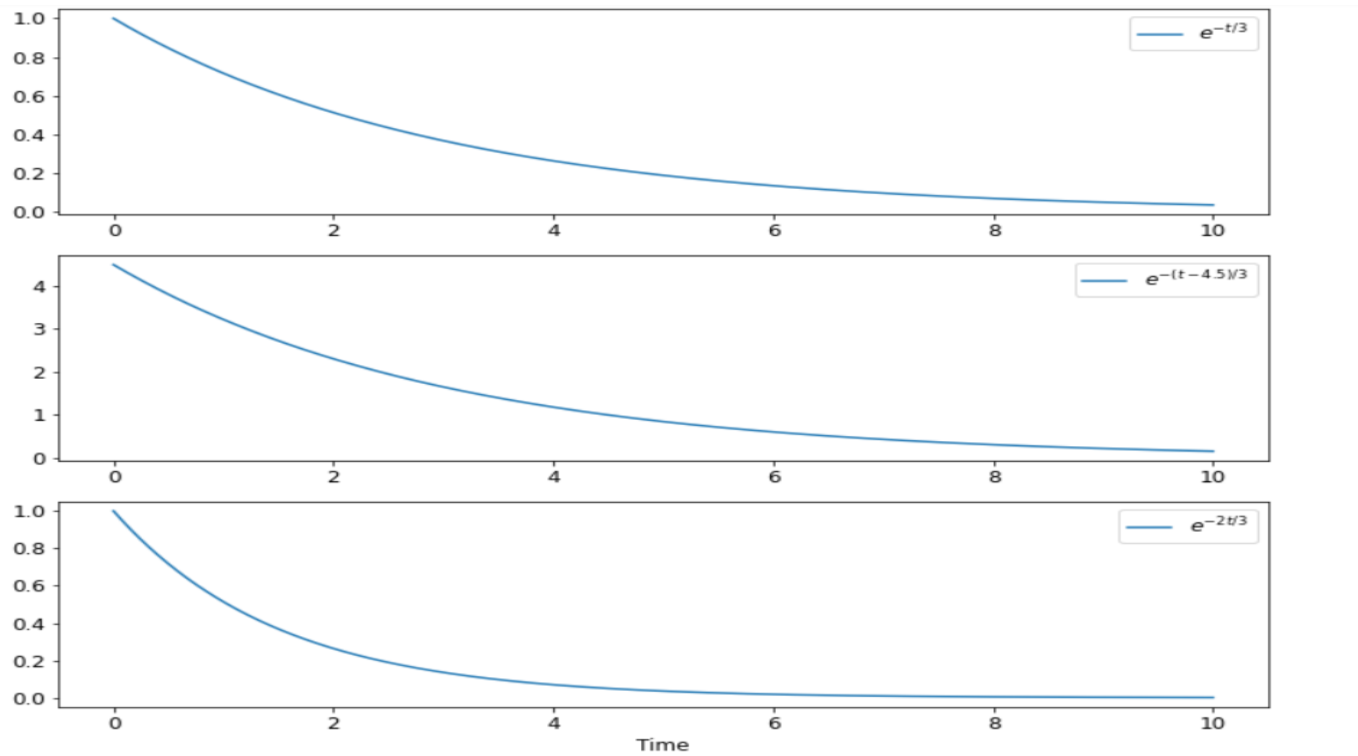

Figure 1: Decaying Exponential Signal

(Fourier Transform)

(Solution)

The fourier transform of a signal x(t) is given by :

$$X(\omega) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt$$

For the given decaying signal x(t), the fourier signal is given by :

$$X(\omega) = \frac{1}{(\frac{1}{\alpha} + j\omega)}$$

Hence, the magnitude and phase spectra can be plotted by :

