Experiment No 03

BECS 32461

Paper D

**VERIFICATION OF SAMPLING THEOREM IN TIME DOMAIN**

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**PROCEDURE**

F01.

% Amplitude and Frequency

A = 1; F = 2;

%Time vector for continuous signal

t = 0:0.001:1;

% Continuous-time sine wave

x\_a = A\*sin(2\*pi\*F\*t);

figure;

subplot(3,1,1)

plot(t,x\_a,'-b')

title('Analogue (Continuous) Input Signal')

ylabel('x\_a','Interpreter','tex')

xlabel('time(sec)')

% Sampling at Nyquist rate

F\_s = 2\*F;

% Sampling points

n = 0:1/F\_s:1;

% Discrete-time signal

x\_s = A\*sin(2\*pi\*F\*n);

subplot(3,1,2)

stem(n,x\_s,'-b')

title('Discreete Time Signal ( F\_s = 2\*F)','Interpreter','tex')

xlabel('samples(n)')

ylabel('x\_s','Interpreter','tex')

% Time vector for reconstruction

t\_r = linspace(0, 1, 1000);

% Reconstruct signal using linear interpolation

x\_linear = interp1(n, x\_s, t\_r, 'linear');

% Reconstruct signal using spline interpolation

x\_spline = interp1(n, x\_s, t\_r, 'spline');

subplot(3,1,3)

hold on

plot(t\_r,x\_spline,'-b')

title('Reconstructed Signal ( F\_s = 2\*F)','Interpreter','tex')

xlabel('time(sec)')

ylabel('x\_r','Interpreter','tex')

A diagram of a function

AI-generated content may be incorrect.

F02.

% Amplitude and Frequency

A = 1; F = 2;

%Time vector for continuous signal

t = 0:0.001:1;

% Continuous-time sine wave

x\_a = A\*sin(2\*pi\*F\*t);

figure;

subplot(3,1,1)

plot(t,x\_a,'-b','LineWidth',1.5)

title('Analogue (Continuous) Input Signal')

ylabel('x\_a','Interpreter','tex')

xlabel('time(sec)')

% Sampling at Nyquist rate

F\_s = 10\*F;

% Sampling points

n = 0:1/F\_s:1;

% Discrete-time signal

x\_s = A\*sin(2\*pi\*F\*n);

subplot(3,1,2)

stem(n,x\_s,'-b','LineWidth',1.5)

title('Discreete Time Signal ( F\_s > 2\*F)','Interpreter','tex')

xlabel('samples(n)')

ylabel('x\_s','Interpreter','tex')

% Time vector for reconstruction

t\_r = linspace(0, 1, 1000);

% Reconstruct signal using linear interpolation

x\_linear = interp1(n, x\_s, t\_r, 'linear');

% Reconstruct signal using spline interpolation

x\_spline = interp1(n, x\_s, t\_r, 'spline');

subplot(3,1,3)

hold on

plot(t\_r,x\_spline,'-b','LineWidth',1.5)

title('Reconstructed Signal ( F\_s > 2\*F)','Interpreter','tex')

xlabel('time(sec)')

ylabel('x\_r','Interpreter','tex')

A graph with blue lines

AI-generated content may be incorrect.

F03.

% Amplitude and Frequency

A = 1; F = 2;

%Time vector for continuous signal

t = 0:0.001:1;

% Continuous-time sine wave

x\_a = A\*sin(2\*pi\*F\*t);

figure;

subplot(3,1,1)

plot(t,x\_a,'-b','LineWidth',1.5)

title('Analogue (Continuous) Input Signal')

ylabel('x\_a','Interpreter','tex')

xlabel('time(sec)')

% Sampling at Nyquist rate

F\_s = 1.5\*F;

% Sampling points

n = 0:1/F\_s:1;

% Discrete-time signal

x\_s = A\*sin(2\*pi\*F\*n);

subplot(3,1,2)

stem(n,x\_s,'-b','LineWidth',1.5)

title('Discreete Time Signal ( F\_s < 2\*F)','Interpreter','tex')

xlabel('samples(n)')

ylabel('x\_s','Interpreter','tex')

