Signals and Systems

Experiment No. # 12

Objective:

The objective of this lab is to create a practical understanding of the Continuous Time Fourier Transform (Chapter 4 of textbook) and to prove some properties of the CTFT. Also, students will learn implementation of the Laplace Transform (Chapter 9 of textbook) and prove some of its properties.

Theoretical Background:

Continuous Time Fourier Transform:

The Continuous Time Fourier Transform is used for representation of continuous-time a-periodic signals.

Properties of the Continuous Time Fourier Transform:

There are many properties associated with the CTFT; in this lab the students will prove the following two properties:

1. Time Shifting Property:
2. This property states that the CTFT of a time shifted continuous time signal is equal to multiplication of the Fourier Transform of the original signal by a complex exponential.

Differentiation Property:

1. This property states that the CTFT of the differentiation of a continuous time signal is equal to multiplication of the CTFT of the original signal with (jw).where, x(t) is:

- a continuous time a-periodic signal
- is the CTFT representation of x(t)

Tasks:

The following tasks are to be performed by each student:

Task 1:

Using symbolic variables, calculate the Fourier transform of a signal . Also calculate the Inverse Fourier Transform to get the original signal. Plot all three signals in a subplot figure.

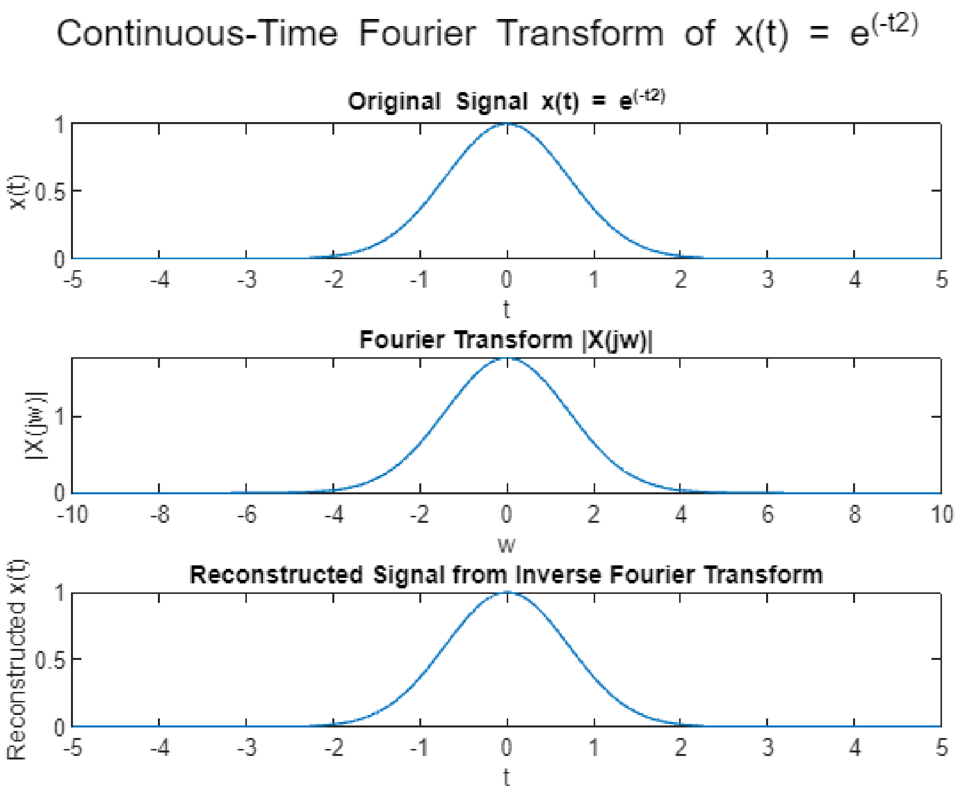
Task 2:

- Prove the time shifting property for the CTFT using the signal . The time shift given to this signal is . Plot the signals in time domain using subplot.
- Using the input signal , prove the differentiation property of the CTFT. Plot the signals in time domain using subplot.