$$|X(\omega)| = \frac{1}{\sqrt{\alpha^2 + \omega^2}}$$

$$\angle X(\omega) = arctan(\frac{x}{\alpha})$$

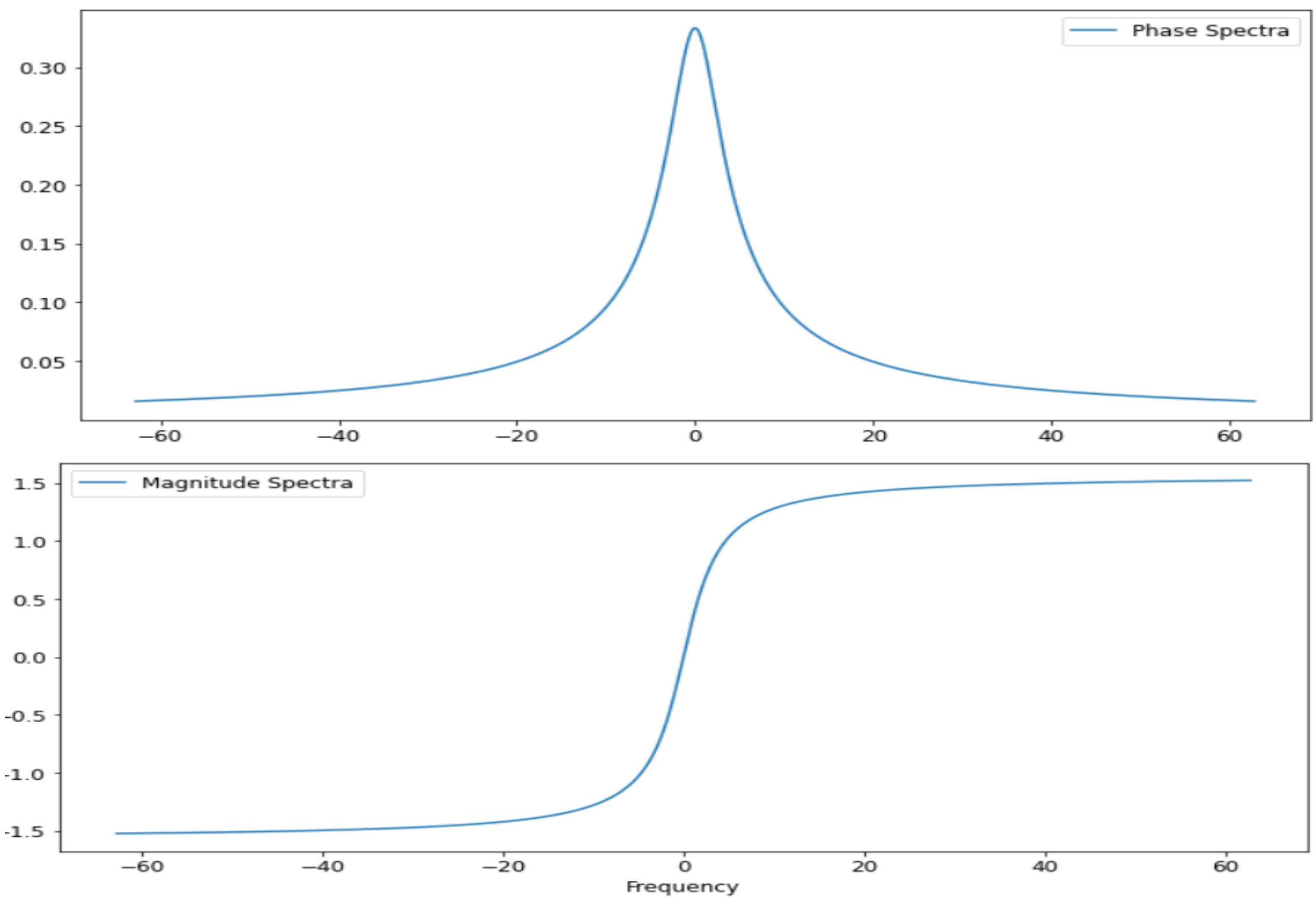

Figure 2: Fourier Transform of x(t)

The fourier transform of $x_2(t)$ and $x_3(t)$ as a function of X(ω) :

$$X_2(\omega) = e^{-4.5j\omega}X(\omega)$$

$$X_3(t) = \frac{X(\frac{\omega}{2})}{2}$$

Problem 2

(Generating Tones)

(Solution)

Two sinusoidal signals of frequency 600Hz and 660 Hz are stored in two variables. 5000 samples of resolution 0.001s are taken of both signals and appended into a single variable. The appended signal generated is stored into 'prob2op.wav'. The plots of the generated signal using plot() and stem function for 100 samples are :

