National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

Department of Electrical Engineering and Computer Science

Faculty Member: Dr. Salman Ghafoor Dated: 21/11/2022

Semester: 5th Section: BEE 12C

EE-232: Signals and Systems

Lab 9: Fourier Transform

Group Members

Name	Reg. No	PLO4 – CLO3 **Viva / Quiz / Lab Performance**	PLO5 - CLO3 **Analysis of data in Lab Report**	PLO8 - CLO4 **Modern Tool Usage**	PLO9 - CLO4 **Ethics and Safety**
		5 Marks	**5 Marks**	**5 Marks**	**5 Marks**
Danial Ahmad	331388				
Muhammad Umer	345834				
Syeda Fatima Zahra	334379				

1 Table of Contents

2 Fourier Transform

2.1 Objectives

This Lab experiment has been designed to familiarize students with the concepts of Fourier Transform in MATLAB

2.2 Equipment

Software

- *MATLAB*

2.3 Lab Instructions

All questions should be answered precisely to get maximum credit. Lab report must ensure following items:

- Lab objectives
- MATLAB codes
- Results (Graphs/Tables) duly commented and discussed
- Conclusion

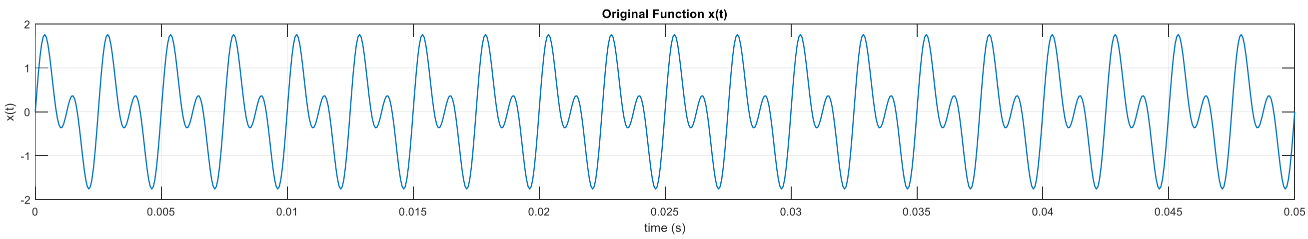
3 Lab Tasks

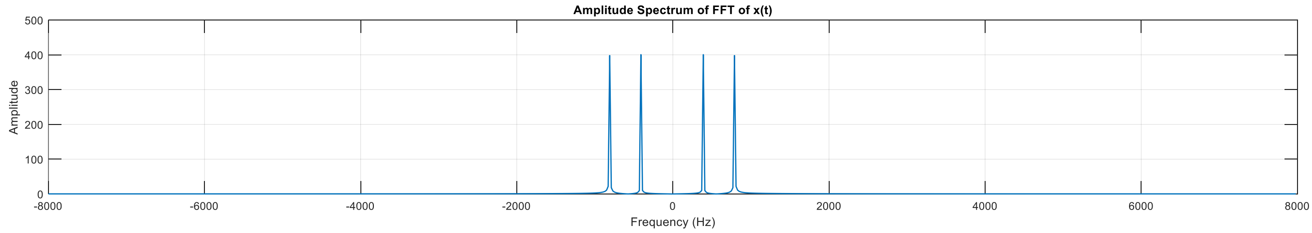
3.1 Lab Task 1

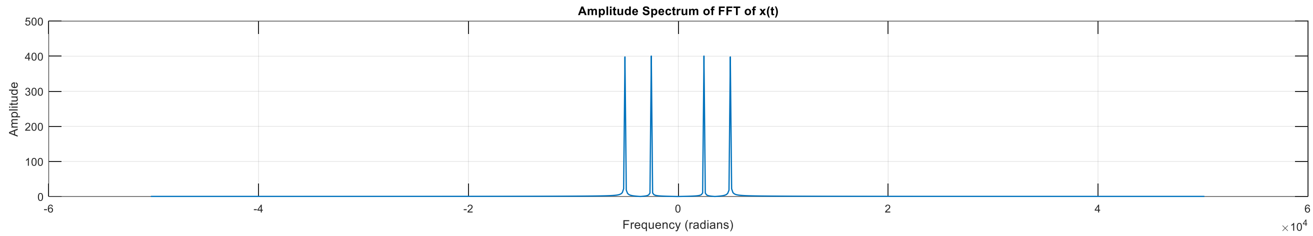
Generate a signal as sum of two sinusoidal of frequency $f_1 = 400\text{Hz}$ and $f_2 = 800\text{Hz}$.

