Professor Fearing EECS120/Problem Set 4 v 1.0 Fall 2014

Due at 4 pm, Fri. Oct. 3 in HW box under stairs (1st floor Cory)

1. (20 pts) Fourier Transforms (Lec. 7)

Calculate the Fourier Series for the following signals using Fourier Transform properties. That is, find the complex scaling coefficients a_k and fundamental frequency $\omega_o = \frac{2\pi}{T_o}$. Sketch the line spectrum ($|a_k|$ vs. ω) for each signal.

a. $\Pi(\frac{t}{2}) * comb(\frac{t}{8})$ b. $\Pi(\frac{t}{4}) * comb(\frac{t}{8})$

c. $t\Pi(\frac{t-2}{2}) * comb(\frac{t}{8})$ d. $t\Pi(\frac{t}{2}) * comb(\frac{t}{8})$

2. (28 pts) Fourier transforms (OW Ch 4, Lec 5,6,7)

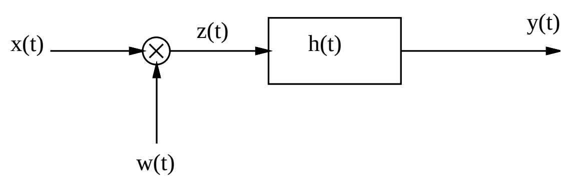
Given $x(t) = cos(4\pi t)$. Sketch $z(t), y(t)$ and the Fourier transforms $Z(j\omega), Y(j\omega)$ for the following, referring to the block diagram below. Sketch should label key heights and frequencies.

a. $w(t) = \sum_{n=-\infty}^{\infty} \delta(t - n/8)$ $h(t) = \delta(t)$.

b. $w(t) = \Pi(t/2)$ $h(t) = \delta(t)$.

c. $w(t) = \Pi(t)$ $h(t) = \sum_{n=-\infty}^{\infty} \delta(t - n/2)$.

d. $w(t) = [2\Pi(t) * \sum_{n=-\infty}^{\infty} \delta(t - n/2)] - 1$ $h(t) = \delta(t)$.



3. (16 pts) Ideal Filters (OW Ch 4, Lec 7)

a. Determine the impulse response $h_{lp}(t)$ of an ideal lowpass filter with $H_{lp}(j\omega) = \Pi(\frac{\omega}{2\pi 1000})$.

b. For some implementations, a finite duration impulse response is desired, e.g. $h_{win}(t) = h_{lp}(t) \cdot \Pi(\frac{t}{0.004})$. Approximately sketch the frequency response for the time-windowed low pass filter $H_{win}(j\omega)$. Note in particular the locations of the relative maxima and minima.

4. (16 pts) Discrete Time Fourier Transform (OW 5-5.3, Lec 7,8)

Compute the DTFT for the following signals:

a) $x[n] = u[n-2] - u[n-6]$

b) $x[n] = \sin(\frac{\pi}{2}n) + \cos(\pi n)$

Find the discrete time signal $h[n]$ for the LTI system which has frequency response:

c) $H(e^{j\omega}) = 1$ for $\pi/4 \leq |\omega| \leq 3\pi/4$ and 0 else

d) $H(e^{j\omega}) = \delta(\omega + \pi/3) + \delta(\omega - \pi/3)$ for $-\pi \leq \omega \leq \pi$

5. (20 pts) Fourier Series in iPython

Download PS4-vowels.ipynb from the class web page. See the directions on the web page for installing iPython on a computer of your choice. Using Audacity (`audacity.sourceforge.net`) or any other sound recorder, record a few seconds of a long "eeee" and a long "oooo". Save the vowels into separate files in .wav file format.

a. For each of the two vowels:

i. Estimate fundamental period T_o.
ii. Using iPython, determine FS coefficients a_k for $-7 \leq k \leq 7$.
iii. Plot $y(t) = \Sigma_{k=-7}^{7} a_k e^{jk\omega_o t}$ and the original signal over a period, and save approximately 2 seconds to a file for playback. Explain any differences you see. Visually, how many terms are needed to get a "reasonable" approximation? (Optionally, you could computer RMS error, in per cent.)
b. Compare the original "eeee" and "oooo" to the synthesized version by listening. How many terms are required in a_k to get a reasonable approximation to the original recording? (Note that the spoken vowel will have an "attack" portion which is not present in the synthesized version.)
c. Optional suggestion: see if a partner can identify the vowel from the synthesized version.