University of Pennsylvania
Department of Electrical and System Engineering
Digital Signal Processing

ESE531, Spring 2017 HW4: DT/CT Systems, Rate Sampling Thursday, Feb. 9th

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Due: Friday, February 17th, 11:59PM

- **Problems:** All problems must be turned in and are not optional for full credit

  1. Homework problems from the book: 4.30, 4.31, 4.39, 4.40, 4.49
  2. Matlab problem 1: Frequency-Domain View of Sampling

     When a continuous-time signal is sampled, its spectrum shows the aliasing effect as we saw in class. To show this effect in reality, an oscilloscope is needed. In MATLAB the effect can only be simulated. To simulate the analog signals, a very high sampling rate will have to be used–at least five times the highest frequency that any analog signal will be allowed to have. Thus we need two "sampling rates"–one for the actual sampling under investigation and the other for simulating the continuous-time signals. A second issue is how to display the Fourier transform of the continuous-time signals. The following M-file should be used to plot the analog spectra. Notice that one of its inputs is the `dt` for simulation (I.e the sampling period under investigation). Make sure you understand what the code is doing.

```
 function fmagplot( xa, dt )
%FMAGPLOT
%      fmagplot( xa, dt )
%
%           xa:  the "ANALOG" CT signal
%           dt:  the sampling interval for the
%                 simulation of the CT signal, xa(t)
%
L = length(xa);
Nfft = round( 2 .^ round(log2(5*L)) ); % <-- next power of 2
Xa = fft(xa, Nfft);
range = 0:(Nfft/4);
ff = range/Nfft/dt;
plot( ff/1000, abs( Xa(1:length(range)) ) )
title('CONT-TIME FOURIER TRANSFORM (MAG)')
xlabel('FREQUENCY (kHz)'), grid
pause
```

(a) Generate a simulated sinusoid analog signal that is a cosine wave with analog frequency f_o.

$$x(t) = cos(2\pi f_0 t + \phi) \qquad 0 \leq t \leq T$$

Choose some signal frequency, f_0, much less than the simulation frequency, f_{sim} and take the phase to be random. Generate samples at the rate $f_{sim} = 80khz$ over a time interval of length T. Choose T so that you get about 900 to 1000 samples of the simulated analog signal. Plot the time signal with `plot` so that the samples are connected. Make sure you label the x-axis correctly. Submit your plot.

(b) Plot the Fourier transform of your signal in part(a) with `fmagplot`.

(c) We want to now sample our simulated CT signal with a sampling period of T_s to generate a DT signal. To avoid unnecessary complication, the ratio of f_{sim} to f_s should be an integer L. Then every Lth sample o fthe x(t) vector can be selected to simulate the sampling. (NOTE: This sampling will actually perform an A/D operation, since the sample is also being quantized to a digital value). Plot the resulting DT signal when $f_s = 8kHz$. Submit your stem plot with axis labeled.

(d) Compute the DTFT of the DT signal and explain how it is related to the Fourier transform from part (b).

(e) EXTRA: Repeat this exercise with different values of signal frequency f_o to see how the frequency domain representations change.

(f) EXTRA: Try repeating this exercise with CT signals that aren't pure sinusoids.