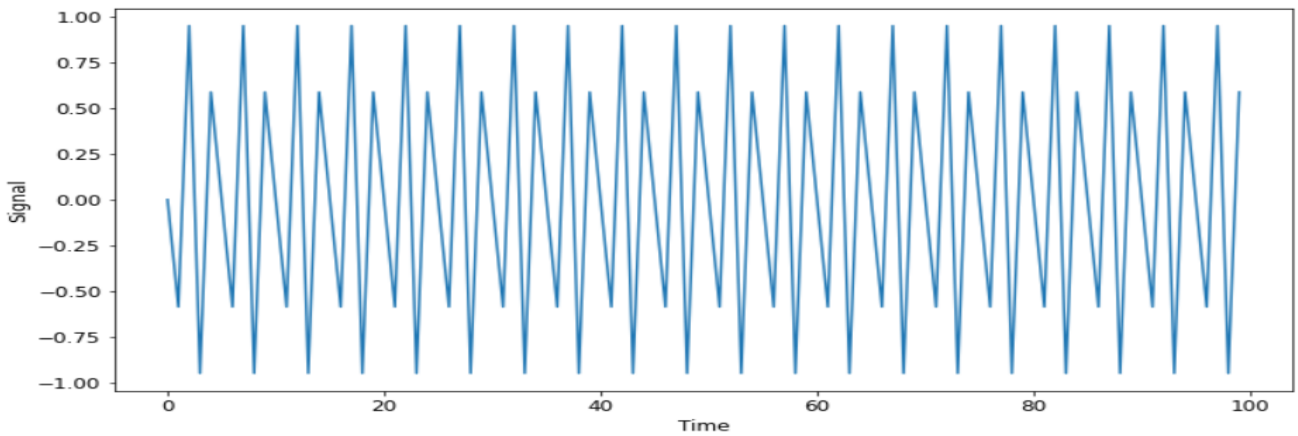

Figure 3: Signal Plot()

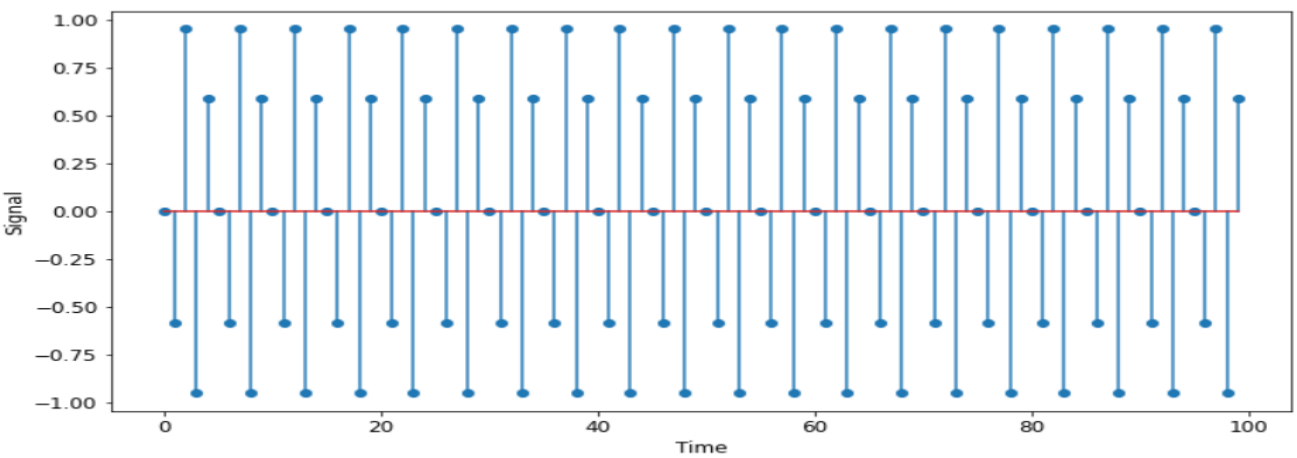

Figure 4: Signal Stem()

Problem 3

(Convolution)

(Solution)

