EE 451 - Exam 3

November 15, 2000

Name: ____

Closed book. You may use a calculator, one page of notes and the class handouts on FIR filter design using Kaiser windows and IIR filter design. Show all work. Partial credit will be given. No credit will be given if an answer appears with no supporting work.

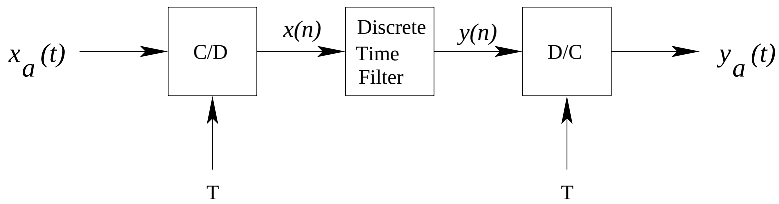
1. You are designing an audio system which uses a DSP chip. The system uses a sampling frequency of 50 kHz. Because of the speed of the DSP chip, your FIR filters can have a maximum length of 129. For (a) and (b) below, assume you are doing your design using a Kaiser window.

   (a) You need a stopband attenuation of 70 dB, and a passband ripple of 0.1 dB. Also, you need a low-pass filter which passes all frequencies below 8 kHz. What will the stopband frequency be?

   (b) If you design a low-pass filter which passes frequencies below 8 kHz, and stops frequencies above 10 kHz, what will be the passband ripple and the stopband attenuation? (Note that these numbers probably will be different than the numbers specified in Part (a).)

   (c) If you need more attenuation than you are able to achieve in (b), should you use an IIR filter instead, or should you use a faster (and more expensive) DSP chip?

2. A continuous-time signal is to be filtered by a discrete-time system as shown below:



The filter must satisfy the following specifications:

(1) The sampling frequency is 20 kHz.
(2) The filter is to be a band-pass filter.
(3) The filter passes frequencies between 4 kHz and 6 kHz.
(4) The passband ripple is at most 0.5 dB.
(5) The filter blocks frequencies below 2 kHz and above 8 kHz.
(6) The stopband attenuation is at least 60 dB.

You are required to design an IIR Butterworth filter using the bilinear transformation.

(a) What are the discrete-time passband and stopband frequencies?

(b) What are the corresponding continuous-time passband and stopband frequencies of the low-pass analog prototype?

(c) What is the order N of the analog prototype?

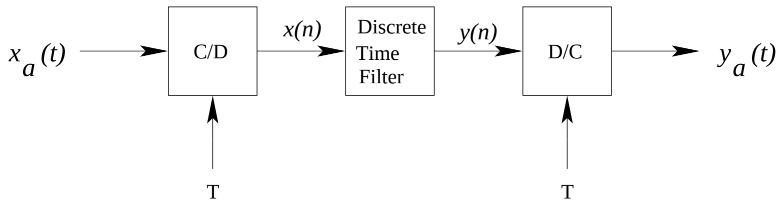
(d) What is the 3 dB frequency Ω_c of the analog prototype?

(e) Where are the poles of the analog prototype located?

(f) If the analog prototype has a pole at $s = 0.5 + 0.5j$, where will the corresponding pole(s) be located in the discrete-time filter?

(g) Does the discrete-time filter have any zeros? If so, where are the zeros located?

3. A continuous-time signal is to be filtered by a discrete-time system as shown below:



The filter must satisfy the following specifications:

(1) The sampling frequency is 20 kHz.
(2) The filter is to be a band-pass filter.
(3) The filter passes frequencies between 4 kHz and 6 kHz.
(4) The passband ripple is at most 0.5 dB.
(5) The filter blocks frequencies below 2 kHz and above 8 kHz.
(6) The stopband attenuation is at least 60 dB.

You are required to design an FIR filter using the window method.

(a) What is the impulse response of the ideal filter you will use?

(b) Which of the common windows discussed in class will be able to meet the specifications? Why?

(c) Assume you decide to design the filter using a Kaiser window. What length M of filter will you need?

(d) What value of β will you use?