Signals Systems and Communication Lab

Laboratory report submitted for the partial fulfillment
of the requirements for the degree of

Bachelor of Technology
in
Electronics and Communication Engineering

by

Mohit Akhouri - 19ucc023

Course Coordinator
Dr. Navneet Upadhyay

Department of Electronics and Communication Engineering
The LNM Institute of Information Technology, Jaipur

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Contents

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Chapter *5*

Experiment - 5

5.1 Aim of the experiment

1. To verify the convolution property of Fourier transform
2. To verify time shifting property of Fourier transform
3. To verify frequency shifting property of Fourier transform

5.2 Software Used

MATLAB

5.3 Theory

5.3.1 About Fourier transform :

In mathematics, a Fourier transform (FT) is a mathematical transform that decomposes functions depending on space or time into functions depending on spatial or temporal frequency, such as the expression of a musical chord in terms of the volumes and frequencies of its constituent notes. The term Fourier transform refers to both the frequency domain representation and the mathematical operation that associates the frequency domain representation to a function of space or time.

The Fourier transform of a function of time is a complex-valued function of frequency, whose magnitude (absolute value) represents the amount of that frequency present in the original function, and whose argument is the phase offset of the basic sinusoid in that frequency. The Fourier transform is not limited to functions of time, but the domain of the original function is commonly referred to as the time domain. There is also an inverse Fourier transform that mathematically synthesizes the original function from its frequency domain representation, as proven by the Fourier inversion theorem.

5.3.2 Convolution property of Fourier transform :

The convolution of two functions $x_1(t)$ and $x_{2](t)}$ is written as h(t)=x_1*x_2 defined by :

$$h(t) = \int_{-\infty}^{\infty} x_1(\tau)x_2(t-\tau) \tag{5.1}$$

The convolution property states that convolution in time domain results in multiplication in frequency domain.

$$x_1(t) * x_2(t) = X_1(\omega).X_2(\omega) \tag{5.2}$$

5.3.3 Time shifting property of Fourier transform :

Time shifting property is as follows :

$$x(t) < - > X(\omega) \tag{5.3}$$

$$x(t - t_o) < - > e^{-j\omega t_o} X(\omega) \tag{5.4}$$

5.3.4 Frequency shifting property of Fourier transform :

Frequency shifting property is as follows :

$$x(t) < - > X(\omega) \tag{5.5}$$

$$e^{j\omega t_o}.x(t) < - > X(\omega - \omega_o) \tag{5.6}$$

5.4 Code and Results

5.4.1 Exercise 1 : Verifying convolution property of Fourier transform

```
% Name = Mohit Akhouri
% Roll no = 19UCC023
% SSC LAB Batch D1 - Monday ( 2-5 pm )

% This code will verify the convolution property of Fourier transform

to = 25;
ts = 1/10;
N = to/ts;
t = ts:ts:to; % defining range for t
fs = 1/ts;
f = linspace(-fs,fs,N);
xt = (t>=0 & t<10); % defining first pulse x(t)
ht = (t>=0 & t<10); % defining second pulse h(t)

figure;
subplot(2,1,1);
plot(t,xt,'Linewidth',1.5);
xlabel('Time(t)->');
ylabel('x(t) ->');
title('Plotting rectangular signal x(t) of length 10');
grid on;
subplot(2,1,2);
plot(t,ht,'Linewidth',1.5);
xlabel('Time(t)->');
ylabel('h(t)->');
title('Plotting rectangular signal h(t) of length 10');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

% Finding convolution in time domain
conv_xh_t = conv(xt,ht); % using function conv to calculate
 convolution in time domain

% plotting figures;
figure;
subplot(2,1,1);
plot(conv_xh_t);
xlabel('time(t) ->');
ylabel('x(t) conv h(t)');
title('Convolution of x(t) and h(t) in time domain');
grid on;

% Finding convolution in frequency domain
conv_xh_f = abs(ifft(fft(xt).*fft(ht))); % taking inverse fft of
 multiplication of fft
% of x(t) and h(t) in frequency domain

% plotting figures;
subplot(2,1,2);
plot(conv_xh_f);
xlabel('frequency(Hz) ->');
```