The convolution of two signals f(x) and g(x) is given by :

$$y(t) = f(t) \circledast g(t)$$

$$y(t) = \sum_{\tau=-\infty}^{\infty} f(\tau) * g(t-\tau)$$

Audio signal is stored in 'Track003.wav' and the convoluting signal 'ConvFile3.txt'. The two signals are convoluted using convolve function. Different modes of convolution are calculated and the written into wav files :

- Same - 'prob3op1.wav'
- Valid - 'prob3op2.wav'
- Full - 'prob3op3.wav'

The convoluting signal, track signal and the convoltion of the signal are plotted :

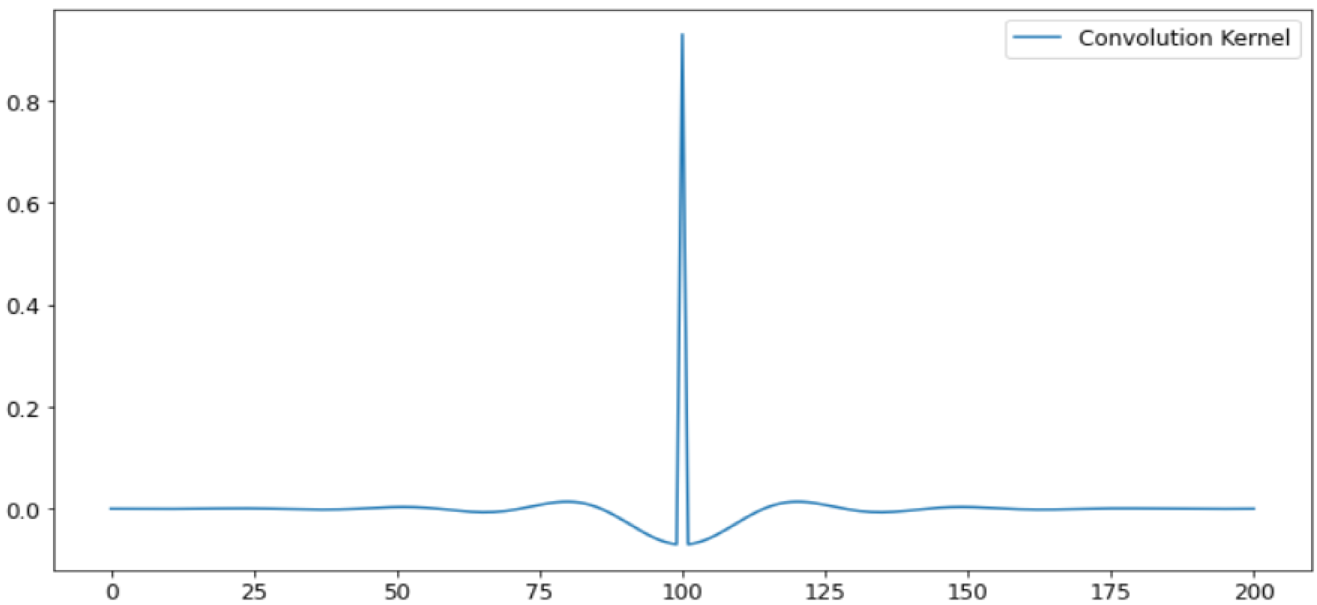

Figure 5: Convoluting Signal

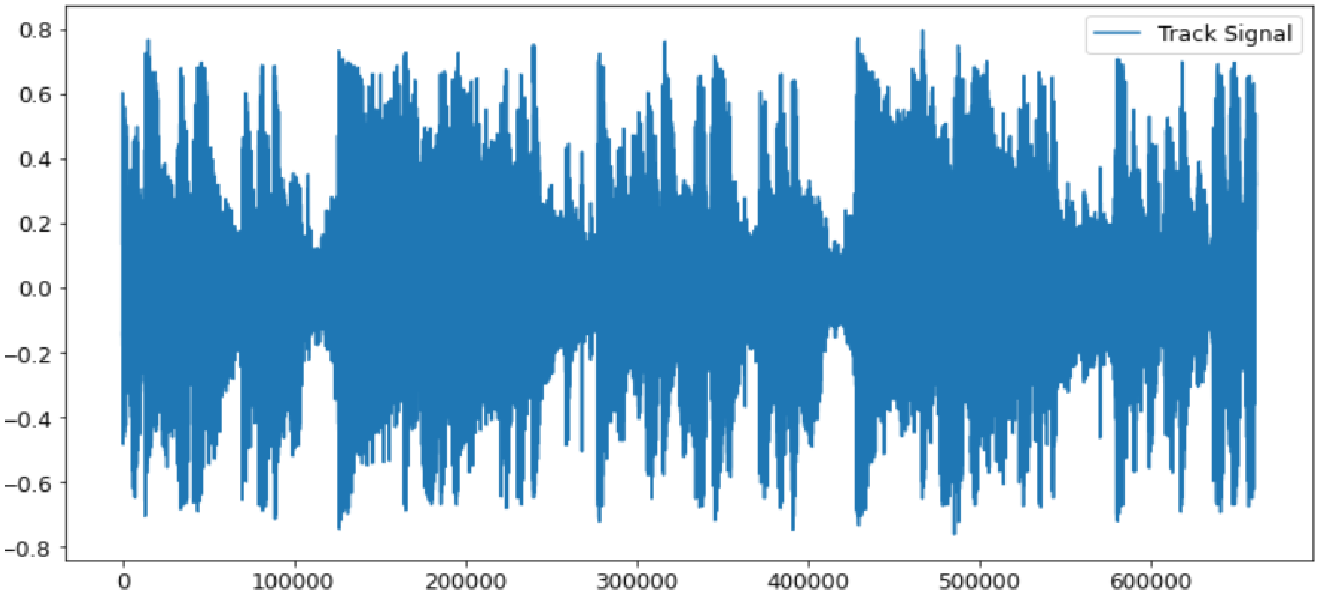

Figure 6: Track Signal

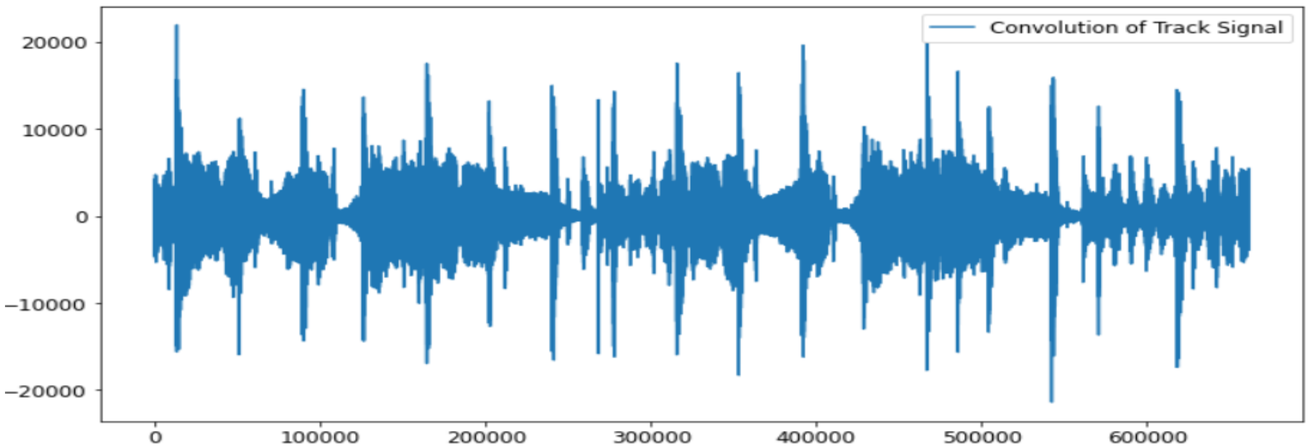

Figure 7: Convolution

From the plot of the convolution, it can be noticed that low frequencies are suppressed from the track signal. Hence it can be seen that it is a High Pass Filter.

