Independent University Bangladesh

Department of Electrical and Electronics Engineering

Lab Report 07

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Course code: EEE 321L

Couse name: Digital Signal Processing Lab

Lab no: 07

Lab title: Study on sampling, signal reconstruction and aliasing

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a) Sampling and discrete time Fourier Transform (DTFT)

Code:

```matlab
% analog signal
dt = 0.00005;
t = -0.005:dt:0.005;
x_a = exp(-1000*abs(t));

% sampling
Fs = 5000;
Ts = 1/Fs;
n = -25:25;
x = exp(-1000*abs(n*Ts));

% DTFT
K = 500;
k = 0:K;
w = pi*k/K;
X = x*exp(-j*n'*w);      % n' for complex multiplication
X = real(X);
w = [-fliplr(w) w(2:K+1)];
X = [fliplr(X) X(2:K+1)];

% Plotting
subplot(2,1,1);

plot(t*1000, x_a);
xlabel('time in ms');
ylabel('x(n)', 'fontsize', 15);
title('Discrete-time Signal', 'fontsize', 15);

hold on;

stem(n*Ts*1000, x);
gtext('Ts=0.2ms', 'fontsize', 12);

hold off;

subplot(2,1,2); plot(w/pi, X);
xlabel('frequency in pi units'); ylabel('X(w)', 'fontsize', 15);
title('Discrete-time Time Fourier Transform', 'fontsize', 15);
gtext('Ts=0.2ms', 'fontsize', 12);
```
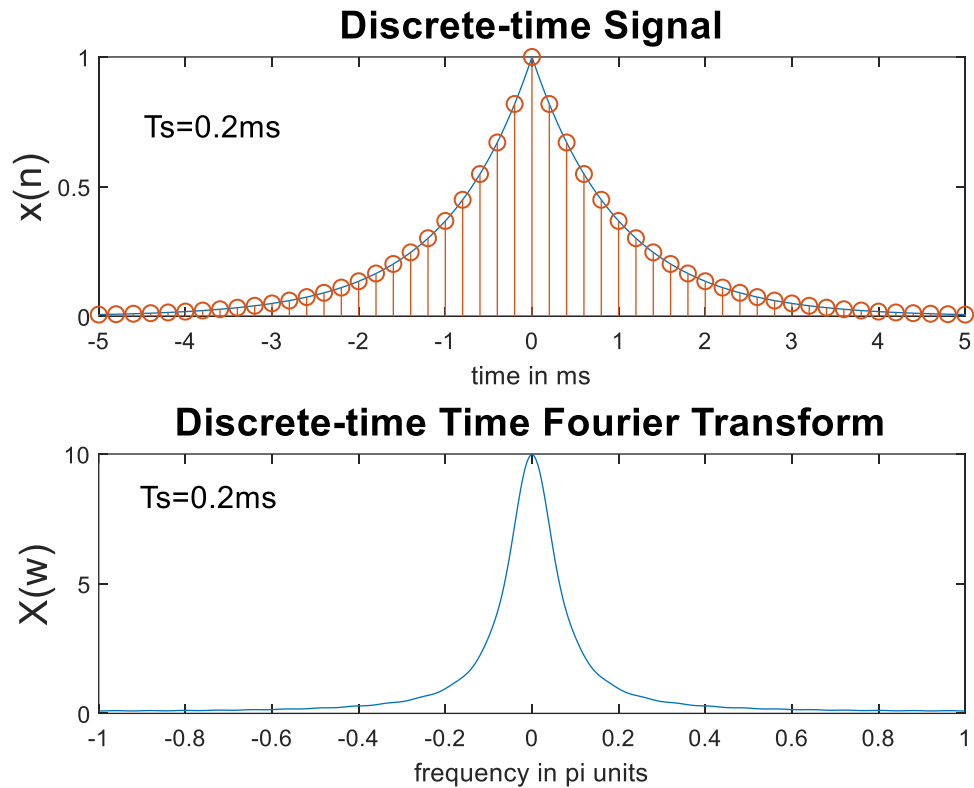
Output:

Discrete-time Signal

Ts=0.2ms

x-axis: time in ms, from -5 to 5
y-axis: x(n), from 0 to 1

Discrete-time Time Fourier Transform

Ts=0.2ms

x-axis: frequency in pi units, from -1 to 1
y-axis: X(w), from 0 to 10

b) Signal reconstruction of $x_a(t) = e^{-1000|t|}$

Code:

```
% original analog signal
t = -0.005:0.00005:0.005;
x_a = exp(-1000*abs(t));
% discrete time signal
Fs = 5000;
Ts = 1/Fs;
n = -25:25;
nTs = n*Ts;
x_n = exp(-1000*abs(nTs));
% analog signal reconstruction
y_a = x_n*sinc(Fs*(ones(length(n),1)*t-nTs'*ones(1,length(t))));
% error
error = max(abs(x_a-y_a))
% plotting
subplot(2,1,1); plot(t*1000,x_a);
ylabel('x(n)', 'fontsize', 15);
title('Discrete Time Signal', 'fontsize', 15);
hold on;
stem(n*Ts*1000, x_n);
```
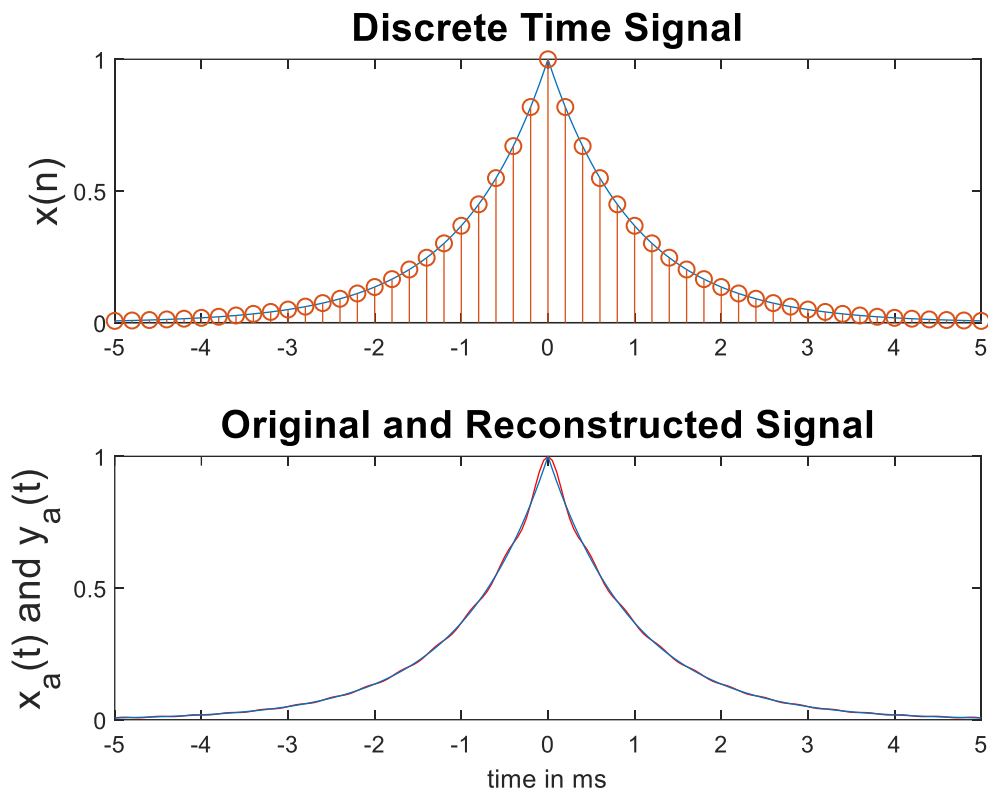
```matlab
hold off;

subplot(2,1,2); plot(t*1000,y_a, 'r');
xlabel('time in ms'); ylabel('x_a(t) and y_a(t)', 'fontsize', 15);
title('Original and Reconstructed Signal', 'fontsize', 15);
hold on;
plot(t*1000, x_a)
```