Figure 5.1 Part 1 of Code for verification of convolution property of Fourier transform

```
ylabel('x(\omega) x h(\omega)');
title('Multiplication (Convolution) of x(\omega) and h(\omega) in
 Frequency domain');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');
```

Figure 5.2 Part 2 of Code for verification of convolution property of Fourier transform

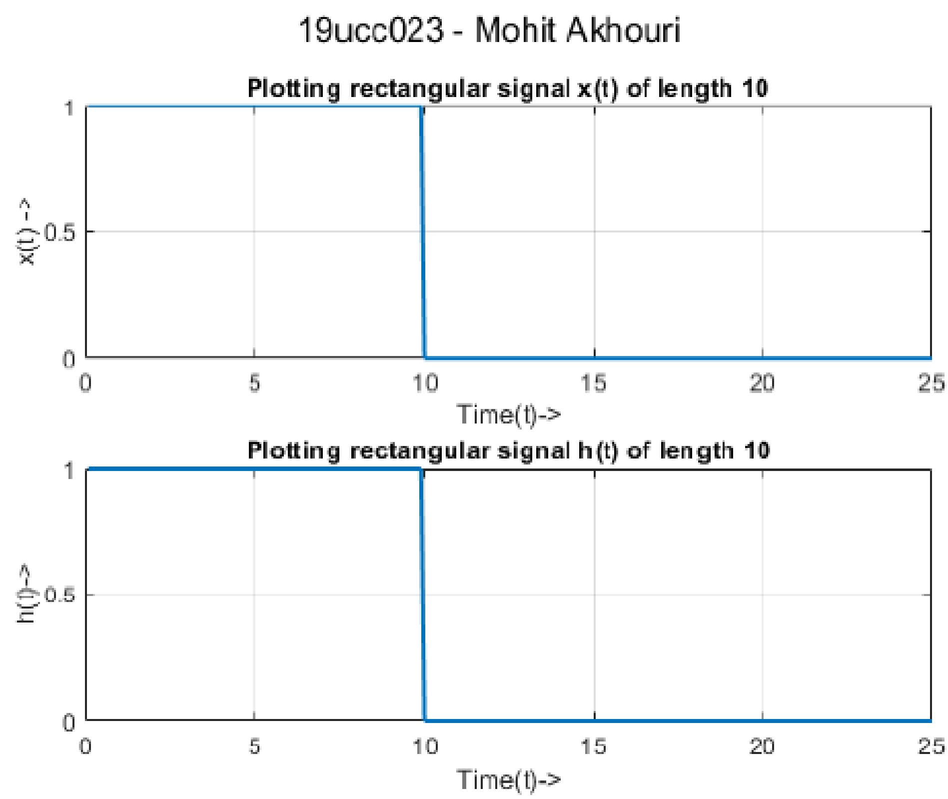

Figure 5.3 Graph of plotted pulses x(t) and h(t) of length 10

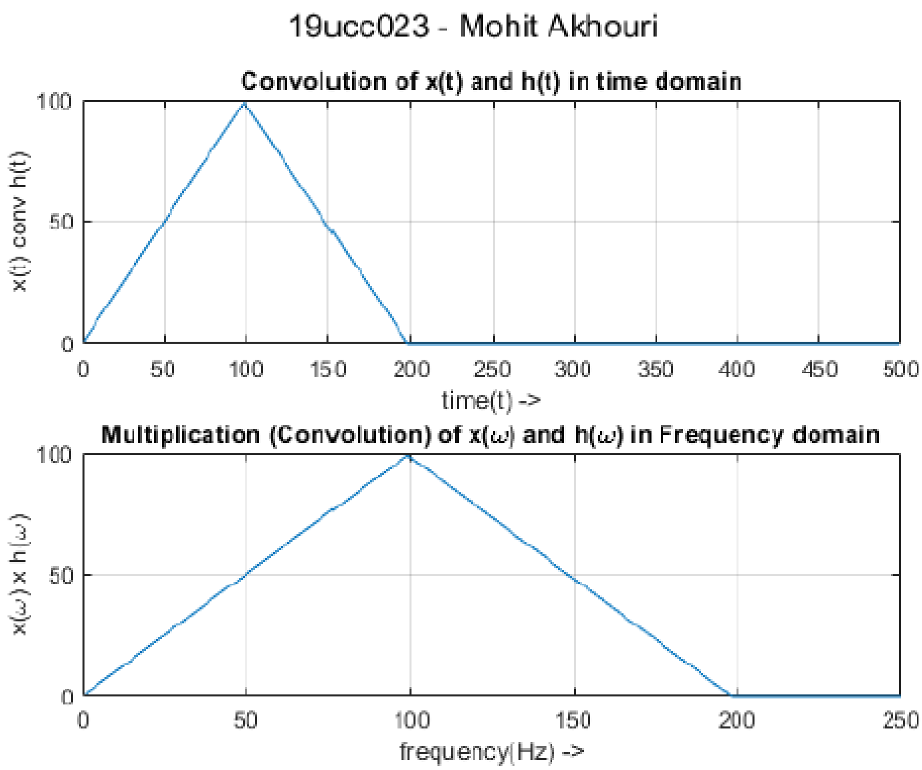

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Figure 5.4 Graph of verification of convolution property of Fourier transform

5.4.2 Exercise 2: Verifying Time shifting property of Fourier transform

```
% Name = Mohit Akhouri
% Roll no = 19UCC023
% SSC LAB Batch D1 - Monday ( 2-5 pm )

% This code will verify the Time shifting property of Fourier
 transform

to = 25; % defining To
ts = 1/10; % defining Ts
N = to/ts; % defining range N
t = ts:ts:to; % defining range for t
fs = 1/ts; % defining frequency fs
f = linspace(-fs,fs,N); % defining frequency f
Xt = (t>=0 & t<10); % defining pulse X(t)

% plotting original signal X(t)
figure;
subplot(2,1,1);
plot(t,Xt,'Linewidth',1.5);
xlabel('Time(t)->');
ylabel('x(t) ->');