% Time vector for reconstruction

t\_r = linspace(0, 1, 1000);

% Reconstruct signal using linear interpolation

x\_linear = interp1(n, x\_s, t\_r, 'linear');

% Reconstruct signal using spline interpolation

x\_spline = interp1(n, x\_s, t\_r, 'spline');

subplot(3,1,3)

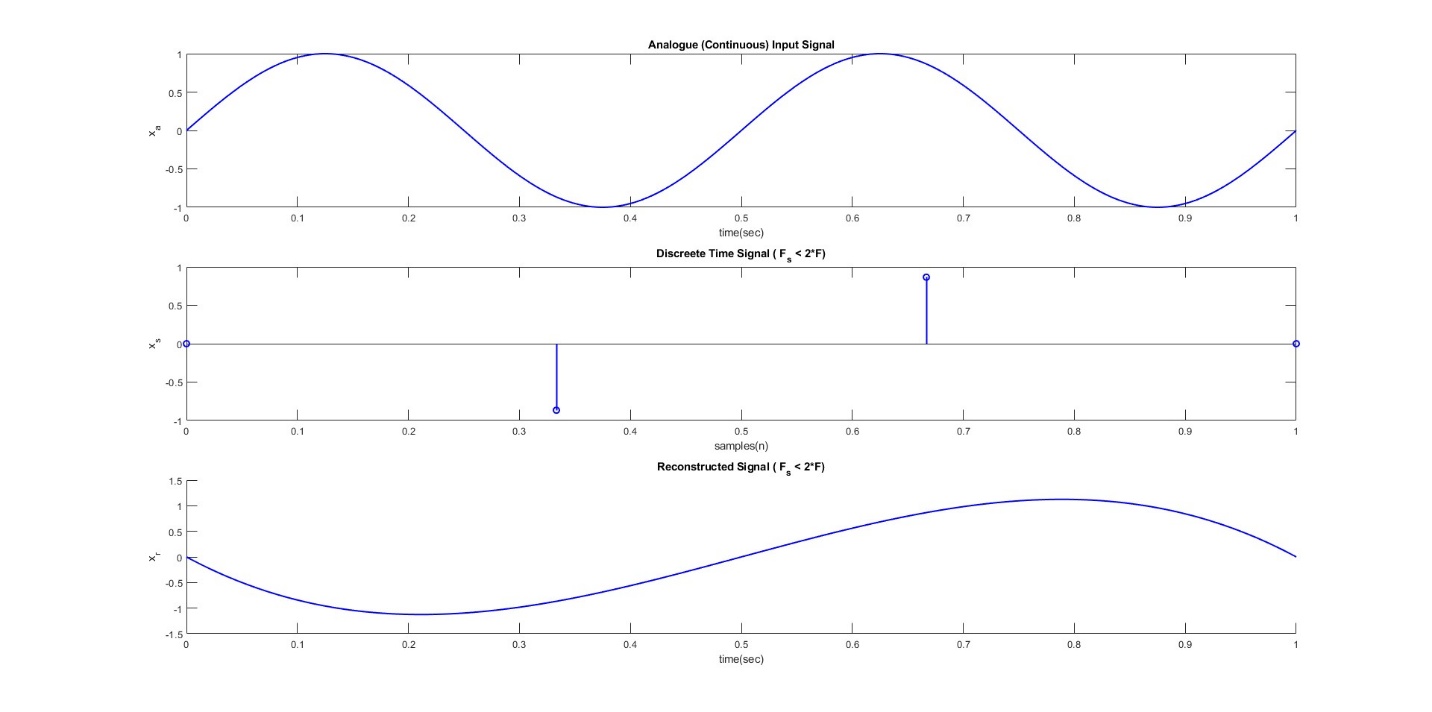
hold on

plot(t\_r,x\_spline,'-b','LineWidth',1.5)

title('Reconstructed Signal ( F\_s < 2\*F)','Interpreter','tex')

xlabel('time(sec)')

ylabel('x\_r','Interpreter','tex')



**EXERCISE**

E01.

