Properties of continuous time Fourier Series

Lab Report # 11

CSE301 - L Signals & Systems Lab

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Properties of Continuous Time Fourier Series

❖ Linearity:

Given two periodic signals x(t) and y(t) having same period, linearity property of FS representation can be expressed as:

$$x(t) \overset{FS}{\leftrightarrow} a_k \;, y(t) \overset{FS}{\leftrightarrow} b_k \Rightarrow x(t) + y(t) \overset{FS}{\leftrightarrow} a_k + b_k$$

❖ Time Shifting:

The time shifting property of FS states that.

$$x(t) \overset{FS}{\leftrightarrow} a_k \Leftrightarrow x(t - t_0) \overset{FS}{\leftrightarrow} e^{-jk\omega 0t} a_k \;, \omega_0 = 2\pi/T$$

❖ Time Reversal:

The time reversal property of FS states that.

$$x(t) \overset{FS}{\leftrightarrow} a_k \Leftrightarrow x(-t) \overset{FS}{\leftrightarrow} a_{-k}$$

❖ Time Scaling:

The time scaling property of FS states that.

$$x(t) = \sum_{k=-\infty}^{\infty} a_k \, e^{-jM\omega t} \Rightarrow x(\alpha t) = \sum_{k=-\infty}^{\infty} a_k \, e^{-jM\omega \alpha t}$$

Lab Objectives

- This lab aims at the understanding of the properties of CT Fourier Series
  - Linearity
  - Time Shifting
  - Time Scaling
  - Time Reversal

TASk #01

- **Problem Statement:**

Given the signal x(t) with ak's

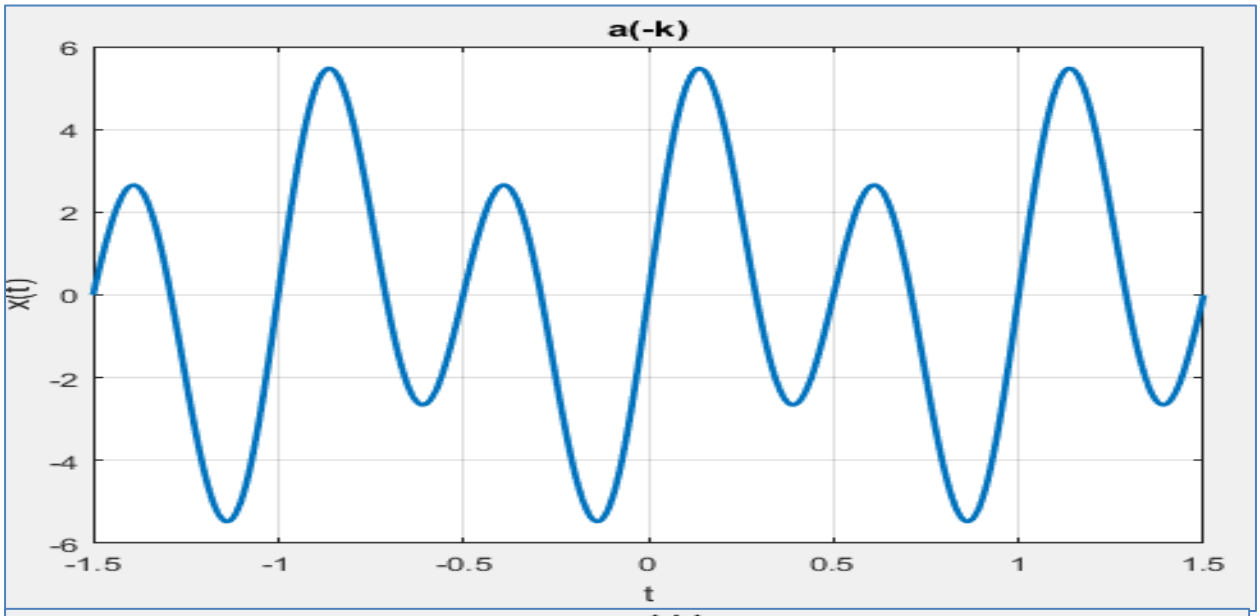
a) Plot the time reverse version of the signal x(-t) directly,