Output: *Error* = 0.0363

Discrete Time Signal

Original and Reconstructed Signal

c) Signal reconstruction of $x_a(t) = \cos(20\pi t + \Theta)$

Code:

```matlab
% original analog signal
t = -0.2:0.00001:0.2;
x_a = cos(20*pi*t);
Ts = 0.005;
Fs = 1/Ts;
n = -40:40;
nTs = n*Ts;
x_n = cos(20*pi*nTs);

% analog signal reconstruction
```

```matlab
y_a = x_n*sinc(Fs*(ones(length(n),1)*t-nTs'*ones(1,length(t))));

% error
error = max(abs(x_a-y_a))

% plotting
subplot(2,1,1); plot(t, x_a);
ylabel('x(n)', 'fontsize', 15);
title('Discrete Time Signal', 'fontsize', 15);
axis([-0.2 0.2 -1.5 1.5]);
hold on;
stem(nTs, x_n); grid;

hold off;

subplot(2,1,2); plot(t,y_a, 'r');
xlabel('x_a(t) and y_a(t)', 'fontsize', 15);
title('Original and Reconstructed Signal', 'fontsize', 15);
hold on;
plot(t, x_a); grid
```
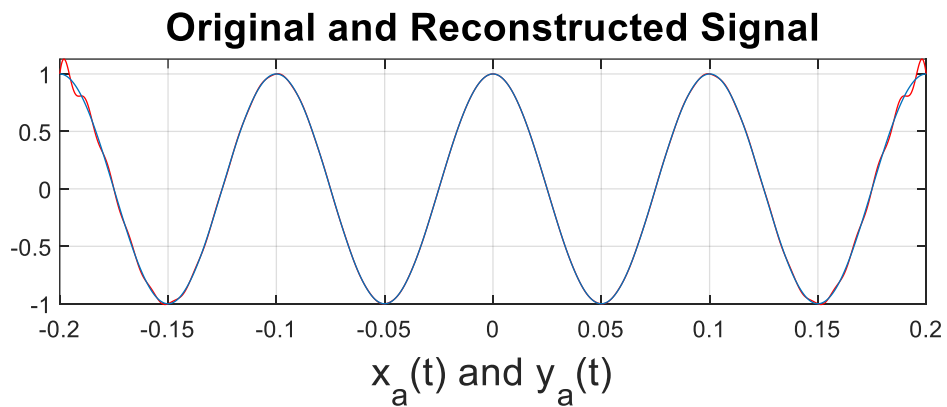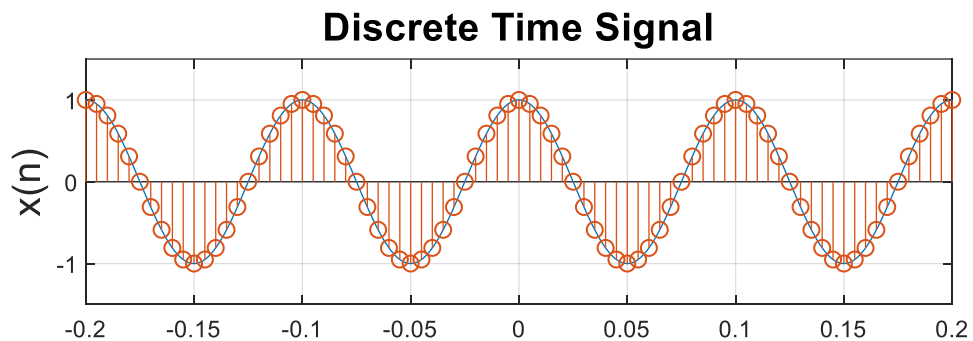
Output: *Error = 0.1374*

Discrete Time Signal

Original and Reconstructed Signal

$x_a(t)$ and $y_a(t)$

d) Assignment:
    i.   Function definition

```matlab
% function to plot sampled and reconstruction signals of sinusoids
function [error] = reconstruct(f, Fs)

% original analog signal
t = -(20/Fs):0.00001:(20/Fs);
x_a = sin(2*pi*f*t);

% discrtete signal
Ts = 1/Fs;
n = -20:20;
nTs = n*Ts;
x_n = sin(2*pi*f*nTs);

% analog signal reconstruction
y_a = x_n*sinc(Fs*(ones(length(n),1)*t-nTs'*ones(1,length(t))));

% error
error = max(abs(y_a-x_a));

%plotting
subplot (2,1,1)
plot(t*1000, x_a);
hold on
stem(nTs*1000, x_n);
title('Discrete-time signal','fontsize',15);
ylabel('x(n)','fontsize',13);
xlabel('time in ms','fontsize',13);
grid;

hold off

subplot(2,1,2);
plot(t, y_a, 'r');
hold on
plot(t, x_a, 'b');
title('Original and Reconstructed signal','fontsize',15);
xlabel('time in ms','fontsize',13);
ylabel('x_a(t) and y_a(t)','fontsize',13);
grid;

end
```

ii.   Call and outputs:

Code:

```
% generate sampled, reconstructed signal plots and error
error = reconstruct(100, 1000)
```

Outputs:

```
error =

    0.0616
```

Discrete-time signal

Original and Reconstructed signal