%Time vector for continuous signal

t = 0:0.001:1;

% Continuous-time sine waves

x1 =sin(25\*pi\*t);

x2 =sin(25\*pi\*(t-0.2));

figure;

subplot(3,1,1)

plot(t,x1,'-m','LineWidth',1.5)

hold on

plot(t,x2,'--g','LineWidth',1.5)

hold off

title('Analogue (Continuous) Input Signal')

ylabel('x(t)','Interpreter','tex')

xlabel('time(sec)')

% Sampling at Nyquist rate

F\_s = 20;

% Sampling points

n = 0:1/F\_s:1;

% Discrete-time signals

x1\_s =sin(25\*pi\*n);

x2\_s =sin(25\*pi\*(n-0.2));

subplot(3,1,2)

stem(n,x1\_s,'b','filled','MarkerFaceColor','yellow','LineWidth',1.5)

title('Discreete Time Signal for x1(t)','Interpreter','tex')

xlabel('samples(n)')

ylabel('x\_s','Interpreter','tex')

subplot(3,1,3)

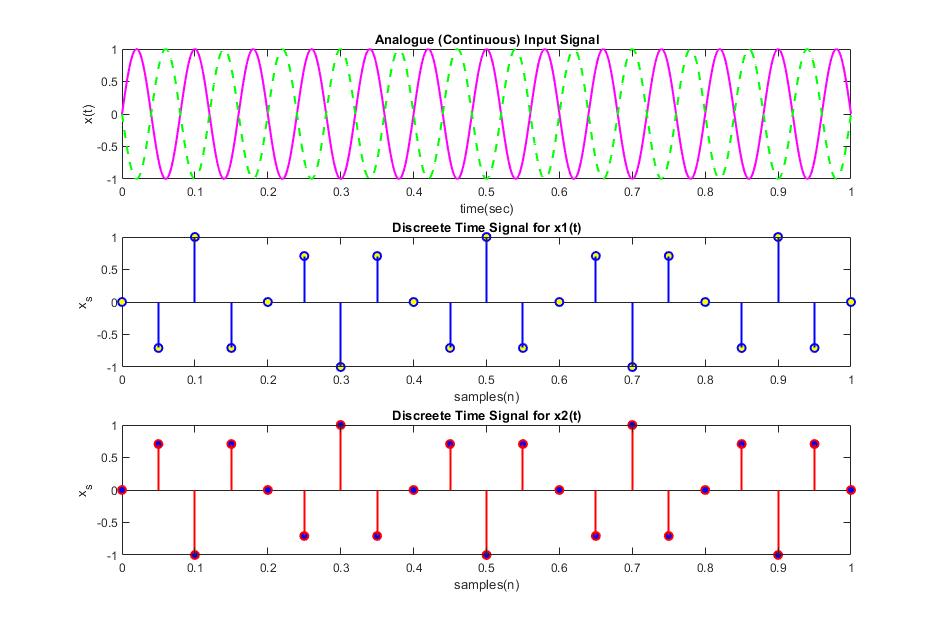
stem(n,x2\_s,'r','filled','MarkerFaceColor','blue','LineWidth',1.5)

title('Discreete Time Signal for x2(t)','Interpreter','tex')

xlabel('samples(n)')

ylabel('x\_s','Interpreter','tex')

* x1(t) and x2(t) time shifting is clearly visible but it is obscured by aliasing.
* To avoid aliasing Fs should be increase to at least 2×12.5=25 Hz or higher, as per the Nyquist criterion.



E02.

%Time vector for continuous signal

t = 0:0.001:1;

% Continuous-time sine waves

x1 =sin(45\*pi\*t);

x2 =sin(5\*pi\*(t));

% Sampling at Nyquist rate

F\_s = 20;

% Sampling points

n = 0:1/F\_s:1;