Use **fft()** function to find the Fourier transform. Show your results. You have to make two plots of the coefficients against frequency axis. One plot should be against frequency in radians. Other plot should be against frequency in Hz. You also need to use function **fftshift().**

```
f1 = 400; f2 = 800; Fs = 20 * f2;
t = 0:1 / Fs:0.05;
x = sin(2 * pi * f1 * t) + sin(2 * pi * f2 * t);
X = fftshift(fft(x, length(t)));
L = length(t);
df = Fs / L;
index = -L / 2:(L / 2) - 1;
frequency_axis = df * index;

subplot(311)
plot(t, x, 'LineWidth', 1.1)
grid
title('Original Function x(t)')
xlabel('time (s)')
ylabel('x(t)')

subplot(312)
plot(frequency_axis, abs(X), 'LineWidth', 1.1)
grid
title('Amplitude Spectrum of FFT of x(t)')
xlabel('Frequency (Hz)')
ylabel('Amplitude')

subplot(313)
plot(2 * pi * frequency_axis, abs(X), 'LineWidth', 1.1)
grid
title('Amplitude Spectrum of FFT of x(t)')
xlabel('Frequency (radians)')
ylabel('Amplitude')
```





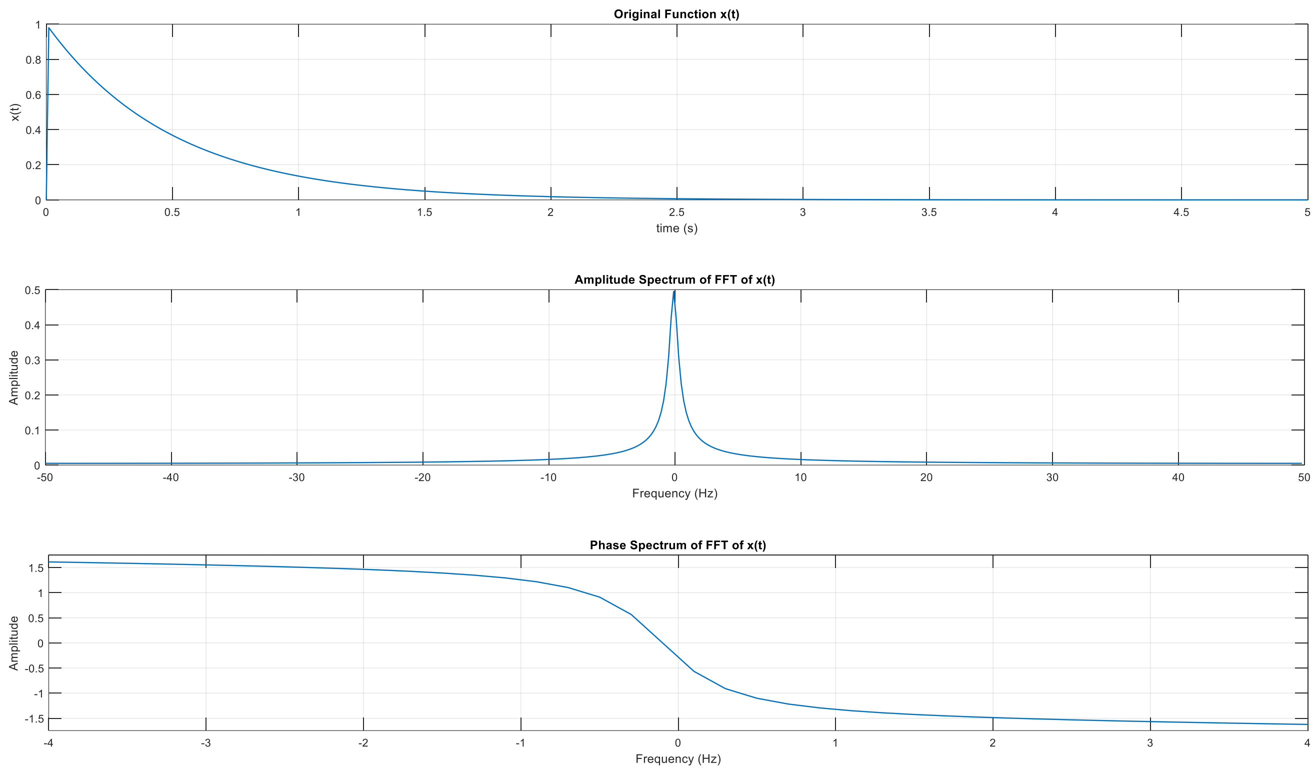


3.2 Lab Task 2

Calculate Fourier transform of $e^{-at}\,u(t)$.Plot the original signal, magnitude and phase of its Fourier transform. You have to make two plots of the coefficients against frequency axis. One plot should be against frequency in radians. Other plot should be against frequency in Hz. You also need to use function **fftshift().**

```
n = 100;
t = 0:1/n:5;
x = exp(-2 * t) .* (t > 0);
X = 1 / n * fftshift(fft(x, length(t)));
L = length(t);
df = n / L;
index = -L / 2:(L / 2) - 1;
frequency_axis = df * index;

subplot(311)
plot(t, x, 'LineWidth', 1.1)
grid
title('Original Function x(t)')
xlabel('time (s)')
ylabel('x(t)')

subplot(312)
plot(frequency_axis, abs(X), 'LineWidth', 1.1)
grid
title('Amplitude Spectrum of FFT of x(t)')
xlabel('Frequency (Hz)')
ylabel('Amplitude')

subplot(313)
plot(frequency_axis, angle(X), 'LineWidth', 1.1)
```

```
axis([-4 4 -pi/1.8 pi/1.8])
grid
title('Phase Spectrum of FFT of x(t)')
xlabel('Frequency (Hz)')
ylabel('Amplitude')
```