Problem 4

(Amplitude Modulation)

(Solution)

The speech signal is first read from 'speech.wav'. First a function mutliplysignals function which returns the following signal :

$$y(t) = \sum_{\tau=-\infty}^{\infty} f(\tau) * g(t-\tau)$$

$$y(n) = s(n)cos(2\pi \frac{F}{F_s} n) \tag{0.1}$$

The plots of the signal and modulated signal are :

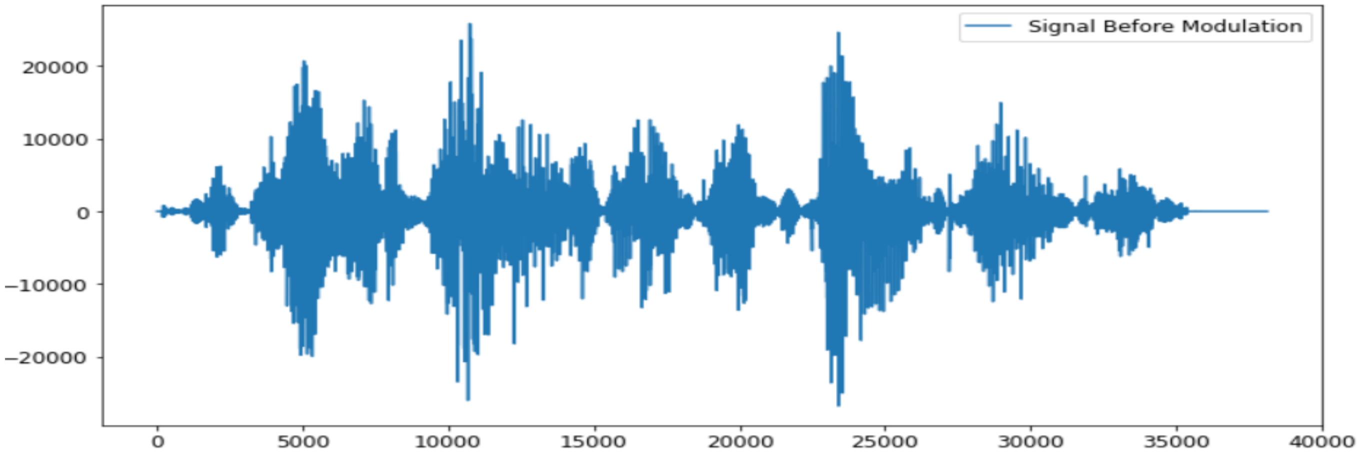

Figure 8: Speech Signal s(n)

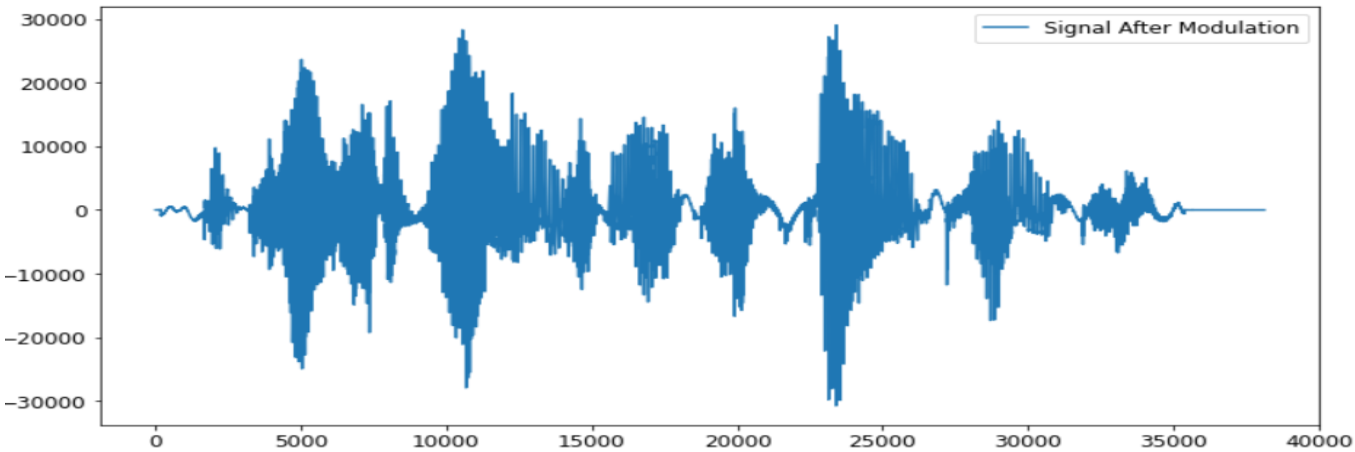

Figure 9: Amplitude Modulate Signal y(n)