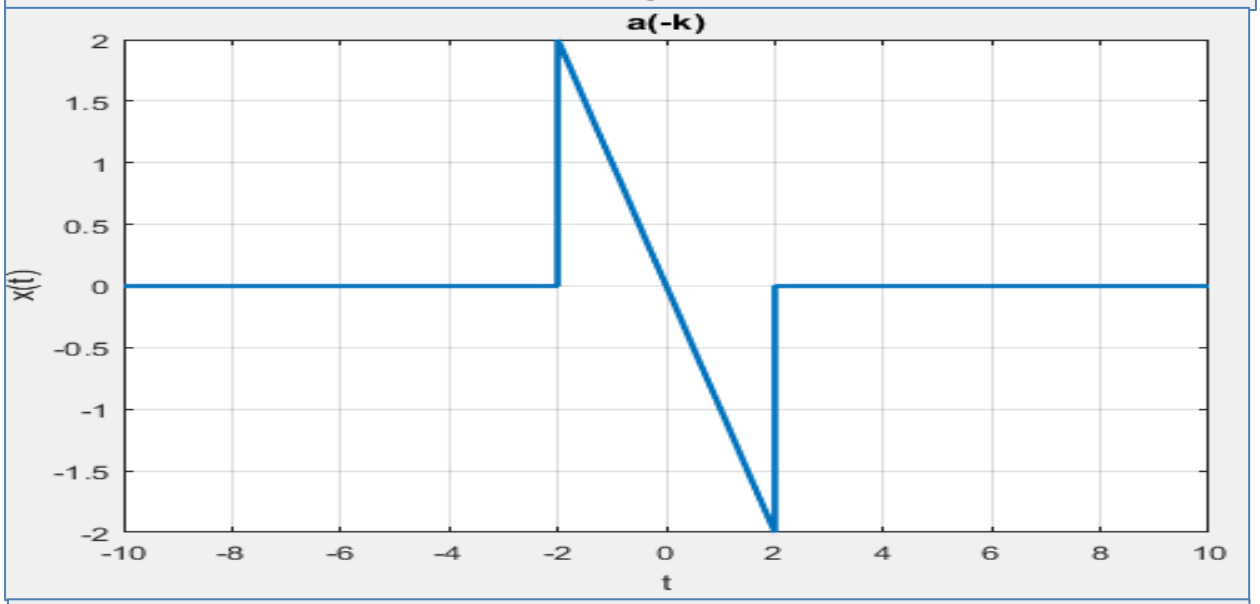
b) Plot FS coefficients a-k of time reversed signal,

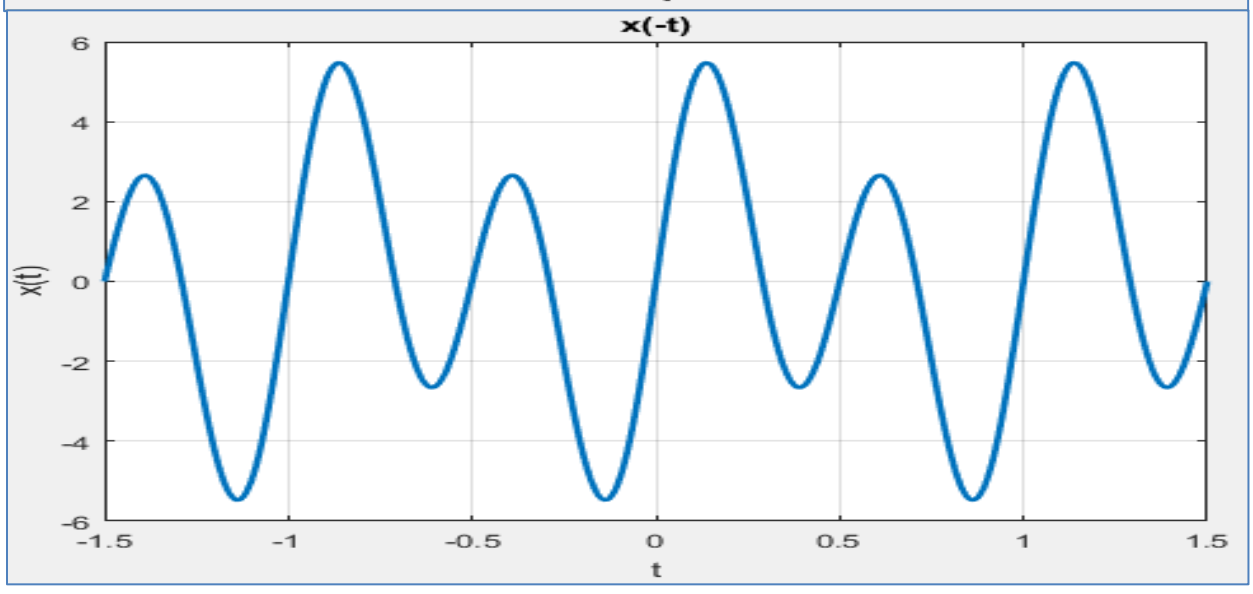
c) Plot the reconstructed time reversed signal using FS coefficients a-k

