ECE 310 **University of Illinois at Urbana-Champaign** **Fall 2015**

Profs. Bresler & Radhakrishnan **Homework 7** **Due: Friday, October 23**

Reading: Chapter 5

---

1. An LSI system is described by the difference equation shown below.

$$y[n] = x[n] - x[n-10]$$

Compute and sketch its magnitude and phase response. Also determine its output to the following inputs:

(a) $x[n] = \cos \frac{\pi}{10} n + 3 \sin\left(\frac{\pi}{3} n + \frac{\pi}{10}\right)$

(b) $x[n] = 10 + 5\cos\left(\frac{2\pi}{5} n + \frac{\pi}{2}\right)$

2. The response of a real LSI system for input

$$x[n] = 3 + \cos\left(\frac{\pi}{4} n + 10°\right) + \sin\left(\frac{\pi}{3} n + 25°\right)$$

is

$$y[n] = 9 + 2\sin\left(\frac{\pi}{4} n + 10°\right) .$$

Determine the system response $\tilde{y}[n]$ for input

$$\tilde{x}[n] = 5 + 2\sin\left(\frac{\pi}{4} n + 15°\right) + 10\cos\left(-\frac{\pi}{3} n + 25°\right) .$$

3. The frequency response of an LSI system is

$$H_d(\omega) = \omega e^{j\sin(\omega)}, \qquad |\omega| \leq \pi .$$

Determine the system output $y[n]$ for the following inputs:

a. $x[n] = 5 + 10e^{j(\frac{\pi}{4} n + 45°)} + j^n$

b. $x[n] = 5 + 10\cos(\frac{\pi}{4} n + 45°) + j^n$.

4. A speech signal $x_a(t)$ is assumed to be bandlimited to 12kHz. It is desired to filter this signal with a bandpass filter that will pass the frequencies between 300Hz and 6kHz by using a digital filter $H_d(\omega)$ sandwiched between an A/D and an ideal D/A.

(a) Determine the Nyquist sampling rate for the input signal.

(b) Sketch the frequency response $H_{d,1}(\omega)$ for the necessary discrete-time filter, when sampling at the Nyquist rate.

5. Consider the system shown in Fig. (1) below. Sketch and label the Fourier Transform of $y_c(t)$ for each of the following cases:

(a) $1/T_1 = 1/T_2 = 10^4$

(b) $1/T_1 = 1/T_2 = 2 \times 10^4$

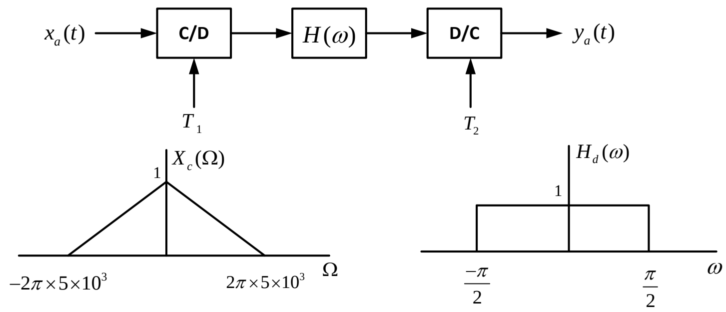

Figure 1: System for Problem 5.

(c) $1/T_1 = 2\times10^4, 1/T_2 = 10^4$

(d) $1/T_1 = 10^4, 1/T_2 = 2\times10^4$

6. Consider the system below with uniform sampling. $X_a(\Omega)$ and $H_d(w)$ are also shown below. Assume $T = 0.5$ msec. Sketch $Y_d(\omega)$, $X_d(\omega)$, and $Y_a(\Omega)$.