LAB SHEET 05

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NYQUIST SHANNON SAMPLING THEOREM

1) Creating signal Xc(t)

```
dt = 0.001;
Tmax = 2;
fs = 6;
Ts = 1/fs;
t = 0:dt:Tmax;
x_t = cos(4*pi*t);
```

2) Sketching Xs(t)

```
n = 0 :floor(Tmax/Ts);
ts = n*Ts;
x_s = cos(4*pi*ts);
```

3) Making the impulse response of Hr

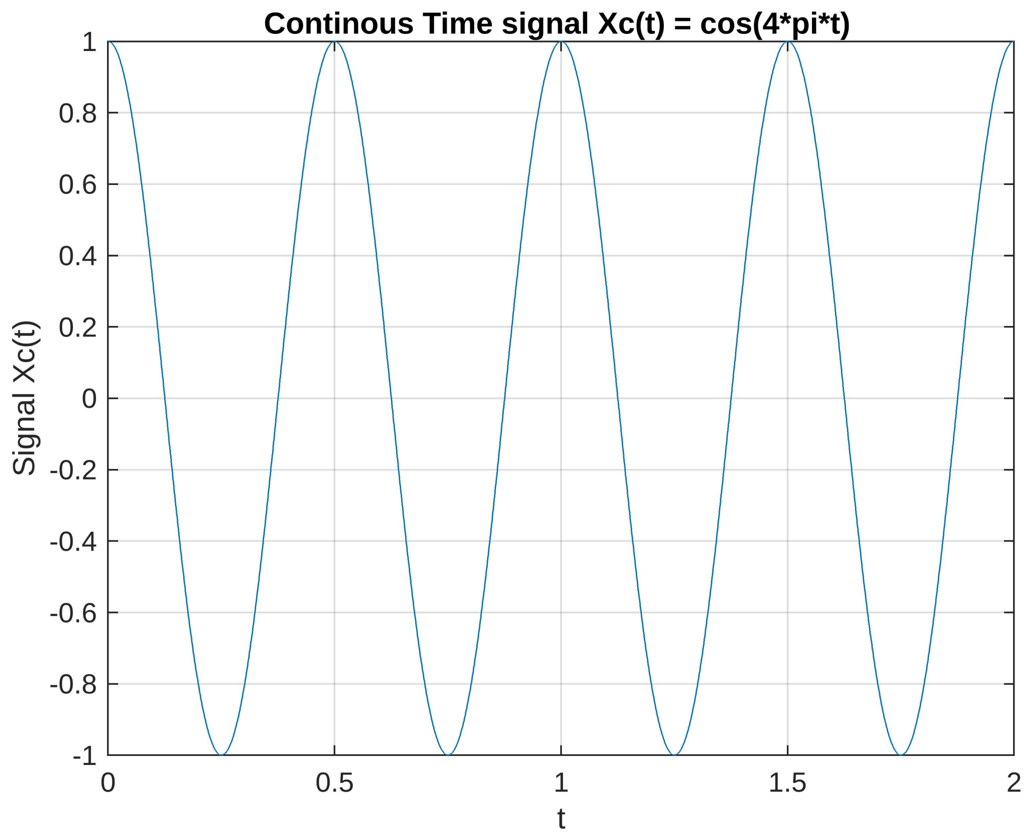
```
hr = @(tc) sin(pi*tc / Ts)./(pi*tc/Ts);
hr_vec = hr(t);
```

4) Convoluting Xc(t) and hr(t) to get Xr(t). Reconstructing the signal.

```
X_r = zeros(size(t));
for k = n
    X_r = X_r + x_s(k+1) * hr(t-k*Ts);
end
```

