Roll No : 22404

Seat No : S1900053019

Name : Atharva Naphade

Problem Statement :-

Verify Sampling theorem using simulation for message signal frequency 2Hz and different sampling frequencies.

Code :- clc; clear all; close all;

fprintf(' '); fprintf('Sampling and Reconstruction'); fprintf(' \n');

F=input('Input1: Frequenncy of analog sinusoid in Hz:'); fn=2\*F;

fprintf('\n Output1: for sinusoid of freq. %d Hz, Nyquist rate is %d Hz \n \n',F, fn); T=1/F;

t=0:0.001\*T:4\*T;

x=2\*cos(2\*pi\*F\*t);

%% UnderSampling

fprintf('\n\n '); fprintf('Case 1: UnderSampling');

fprintf(' \n');

fsun=input('Input2: Choose appropriate Sampling frequency in Hz: '); if fsun >= fn

error('For Undersampling, sampling frequency must be samller than Nyquist rate')

endif t1=0:(1/fsun):4\*T; xun=2\*cos(2\*pi\*F\*t1);

%% NyquistSampling

fprintf('\n\n '); fprintf('Case 2: NyquistSampling');

fprintf(' \n'); fsn=input('Choose appropriate Sampling frequency in Hz:'); if fsn ~= fn

error('For Nyquistsampling, sampling frequency must be equal to Nyquist rate') endif

t2=0:(1/fsn):4\*T; xn=2\*cos(2\*pi\*F\*t2);

%% OverSampling

fprintf('\n\n '); fprintf('Case 3: OverSampling');

fprintf(' \n'); fsov=input('Choose appropriate Sampling frequency in Hz:'); if fsov <= fn

error('For Oversampling, sampling frequency must be greater than Nyquist rate') endif

t3=0:(1/fsov):4\*T; xov=2\*cos(2\*pi\*F\*t3);

%% ReconstructedAnlog Signal

% Case 1: From UnderSampled signal xr1=zeros(1,length(t));

for k=1:length(t)

for p= 1:length(t1)

xr1(k)=xr1(k)+xun(p)\*sinc((k-1)\*fsun\*0.001\*T-(p-1)); end

end

% Case 2: From NyquistSampled signal xr2=zeros(1,length(t));

for k=1:length(t)

for p= 1:length(t2)

xr2(k)=xr2(k)+xn(p)\*sinc((k-1)\*fsn\*0.001\*T-(p-1)); end

end

% Case 3: From OverSampled signal xr3=zeros(1,length(t));

for k=1:length(t)

for p= 1:length(t3)

xr3(k)=xr3(k)+xov(p)\*sinc((k-1)\*fsov\*0.001\*T-(p-1)); end

end

%% Plotting figure subplot(4,2,1);

plot(t,x,'-','LineWidth',2);

title(['Sinusoid analog signal (' num2str(F) ' Hz) to be sampled']); xlabel('time');

ylabel('amplitude');

subplot(4,2,2);

plot(t,x,'-','LineWidth',2);

title(['Sinusoid analog signal (' num2str(F) ' Hz) to be reconstructed']); xlabel('time');

ylabel('amplitude');

subplot(4,2,3);

plot(t,x,'--','LineWidth',1); hold on;

stem(t1,xun,'k','LineWidth',2,'MarkerFaceColor','red', 'MarkerEdgeColor','yellow'); title(['UnderSampled signal with ' num2str(fsun) ' Hz Sampling rate']); xlabel('time');

ylabel('amplitude');

%legend('Original analog', 'UnderSampled');

subplot(4,2,5);

plot(t,x,'--','LineWidth',1); hold on;

stem(t2,xn,'k','LineWidth',2,'MarkerFaceColor','red', 'MarkerEdgeColor','yellow'); title(['NyquistSampled signal with ' num2str(fn) ' Hz Sampling rate']); xlabel('time');

ylabel('amplitude');

%legend('Original analog', 'NyquistSampled');

subplot(4,2,7);

plot(t,x,'--','LineWidth',1); hold on;

stem(t3,xov,'k','LineWidth',2,'MarkerFaceColor','red', 'MarkerEdgeColor','yellow');

title(['OverSampled signal with ' num2str(fsov) ' Hz Sampling rate']); xlabel('time');

ylabel('amplitude');

%legend('Original analog', 'OverSampled');

subplot(4,2,4);

plot(t,x,'--','LineWidth',1); hold on;

plot(t,xr1,'-','LineWidth',2);

stem(t1,xun,'k','LineWidth',2,'MarkerFaceColor','red', 'MarkerEdgeColor','yellow'); title('Reconstructed signal (red) from UnderSampled signal');

ylim([-2.5,2.5]);

xlabel('time'); ylabel('amplitude');

%legend('Original analog','Reconstructed signal','UnderSampled signal',"location", "southoutside");

subplot(4,2,6);

plot(t,x,'--','LineWidth',1); hold on;

plot(t,xr2,'-','LineWidth',2);

stem(t2,xn,'k','LineWidth',2,'MarkerFaceColor','red', 'MarkerEdgeColor','yellow'); title('Reconstructed signal (red) from NyquistSampled signal');

ylim([-2.5,2.5]);

xlabel('time'); ylabel('amplitude');

%legend('Original analog','Reconstructed signal','NyquistSampled signal');

subplot(4,2,8);

plot(t,x,'--','LineWidth',1);

hold on;

plot(t,xr3,'-','LineWidth',2);

stem(t3,xov,'k','LineWidth',2,'MarkerFaceColor','red', 'MarkerEdgeColor','yellow'); title('Reconstructed signal(red) from OverSampled signal');

ylim([-2.5,2.5]);

xlabel('time'); ylabel('amplitude');

%legend('Original analog','Reconstructed signal','OverSampled signal');

Output Window : -

Sampling and Reconstruction

Input1: Frequenncy of analog sinusoid in Hz:2

Output1: for sinusoid of freq. 2 Hz, Nyquist rate is 4 Hz

Case 1: UnderSampling

Input2: Choose appropriate Sampling frequency in Hz: 2

Case 2: NyquistSampling

Choose appropriate Sampling frequency in Hz:4

Case 3: OverSampling

Choose appropriate Sampling frequency in Hz:8

