Fall 2017 EE 313 Linear Systems and Signals Prof. Evans

Homework #6

# Infinite Impulse Response (IIR) Filters

Assigned on Friday, October 27, 2017

Due on Friday, November 3, 2017, by 12:30 pm via Canvas submission

*Late homework will not be accepted*.

***Reading***: McClellan, Schafer & Yoder, *Signal Processing First*, 2003, Ch. 7-8.

Companion Web site with demos and other supplemental information: <http://dspfirst.gatech.edu/>

Web site contains solutions to selected homework problems from *DSP First*.

Contact information for the teaching assistant, Ms. Ghosh, is available at

<https://utexas.instructure.com/files/43676674/download?download_frd=1>

Office hours for Ms. Ghosh and Prof. Evans follow, as well as Prof. Evans’ coffee hours on Friday.

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| ***Time Slot*** | ***Monday*** | ***Tuesday*** | ***Wednesday*** | ***Thursday*** | ***Friday*** |
| **9:00 am** |  |  | **Ghosh** |  |  |
| **9:30 am** |  |  | **Ghosh** |  |  |
| **10:00 am** |  |  | **Ghosh** |  |  |
| **10:30 am** |  |  |  |  |  |
| **11:00 am** |  | **Ghosh** |  | **Ghosh** |  |
| **11:30 am** |  | **Ghosh** |  | **Ghosh** |  |
| **12:00 pm** |  | **Ghosh** |  | **Ghosh** | Evans (EER cafe) |
| **12:30 pm** |  | Evans (EER 1.516) |  | Evans (EER 1.516) | Evans (EER cafe) |
| **1:00 pm** |  | Evans (EER 1.516) | Evans (EER 6.882) | Evans (EER 1.516) |  |
| **1:30 pm** |  | Evans (EER 1.516) | Evans (EER 6.882) | Evans (EER 1.516) |  |
| **2:00 pm** |  |  | Evans (EER 6.882) | Evans (EER 6.882) |  |
| **2:30 pm** |  |  |  | Evans (EER 6.882) |  |
| **3:00 pm** |  |  |  | Evans (EER 6.882) |  |

EE 313 tutoring is available on Mondays through Thursdays from 7:00pm to 10:00pm in ETC 4.150:

[http://www.ece.utexas.edu/undergraduate/tutoring](http://www.ece.utexas.edu/undergraduate/tutoring" \t "_blank)

***\*\* Assume that all filters in this homework set are linear and time-invariant. \*\****

**1. Transfer Function, Difference Equation and Frequency Response Connections. *25 points*.**

*Signal Processing First*, problem P-8.13, page 240. *Please also answer the following questions.*

Plot the frequency response for each filter represented by a pole-zero plot. Once you match the pole-zero plot to the difference equation, use freqz(numer, denom) where numer is the vector of feed-forward coefficients [*b*0 *b*1 … *bM*] and denom is the vector of feedback coefficients [1 –*a*1 –*a*2  … –*aN*]. (Note: I had forgotten the leading 1 in denom on lecture slide 11-9.) The numer and denom vectors are also the coefficients in the numerator and denominator of the z-domain transfer function.

Indicate each filter’s frequency selectivity as lowpass, highpass, bandpass, bandstop, allpass or notch*.*

**2. First-Order IIR Filter. *25 points.***

*Signal Processing First*, problem P-8.15, page 241. Also: (c) Draw the block diagram of the IIR filter.

**3. Second-Order IIR Filter. *25 points.***

*Signal Processing First*, problem P-8.19, page 243. Please complete the following additional part:

(d) Plot the frequency response using freqz. What is the frequency selectivity of the filter? Lowpass, highpass, bandpass, bandstop, allpass, or notch.

1. **Convolution of Infinite-Length Signals. *25 points.***

Sometimes it’s easier to work a problem in the time domain, and other tines, it’s easier to work the problem in a transform domain.

1. *y*[*n*] = *x*1[*n*] \* *x*2[*n*] where *x*1[*n*] = *an* *u*[*n*] and *x*2[*n*] = *bn* *u*[*n*]. Handout F “Convolution of Two Causal Exponential Sequences” computes the convolution in the time domain as Case #1 at

http://users.ece.utexas.edu/~bevans/courses/signals/handouts/Appendix%20F%20Convolution%20Exp%20Sequences.pdf

Find *y*[*n*] using *z*-transforms.

*Hint: You may need to use partial fractions decomposition of the product X1(z) X2(z). Please see Section 8-7.2 in Signal Processing First.*

1. *y*[*n*] = *x*1[*n*] \* *x*2[*n*] where *x*1[*n*] = *bn* *u*[*n*] and *x*2[*n*] = *bn* *u*[*n*]. Handout F “Convolution of Two Causal Exponential Sequences” computes the convolution in the time domain as Case #2. See the Web address in part (a).

Find *y*[*n*] using *z*-transforms. When *x*1[*n*] = *x*2[*n*], we have resonance.

*Hint: You may need to use partial fractions decomposition of the product X1(z) X2(z). Please see Section 8-7.2 in Signal Processing First. The product X1(z) X2(z) has a repeated pole.*

As stated on the course descriptor, “Discussion of homework questions is encouraged. Please be sure to submit your own independent homework solution.”

NOTE: In your solutions, please put all work for problem 1 together, then all work for problem 2 together, etc. Please see additional homework guidelines on the homework page.