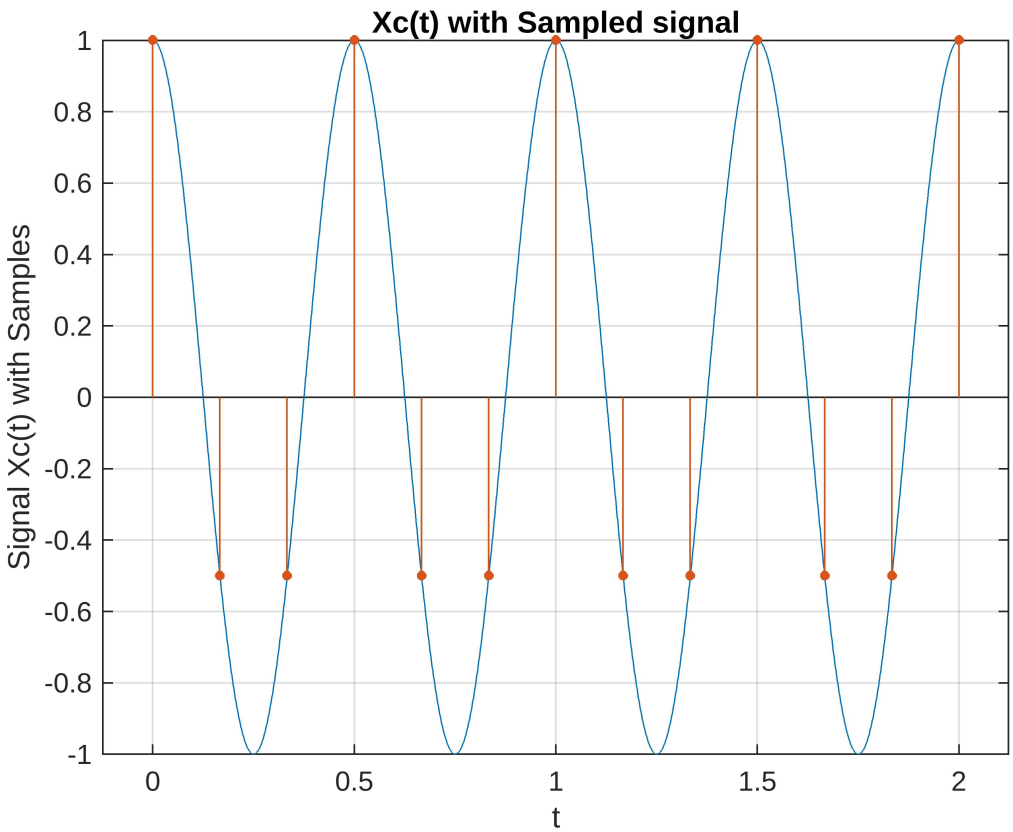
5) Plotting Xc(t)

```
plot(t,x_t);
title("Continous Time signal Xc(t) = cos(4*pi*t) ");
xlabel('t');
ylabel('Signal Xc(t)');
grid on;
```

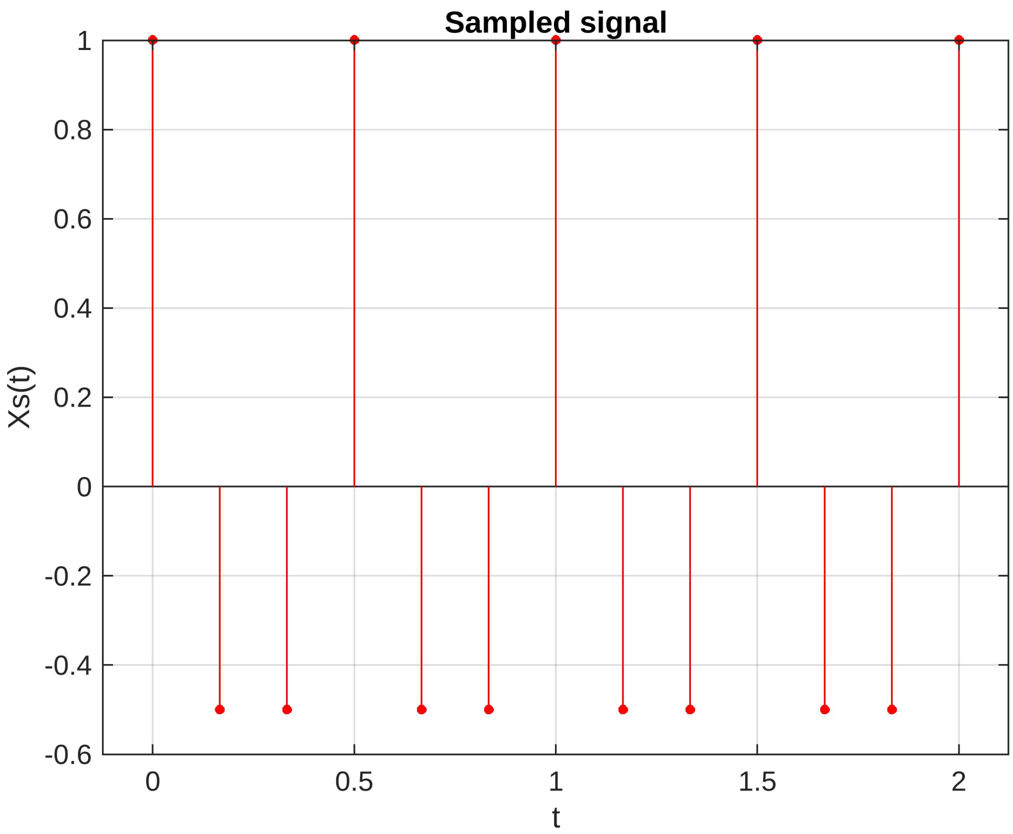


6) Plotting Continous signal with sample signal and sampling signal.

```
plot(t,x_t);
hold on;
stem(ts,x_s,'filled','o','MarkerSize',3)
title("Xc(t) with Sampled signal");
xlabel('t');
ylabel('Signal Xc(t) with Samples');
grid on;
hold off;
```