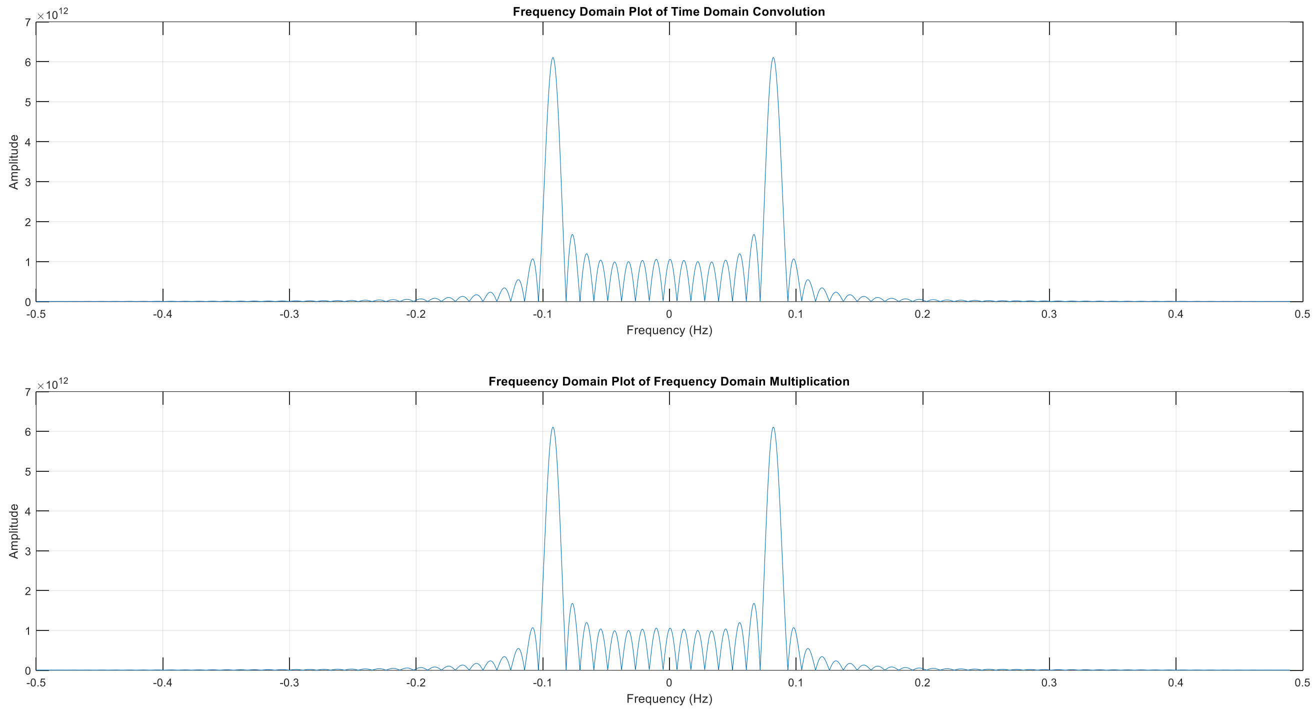


3.3 Lab Task 3

Convolve the signals $x_1(t) = e^{at}u(t)$ and $x_2(t) = \sin(t)u(t)$ for 100 samples. Verify that "convolution in time domain equals multiplication in frequency domain".

```
t = linspace(-5, 50, 100);
x_1 = exp(0.5 * t) .* (t > 0);
x_2 = sin(t) .* (t > 0);
L = length(t);
timeplot = conv(x_1, x_2, 'full');
f = (-L / 2:0.001:(L / 2) - 1) / L;
freqplot = fftshift(fft(x_1, length(f))) .* fftshift(fft(x_2, length(f)));

subplot(211)
plot(f, abs(fftshift(fft(timeplot, length(f)))));
grid
title('Frequency Domain Plot of Time Domain Convolution')
xlabel('Frequency (Hz)')
ylabel('Amplitude')
```

```
subplot(212)
plot(f, abs(freqplot));
grid
title('Frequeency Domain Plot of Frequency Domain Multiplication')
xlabel('Frequency (Hz)')
ylabel('Amplitude')
```



As apparent from the two plots, the statement "convolution in time domain equals multiplication in frequency domain" is verified.

4 Conclusion

In this lab we further familiarized ourselves with the concept of Fourier transforms in MATLAB. We saw how the Fourier transforms the sum of two sinusoidal functions with different frequencies behaves, by looking at the output graph plots in MATLAB. In addition to that we proved that multiplication in frequency domain is actually convolution in the time domain.