

## EE 473 HW 4 (Fall 2019)

- 1) Homework is due **November 26, Tuesday!**
- 2) Be neat and well-organized with your submission and coding. Sloppy homeworks, including hand-written ones, will be rewarded with a 25-point deduction.
- 3) Do NOT exceed 4 pages. Additional pages will not be graded, or even looked at.

**1: Reading.** Oppenheim and Schaffer/2e, Chapter 5 is over. The week of Nov. 18, we will complete Appendix B, Chapter 6 (Sections 6.1-6.5), and start Chapter 7 with IIR filter design.

**2: All-Pass.** Consider the following discrete-time all-pass systems.

System 1:

$$y[n] = x[n - 3],$$

System 2:

$$y[n] - \frac{3}{4}y[n - 1] = -\frac{3}{4}x[n] + x[n - 1].$$

- (a) Plot the magnitude and phase of the frequency response  $H_1(e^{j\omega})$  of System 1. Does the magnitude response confirm that this is an all-pass system?
- (b) Repeat (a) for System 2. How do the phases of  $H_1(e^{j\omega})$  and  $H_2(e^{j\omega})$  compare? Do you expect to see identical outputs when the inputs to the two systems are the same?
- (c) Let  $x[n] = (3/4)^n u[n]$ . Plot  $x[n]$  for  $n = 0, 1, \dots, 50$ .
- (d) Plot in the same graph the respective outputs  $y_1[n]$  and  $y_2[n]$  of Systems 1 and 2 in response to  $x[n]$  in (c) for  $n = 0, 1, \dots, 50$ . Are the outputs the same?
- (e) Using the command `fft`, compute 1024 samples of the DTFTs  $X(e^{j\omega})$ ,  $Y_1(e^{j\omega})$  and  $Y_2(e^{j\omega})$ . Form the vectors `X`, `Y1` and `Y2` that respectively contain the samples from  $X(e^{j\omega})$ ,  $Y_1(e^{j\omega})$  and  $Y_2(e^{j\omega})$ , and plot their magnitudes. How do they compare? Which of the two outputs looks like the input, and why? Does preserving the magnitude of the DTFT of a signal guarantee that the signal will not be distorted in time-domain? Justify your answers.
- (f) Consider the cascade of System 2 with itself; that is, two back-to-back System 2s. Let  $y_{22}[n]$  be the output of the cascaded system in response to  $x[n]$  defined in (c). Is  $|Y_{22}(e^{j\omega})| = |X(e^{j\omega})|$ ? In general, if you cascade arbitrary number of System 2s, will the overall output have the same DTFT magnitude as the input?