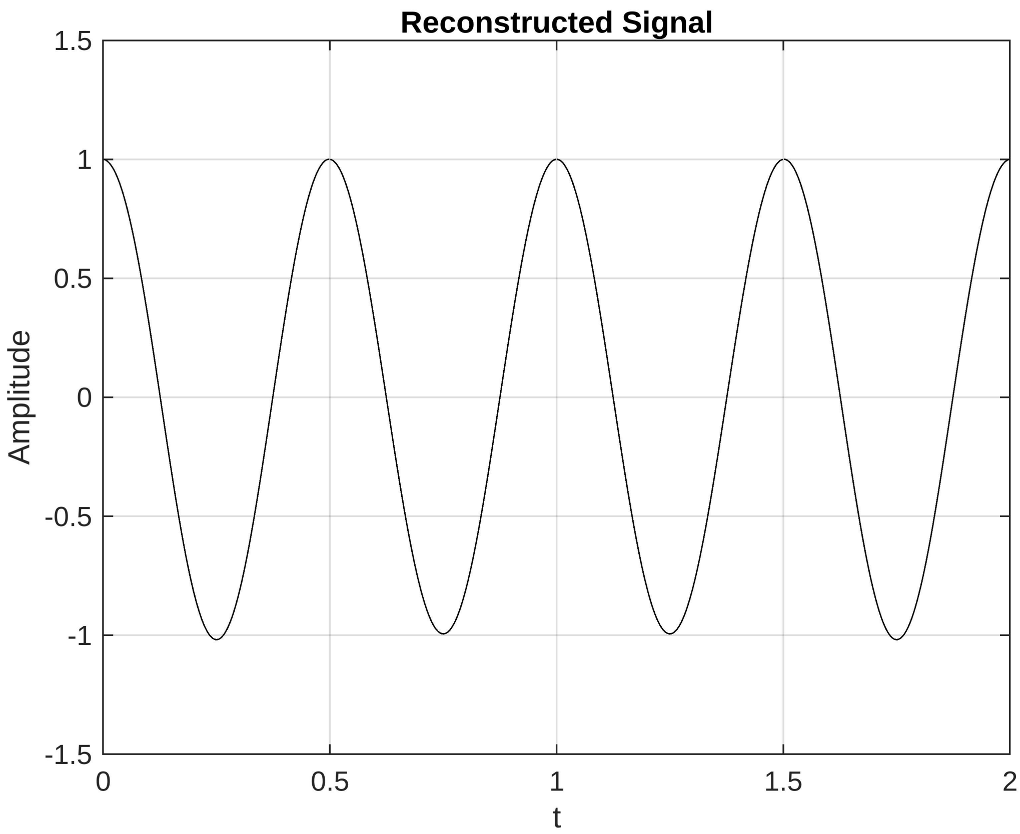



```
stem(ts,x_s,'filled','r','Markersize',3);
title("Sampled signal");
xlabel("t");
ylabel("Xs(t)");
grid on;
```



7) Plotting Xr(t)