Task 1:

```
% Define symbolic variables
```

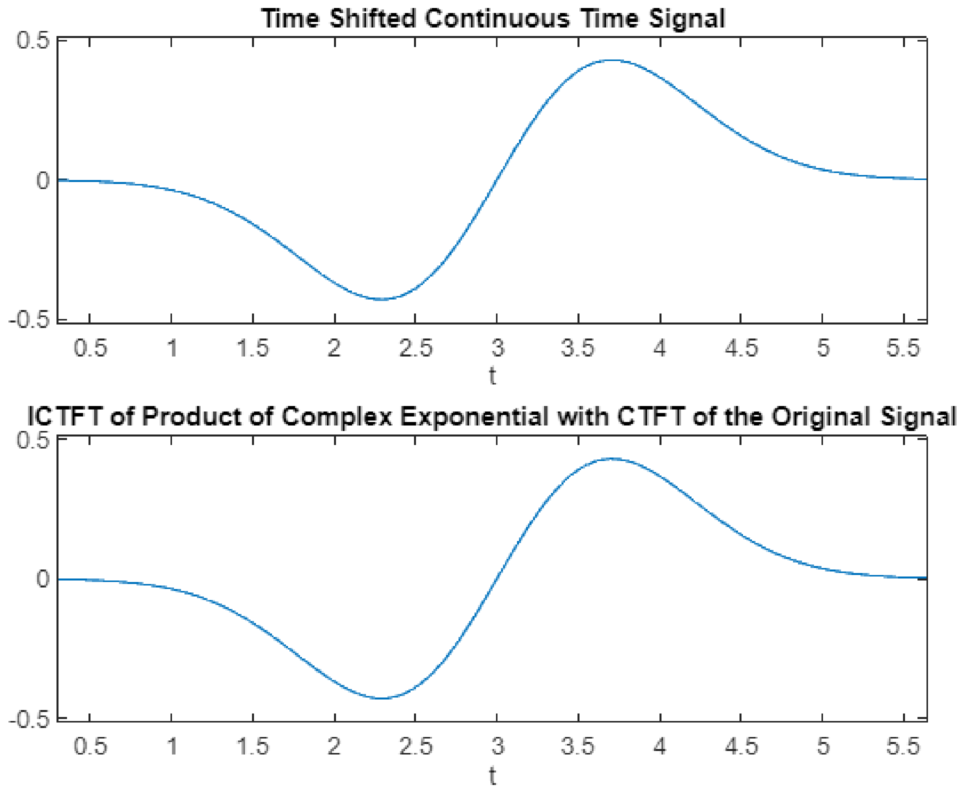
```matlab
syms t w

% Define the signal x(t)
x_t = exp(-t^2);

% Calculate the Fourier transform of x(t)
X_w = CTFT(x_t);

% Calculate the Inverse Fourier Transform to get the original signal
x_reconstructed_t = ICTFT(X_w);

% Plot the original signal, its Fourier transform, and the reconstructed signal
figure;

% Original signal x(t)
subplot(3, 1, 1);
fplot(x_t, [-5, 5]);
title('Original Signal x(t) = e^(-t^2)');
xlabel('t');
ylabel('x(t)');

% Fourier transform X(jw)
subplot(3, 1, 2);
fplot(abs(X_w), [-10, 10]);
title('Fourier Transform |X(jw)|');
xlabel('w');
ylabel('|X(jw)|');

% Reconstructed signal from Inverse Fourier Transform
subplot(3, 1, 3);
fplot(x_reconstructed_t, [-5, 5]);
title('Reconstructed Signal from Inverse Fourier Transform');
xlabel('t');
ylabel('Reconstructed x(t)');

% Adjust subplot layout
sgtitle('Continuous-Time Fourier Transform of x(t) = e^(-t^2)');
```



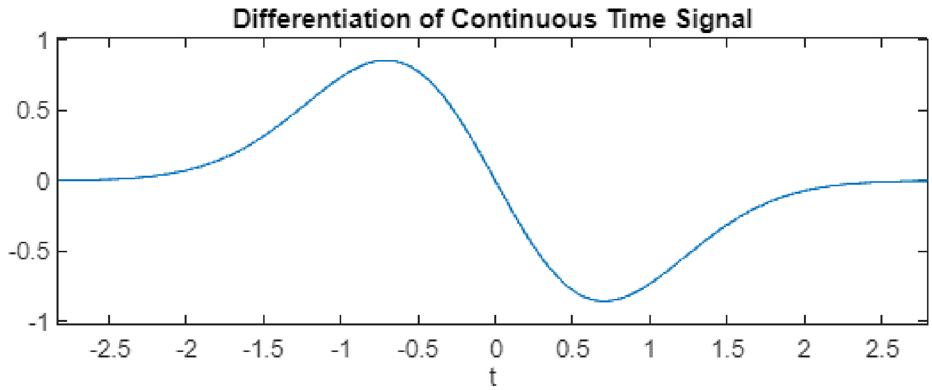
Task 2:

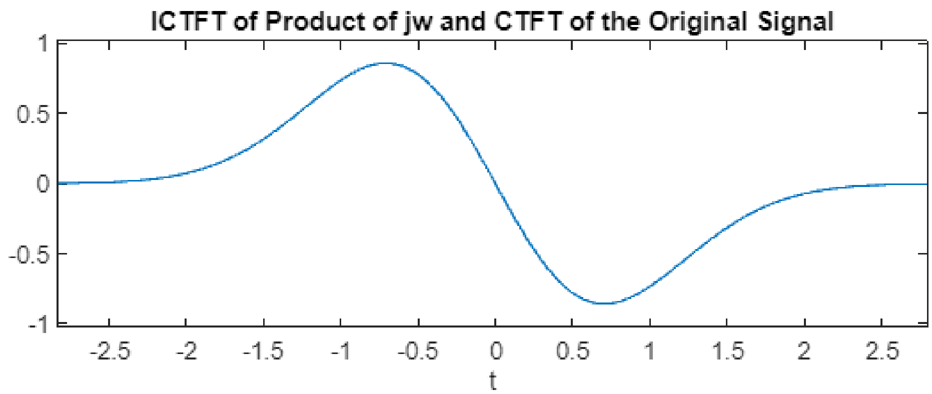
```
% Symbolic variables
syms w t

to = 3;
x = t * exp(-t^2);

figure;

% LHS
LHS = subs(x, t, t-to);
subplot(2,1,1);
ezplot(LHS);

title('Time Shifted Continuous Time Signal');

% RHS
X = CTFT(x);
Z = X .* exp(-1i .* w .* to);

RHS = ICTFT(Z);
subplot(2,1,2);
ezplot(RHS);
```

```
title('ICTFT of Product of Complex Exponential with CTFT of the Original Signal')
```




```
syms w t
y = exp(-t^2);

figure;

% LHS
LHS = diff(y,t);

subplot(2,1,1);
ezplot(LHS);

title('Differentiation of Continuous Time Signal');

% RHS
Y = CTFT(y);
Z = (1i .* w) * (Y);

RHS = ICTFT(Z);

subplot(2,1,2);
ezplot(RHS);

title('ICTFT of Product of jw and CTFT of the Original Signal');
```


Differentiation of Continuous Time Signal
1
0.5
0
-0.5
-1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
t


ICTFT of Product of jw and CTFT of the Original Signal
1
0.5
0
-0.5
-1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
t