- **Code & Output:**

```
clc
clear all
close all
t = -1.5:0.005:1.5;
T = 1;
w0 = 2*pi/T;
M = 10;
x = zeros(1,length(t));
k = -M:M;
for k = -M:M
    if abs(k)<3
x = x + j*k*exp(j*k*w0*t);
    else
x = x + 0*exp(j*k*w0*t);
    end
end
figure;
set(gcf,'defaultaxesfontsize',9)
plot(-t,real(x),'lineWidth',2);
grid;
xlabel('t'); ylabel('x(t)') ;
title('x(-t)');
x1=-M:-2;
y1=0.*x1;
x2=-2:2;
x3=2:M;
y3=0.*x3;
kk = [ x1 x2 x3 ];
ak = [ y1 y2 y3 ];
figure;
plot( -kk , imag(ak),'lineWidth',2);
grid;
xlabel('t'); ylabel('x(t)') ;
title('a(-k)');
xx = zeros(1,length(t));
for k = -M:M
    if abs(k)<3
xx = xx + j*-k*exp(j*k*w0*t);
    else
xx = xx + 0*exp(j*k*w0*t);
    end
end
figure;
plot(t , real(xx),'lineWidth',2);
grid;
xlabel('t'); ylabel('x(t)') ;
title('a(-k)');
```


a(-k)
x(t)
t
6
4
2
0
-2
-4
-6
-1.5
-1
-0.5
0
0.5
1
1.5


a(-k)
x(t)
t
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-10
-8
-6
-4
-2
0
2
4
6
8
10


x(-t)
x(t)
t
6
4
2
0
-2
-4
-6
-1.5
-1
-0.5
0
0.5
1
1.5

TASK # 02

- **Problem Statement:**

Given the periodic square wave x(t) with T = 1 & T1 = 0.25, rewrite the above code for time scaling when value of alpha is 2 i.e. x(αt) = x(2t).

- **Code & Output:**

```
clc
clear all
close all
t = -1.5:0.005:1.5;
xcos = cos(2*pi*t);
xt = xcos>0;
k = -50:50;
T = 1;
T1 = 0.25;
ak = sin(k*2*pi*(T1/T))./(k*pi);
ak(51) = 2*T1/T;
alp1 = 2;
w0 = 2*pi/T;
w1 = alp1*w0;
xat1 = zeros(1,length(t));
```

```
for k = -50:50
xat1 = xat1 +ak(k+51)*exp
(j*k*w1*t);
end
figure(1);
subplot(2,1,1);
plot(t,xt,'lineWidth',2);
ylabel('x(t)');
title('Periodic Square Wave
(T=1, T1=0.25)');
axis([-1.5 1.5 -0.2 1.2]);
grid;
subplot(2,1,2);
plot(t,real(xat1),'lineWidth',2);
ylabel('x(t)');
title('Reconstruction from ak''s
(alp1=2, w1=2*w0)');
axis([-1.5 1.5 -0.2 1.2]); grid;
```