(Fourier Transform of Amplitude Modulation)

(Solution)

According to Frequency Shifting property of Continuous Time Fourier Transform : If X(ω) is the fourier transform of x(t), then

$$X(\omega) \Leftrightarrow x(t)$$

$$X(\omega - \omega_o) \Leftrightarrow x(t)e^{-j\omega_o t}$$

$$X(\omega + \omega_o) \Leftrightarrow x(t)e^{j\omega_o t}$$

Since $cos(\omega_o t) = \frac{e^{j\omega_o t} + e^{-j\omega_o t}}{2}$,

$$\frac{X(\omega + \omega_o) + X(\omega - \omega_o)}{2} \Leftrightarrow x(t)cos(\omega_o t)$$

From the above equation, it can be seen that the fourier transform of x(t)cos($2\pi F_o t$) can be obtained by adding the shifted signals of fourier transform on both sides and dividing by 2. The FFT plots of the signal and the modulated signal are :

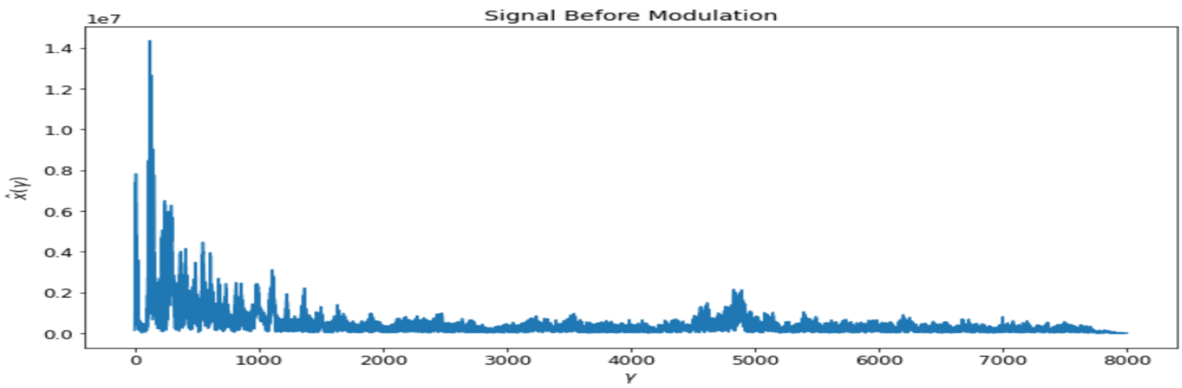

Figure 10: Speech Signal s(n) FFT Plot

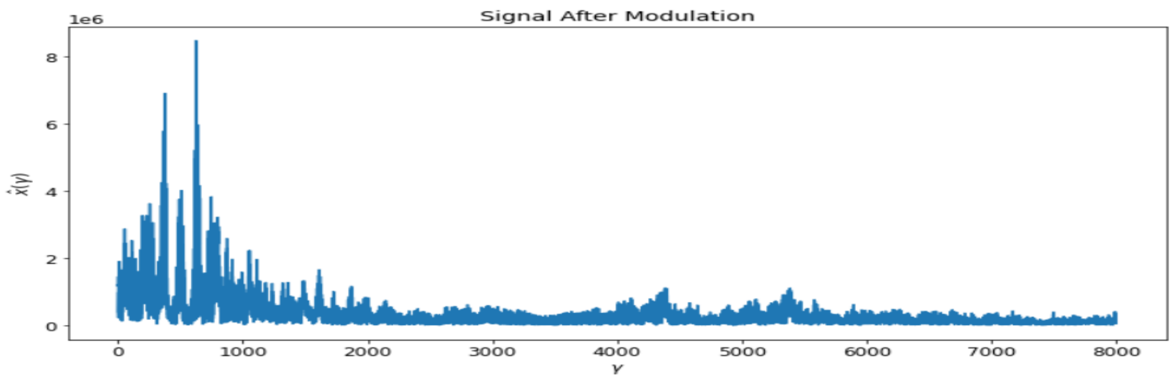

Figure 11: Amplitude Modulate Signal y(n) FFT Plot

Code Repository

The code, input and output of all the problems is in the following repository :
`https://github.com/KaranTejas/DSP-Lab/tree/main/Experiment1`.