title('Plotting rectangular signal X(t) of length 10');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');

To = 5; % defining value by which signal is to be plotted
Ft = fftshift(fft(Xt)); % taking fft of X(t)
shift_Ft = exp(-1j*2*pi*f*To).*Ft; % Shifting fourier transform
Shift_Ift = abs(ifft(shift_Ft)); % Taking inverse fourier transform
t1 = t + To;
Shift_Ift = Xt;

% plotting X(t-5)
figure;
subplot(2,1,1);
plot(t1,Shift_Ift,'Linewidth',1.5);
xlabel('time(t)->');
ylabel('X(t-5)->');
title('Shifting X(t) by 5 units to right, Plotting X(t-5)');
grid on;


To = -5; % defining value by which signal is to be plotted
Ft = fftshift(fft(Xt)); % taking fft of X(t)
shift_Ft = exp(-1j*2*pi*f*To).*Ft; % Shifting fourier transform
Shift_Ift = abs(ifft(shift_Ft)); % Taking inverse fourier transform
t2 = t + To;
Shift_Ift = Xt;

% plotting X(t+5)
subplot(2,1,2);
plot(t2,Shift_Ift,'Linewidth',1.5);
```

Figure 5.5 Part 1 of Code for verification of Time shifting property of Fourier transform

```
xlabel('time(t)->');
ylabel('X(t+5)->');
title('Shifting X(t) by 5 units to left, Plotting X(t+5)');
grid on;
sgtitle('19ucc023 - Mohit Akhouri');
```

Figure 5.6 Part 2 of Code for verification of Time shifting property of Fourier transform