% Discrete-time signals

x1\_s =sin(45\*pi\*n);

x2\_s =sin(5\*pi\*n);

figure;

subplot(3,1,1)

plot(t,x1,'-g','LineWidth',1.5)

hold on

stem(n,x1\_s,'m','filled','LineWidth',1.5)

hold off

title('Analogue (Continuous) Input Signal')

ylabel('x(t)','Interpreter','tex')

xlabel('time(sec)')

subplot(3,1,2)

plot(t,x2,'-g','LineWidth',1.5)

hold on

stem(n,x2\_s,'m','filled','LineWidth',1.5)

title('Analogue (Continuous) Input Signal')

ylabel('x(t)','Interpreter','tex')

xlabel('time(sec)')

subplot(3,1,3)

stem(n,x1\_s,'g','filled','LineWidth',1.5)

hold on

stem(n,x2\_s,'r','LineWidth',1.5)

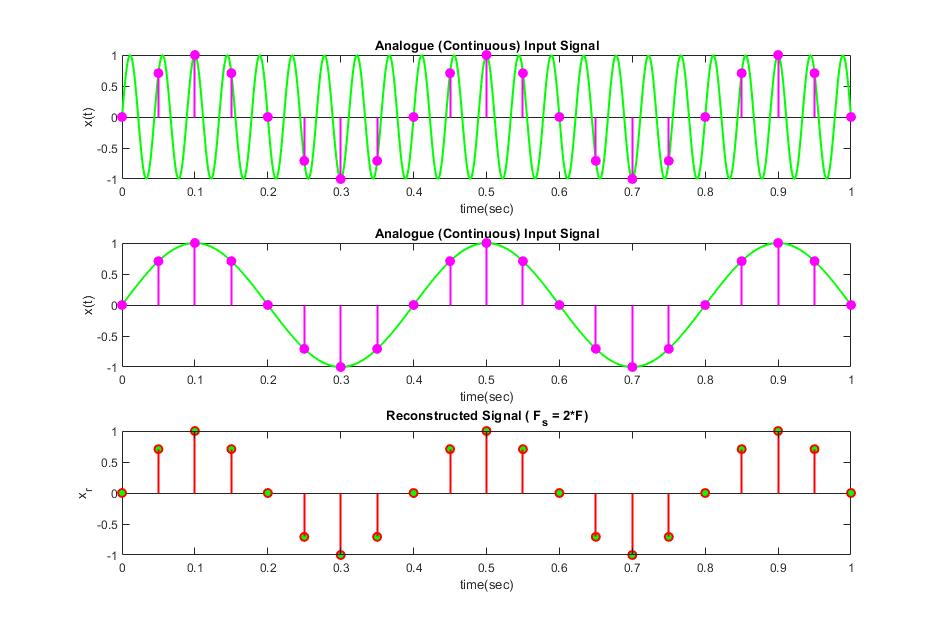
hold off

title('Reconstructed Signal ( F\_s = 2\*F)','Interpreter','tex')

xlabel('time(sec)')

ylabel('x\_r','Interpreter','tex')

* The sampled version of x1(t) x1​(t) appears identical to x2(t) x2​(t) due to aliasing. This happens because the sampling frequency Fs=20 Hz is insufficient to distinguish between the two signals.
* The aliasing phenomenon occurs because the frequency of x1(t) x1​(t) exceeds the Nyquist frequency (Fs/2=10 Hz).



E03.

%Time vector for continuous signal

t = 0:0.001:1;

% Continuous-time sine waves

x =sin(10\*pi\*t) + sin(50\*pi\*t);

figure;

subplot(4,1,1)

plot(t,x,'-m','LineWidth',1.5)

title('Analogue (Continuous) Input Signal')

ylabel('x(t)','Interpreter','tex')

xlabel('time(sec)')

% Sampling at Nyquist rate

F\_s = 120;

% Sampling points

n = 0:1/F\_s:1;

% Discrete-time signals

x\_s =sin(10\*pi\*n) + sin(50\*pi\*n);

subplot(4,1,2)

stem(n,x\_s,'-b','MarkerFaceColor','yellow','LineWidth',1.5)

title('Discreete Time Signal','Interpreter','tex')

xlabel('samples(n)')

ylabel('x\_s','Interpreter','tex')

% Time vector for reconstruction

t\_r = linspace(0, 1, 1000);

% Reconstruct signal using linear interpolation

x\_linear = interp1(n, x\_s, t\_r, 'linear');

