EE 20N: Structure and Interpretation of Signals and Systems

Department of Electrical Engineering and Computer Sciences — HOMEWORK 7

UNIVERSITY OF CALIFORNIA BERKELEY — **Due** 11:59pm 10/25/2013

1. Q. 5 in LV Chapter 10.
2. Q. 6 in LV Chapter 10.
3. Q. 15 in LV Chapter 10.
4. Consider the comb filter in the Guitar Lab:

$$y(n) = \alpha y(n - N) + x(n).$$

   a) What is the DTFT of the impulse signal $\delta(n)$?

   b) We now inject the impulse into the comb filter. Compute the DTFT $Y(\omega)$ of the output of the filter when the input is the impulse, i.e. of the impulse response of the filter. Sketch the magnitude of the DTFT $|Y(\omega)|$. Where are the peaks? What are the qualitative effects of changing the parameters N and α on the shape of $|Y(\omega)|$?

   c) We want to use the impulse response of the filter to simulate a guitar sound, which is modeled as a periodic signal with fundamental frequency at 440 Hz and two additional harmonics at 880 Hz and 1320 Hz. Choose the filter parameters and the sampling rate such that the peaks of $Y(\omega)$ coincide with these frequencies. Justify your choice of parameters.

   d) There is however an additional peak at 0 Hz in $|Y(\omega)|$ which is not present in the guitar sound. Fortunately, the human ear is not sensitive to low frequencies below 20 Hz, but we need to make sure that the lobe centered around 0 Hz decays fast enough so that there is not much signal component above 20 Hz. Use the remaining degrees of freedom in the choice of your filter parameters to make sure that $|Y(\omega)|$ at 20 Hz is less than -10 dB of the peaks. Again, justify your choice of parameters.

5. Consider a cascade of two LTI systems, as shown below in the figure below. The impulse response of system A is $h_A[n] = \delta[n] + 2\delta[n-1] + \delta[n-2]$, and the impulse response of system B is $h_B[n] = \delta[n] - \delta[n-1] + \delta[n-2] - \delta[n-3]$. The input to this cascade of systems is $x[n] = \delta[n]$.

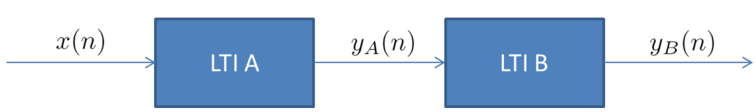

Figure 1: Cascade of LTI system

   a) Using the flip and drag method of computing convolution, calculate and draw $y_A[n]$ and $y_B[n]$.

   b) Using the definition of convolution, compute $y_A[n]$ and $y_B[n]$ analytically. Verify that the answer matches your plot from the previous part.

   c) Using the definition of DTFT, compute $H_A(e^{i\omega})$ and $H_B(e^{i\omega})$.

   d) Compute $X(e^{i\omega})$, $Y_A(e^{i\omega})$, and $Y_B(e^{i\omega})$

e) What is the relationship between $x[n]$, $h_A[n]$, $h_B[n]$, and $y_B[n]$? What is the relationship between $X(e^{i\omega})$, $H_A(e^{i\omega})$, $H_B(e^{i\omega})$, and $Y_B(e^{i\omega})$?