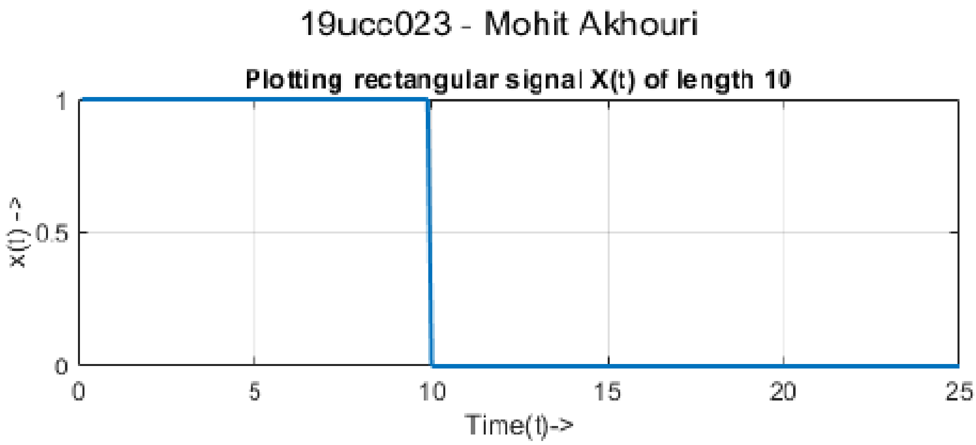

Figure 5.7 Graph of plotted pulse X(t) of length 10

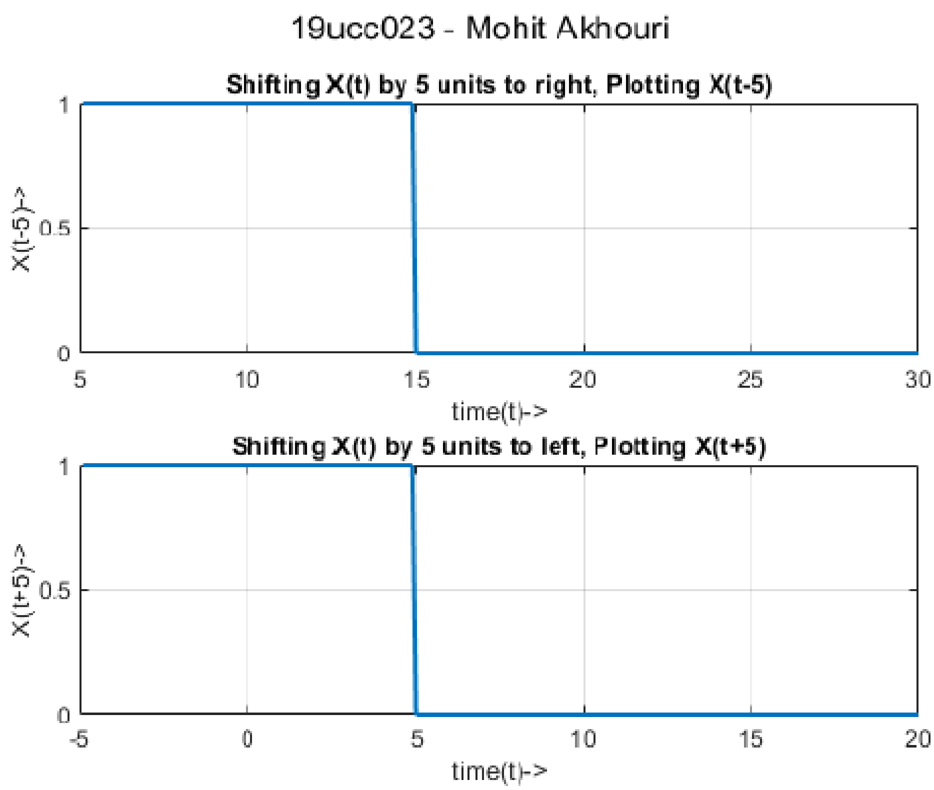

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Figure 5.8 Graph of verification of Time shifting property by plotting X(t+5) and X(t-5)

5.5 Conclusion

In this experiment, we learnt about the Time shifting, Convolution and Frequency shifting property of Fourier transform and implemented functions for verification of Time shifting and Convolution property of Fourier transform.