% Reconstruct signal using spline interpolation

x\_spline = interp1(n, x\_s, t\_r, 'spline');

subplot(4,1,3)

plot(t,x,'-g','LineWidth',1.5)

hold on

plot(t\_r,x\_linear,'--b','LineWidth',1.5)

title('Reconstructed Signal Liner','Interpreter','tex')

xlabel('time(sec)')

ylabel('x\_r','Interpreter','tex')

subplot(4,1,4)

plot(t,x,'-m','LineWidth',1.5)

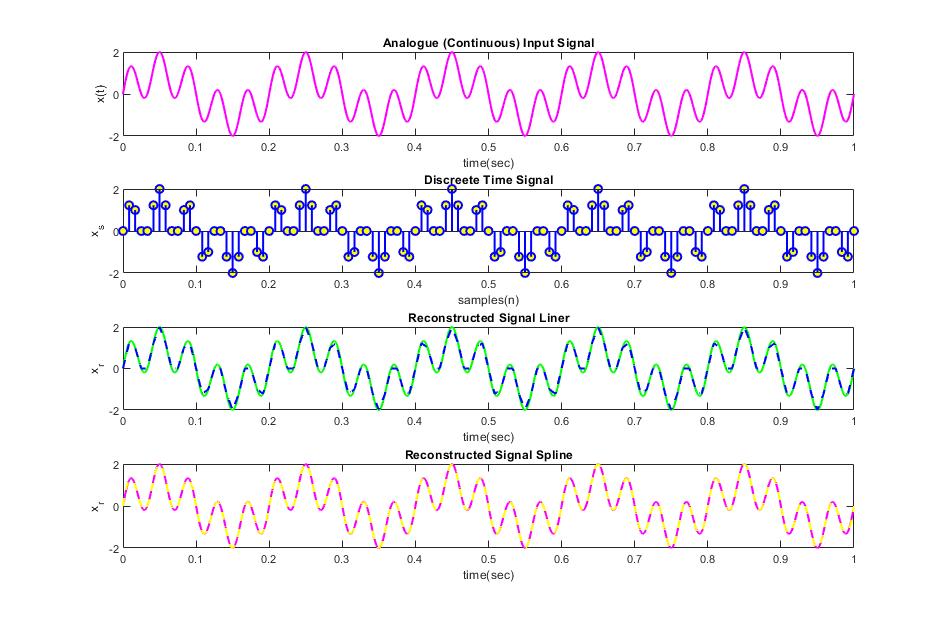
hold on

plot(t\_r,x\_spline,'--y','LineWidth',1.5)

title('Reconstructed Signal Spline','Interpreter','tex')

xlabel('time(sec)')

ylabel('x\_r','Interpreter','tex')



E04.

%Time vector for continuous signal

t = 0:0.001:1;

% Continuous-time sine waves

x =sin(50\*pi\*t) + sin(90\*pi\*t);

figure;

subplot(3,1,1)

plot(t,x,'-g','LineWidth',1.5)

title('Analogue (Continuous) Input Signal')

ylabel('x(t)','Interpreter','tex')

xlabel('time(sec)')

% Sampling at Nyquist rate

F\_s = 190;

% Sampling points

n = 0:1/F\_s:1;

% Discrete-time signals

x\_s =sin(50\*pi\*n) + sin(90\*pi\*n);

subplot(3,1,2)

plot(t,x,'-g','LineWidth',1.5)

hold on

stem(n,x\_s,'-b','MarkerFaceColor','yellow','LineWidth',1.5)

hold off

title('Discreete Time Signal','Interpreter','tex')

xlabel('samples(n)')

ylabel('x\_s','Interpreter','tex')

% Time vector for reconstruction

t\_r = linspace(0, 1, 1000);

% Reconstruct signal using spline interpolation

x\_spline = interp1(n, x\_s, t\_r, 'spline');

subplot(3,1,3)

plot(t,x,'-g','LineWidth',1.5)

hold on

plot(t\_r,x\_spline,'--m','LineWidth',1.5)

title('Reconstructed Signal Spline','Interpreter','tex')

xlabel('time(sec)')

ylabel('x\_r','Interpreter','tex')