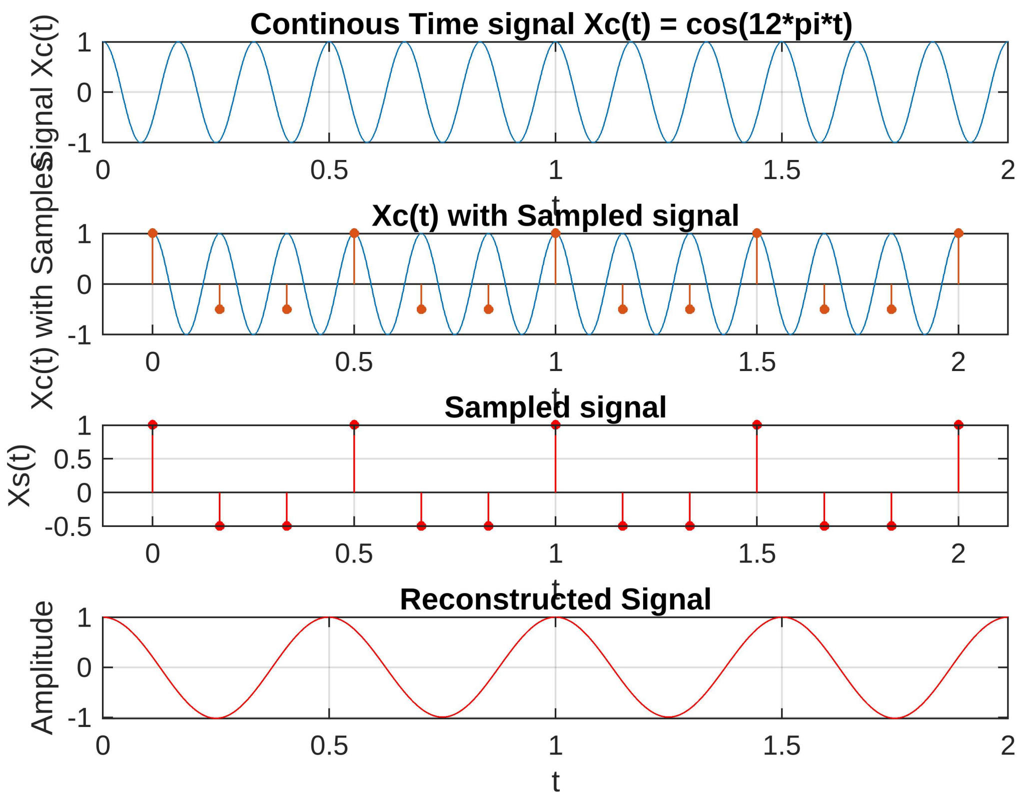
```
plot(t,X_r,'bla');
title('Reconstructed Signal');
xlabel('t');
ylabel('Amplitude');
grid on;
```


Reconstructed Signal
1.5
1
0.5
0
-0.5
-1
-1.5
Amplitude
0
0.5
1
1.5
2
t

8) Doing the whole excercise using Xc(t) = cos(12*pi*t).

```
%recreating Xc(t)
dt = 0.001;
Tmax = 2 ;
fs = 6;
Ts = 1/fs;
t = 0:dt:Tmax;
x_t = cos(12*pi*t);
%Making Xs(t)
n = 0 :floor(Tmax/Ts);
ts = n*Ts;
x_s = cos(4*pi*ts);
%Impulse response
hr = @(tc) sin(pi*tc / Ts)./(pi*tc/Ts);
hr_vec = hr(t);
% Reconstructing the signal using HR filter
X_r = zeros(size(t));
for k = n
    X_r = X_r + x_s(k+1) * hr(t-k*Ts);
end
%plotting Xc(t)
subplot(4,1,1);
plot(t,x_t);
title("Continous Time signal Xc(t) = cos(12*pi*t) ");
xlabel('t');
ylabel('Signal Xc(t)');
grid on;
%plotting Sampled signal and with continous signal.
subplot(4,1,2)
plot(t,x_t);
hold on;
stem(ts,x_s,'filled','o','MarkerSize',3)
title("Xc(t) with Sampled signal");
xlabel('t');
ylabel('Xc(t) with Samples');
grid on;
hold off;
subplot(4,1,3)
stem(ts,x_s,'filled','r','Markersize',3);
title("Sampled signal");
xlabel("t");
ylabel("Xs(t)");
grid on;
% plotting Reconstructed Signal Xr(t
subplot(4,1,4)
plot(t,X_r,'r');
```

```
title('Reconstructed Signal');
xlabel('t');
ylabel('Amplitude');
grid on;
```



9) Report of my observations.

Observations:

case1 : Xc(t) = cos(4*pi*t)

1. **Frequency :**The continuous signal has a frequency of 2 Hz. Since the sampling rate is 6 Hz (which is 3 times the signal frequency), it satisfies the condition for no aliasing (as fs≥2fm) and provides a faithful representation of the signal.
2. **Sampling:** Sampling is done at regular intervals determined by the sampling period Ts=1/6.
3. **Reconstruction:** Using convolution with a sinc function for reconstruction, the sampled data closely follows the original signal, ensuring smoothness. The resulting plots show a good match between the continuous and reconstructed signals.

Case 2: Xc(t) = cos(12*pi*t)

1. **Frequency:** Here, the signal frequency is 6 Hz, and since the sampling rate is also 6 Hz, it is equal to the Nyquist rate, leading to aliasing as fs<2fm.

2. **Sampling:** The samples are taken at the same intervals, but due to the sampling frequency equaling the signal frequency, aliasing occurs.
3. **Reconstruction:** Convolution with a sinc function still applies, but the reconstructed signal differs from the original due to the aliasing. The plots would show this mismatch between the continuous and reconstructed signals.