EE 311
Final Exam Review
Spring 2013/14

Final Exam is Friday, May 2, 2014 at 8:00am

1. The final exam will be similar to the old exams except for the new material covered since Hour Exam 3.

2. The first page will be mostly short answer questions. Here is a sample question:

IIR filters
A) have multiple feedback terms
B) may not have poles at the origin
C) may be unstable
D) usually have linear phase
E) have all positive impulse response terms

3. There will be a section containing pole/zero plots which ask you to specify the filter type, stability, causality, etc.

4. Problems which require some calculation may include problems on WINDOWING, finding the BLT (including pre-warping), finding state variables, or determining stability.

5. There will be at least one question regarding separation into second order sections for either a parallel or cascaded implementation.

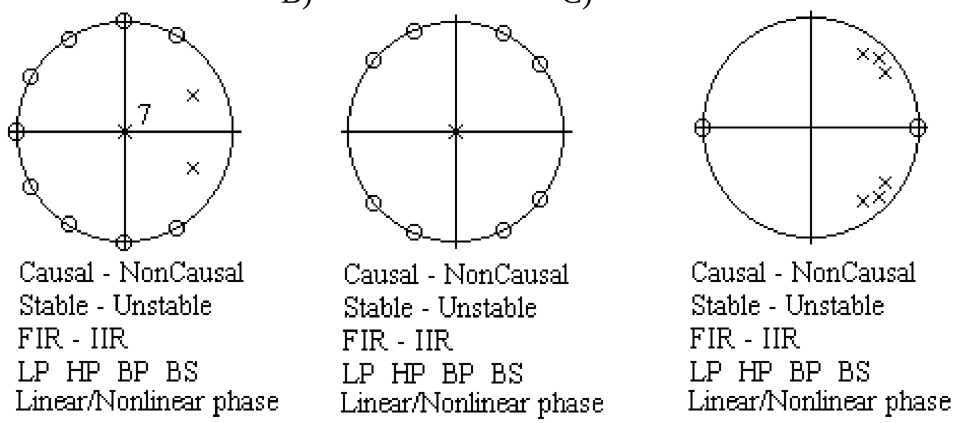
6. In general, you should have plenty of time to complete the final. Most students should be done in an hour and 15 minutes.

EE 311 **April 23, 2014**
Final Exam Review Questions

1. What is the sampling theorem?

2. Circle all those terms below which apply to the systems shown.

A) B) C)



3. A given idealized filter has an impulse response given by:

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h(nT) = {..., .1, .1, -.4, .6, 1, .6, -.4, .1, .1, ...}
                   ^
```

where (^) denotes the n = 0 term. If the window used to design this filter is given by:

$W(nT) = 2^{-n}$ n >= 0
2^{n} n < 0

Design the filter. Show your work.

4. An IIR filter has been designed using the bilinear transform. If the final design that was implemented has a cutoff frequency of 200 Hz and the sample frequency was 600 Hz, what was the cutoff frequency of the analog filter BEFORE it was warped. Show your calculations.

5. Given that:

X1(k+1) = .8X1(k) + .5X2(k)
X2(k+1) = 1.5X1(k) - 2X2(k) + u(k)
Y(k) = X1(k) + .5X2(k) + u(k)

A.) Write the A, B, C, and D matrices.

B.) Is this filter stable. Show your calculations.

6. A digital filter has been divided into two parallel sections using partial fraction expansions. The matrices for the two sections is given below. Write a complete pseudocode program to implement the filter using these two parallel sections. The filter has a filter gain constant, K, which is equal to 1.4. You may assume the existence of an AtoD and DtoA subroutine.

Section 1:

$$\overline{A} = \begin{bmatrix} .1 & .5 \\ -.5 & .3 \end{bmatrix} \quad \overline{B} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \quad \overline{C} = [.9 \quad .7] \quad \overline{D} = [1]$$

Section2:

$$\overline{A} = \begin{bmatrix} .9 & .3 \\ -.1 & .5 \end{bmatrix} \quad \overline{B} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \quad \overline{C} = [.8 \quad .6] \quad \overline{D} = [0]$$

7. A linear system has a step response given by
$Y_{step}(k)$ = `{.1 .2 .4 .7 .5 .5 .5 .5 .5 ...}`
A) What is the corresponding impulse response? (Show your work.)

B) Is it possible to determine from the step response alone whether this filter is a low pass, band pass, band stop, or a high pass filter. If so, explain what kind of filter it is and how you are able to determine your result. If not, why are you unable to determine the filter type.

8. Suppose you have a noncausal difference equation. How could the filter it represents be implemented.

9. If H(s) is given below answer the following questions.

$$H(S) = \frac{S+1}{(S/10+1)(S/20+1)}$$

A) Is this filter band limited. Explain your answer.

B) If the BLT is done on this filter will the resulting digital filter be stable or not. Explain your answer.

C) If the BLT is done will the resulting digital filter have any zeros at z = -1. Explain your answer.

D) If you use the BLT on this filter, what would be a good number for a sample frequency. Explain your answer.

10. The transfer function for a Butterworth filter can be written as

$$H_B(s) = \frac{K}{\prod_{i=1}^{N}(s - p_i)}$$

where K is a gain constant and p_i represents a left plane pole which may be complex. Show that when the BLT is applied to this transfer function the resulting transfer function in z always has N zeros at z = -1.

11. Consider the RC circuit which has the frequency characteristics of a low pass filter and a transfer function given by

$$H(s) = \frac{1/(rc)}{s + 1/(rc)}$$

A) If the cutoff frequency for the filter is given by $f_c = 1/(2\pi rc) = 3{,}200$Hz, what is an appropriate sample frequency for this filter? Justify your answer.

B) Write a new transfer function H'(s) which has replaced by f_c' where f_c' is determined as the prewarped frequency for the BLT using the sample frequency found in part A.

C) Apply the BLT to your prewarped filter to find H(z).

12. You are required to design a digital filter to meet a desired set of specifications in the frequency domain. Answer the following questions:

A) How would you decide whether the filter should be IIR or FIR

B) Assuming that the filter is to be IIR how would you decide between Butterworth, Chebyshev, or Elliptical?

13. Explain why the BLT is likely to give a better high frequency digital filter response than the invariant impulse response technique for typical analog filters.

14. Find the transfer function in z for a digital notch filter which has a single complex pole pair and a single complex zero pair if the sample frequency is 300Hz and the notch is to be at 60Hz with a bandwidth of 2Hz.

15. If a movie camera takes a picture of a spinning spoked wheel, the images produced by the camera may show the wheel turning at a rate that is different from reality. Explain why this is true an how it is related to the sampling theorem.

16. Explain how the error introduced by coefficient quantization is related to the sample frequency chosen for implementation.