ECE 410 Introduction to Signal Processing

Problem Set 9

Fall 2004

Issued: Wednesday, December 1, 2004 **Due:** Tuesday, December 7, 2004

Reading in *Oppenheim and Schafer with Buck*

12/2/04	—	Section 4.6
12/5/04	—	Sections 10.0-10.2
12/7/04	—	Sections 10.3, 10.5

Final Exam Announcement:
The final exam time was originally listed incorrectly on the syllabus. The final exam is December 14, 2004 from 1:30-4:15pm. The HTML and PDF versions of the syllabus have been corrected. See the Syllabus page on the web to view/print out a revised copy. The final exam is cumulative. It will cover all lectures, problem sets 1-10, and Matlab projects I-III. The exam will be closed book, but three 8.5 x 11 inch sheets of notes (both sides) are allowed.

As announced in class, this problem set is optional. If you choose to turn it in, it is due on Tuesday, 12/7. If you choose not to turn it in, you are still responsible for the material, but your homework average will only be computed based on Problem Sets 1-8.

Please explain all your answers. Answers without explanations will receive no credit.

Problem 7.5 in *Oppenheim/Schafer/Buck*

Problem 7.6 in *Oppenheim/Schafer/Buck*

Problem 7.11 in *Oppenheim/Schafer/Buck*

Problem 7.14 in *Oppenheim/Schafer/Buck*

Problem ECE410-6
We wish to design an FIR lowpass filter satisfying the specifications

$$\begin{aligned} 0.9 \le |H(e^{j\omega})| \le 1.1, &\qquad 0 \le |\omega| \le 0.4\pi \\ |H(e^{j\omega})| \le 0.06, &\qquad 0.6\pi \le |\omega| \le \pi \end{aligned}$$

by applying a window $w[n]$ to the impulse response $h_d[n]$ for the ideal discrete-time lowpass filter with cutoff $\omega_c = 0.5\pi$. Which of the windows listed in Section 7.21 of Oppenheim and Schafer can be used to meet this specification? For each window that you claim will satisfy this specification, give the minimum length $M + 1$ required for the filter.

Problem ECE410-7 (Old ECE-410 Exam Question)
Susan designed two DT filters using the CT prototype filter with the frequency response shown in Figure 1. She designed Filter A using the impulse invariance method. She designed Filter B using the bilinear transformation method. Susan used the design parameter $T_d = 2$ for both of these methods. Note that the frequency response of the CT prototype filter is between 0.9 and 1.0 in the passband and 0 and 0.1 in the stopband. These tolerances are indicated by the dashed lines in Figure 1.

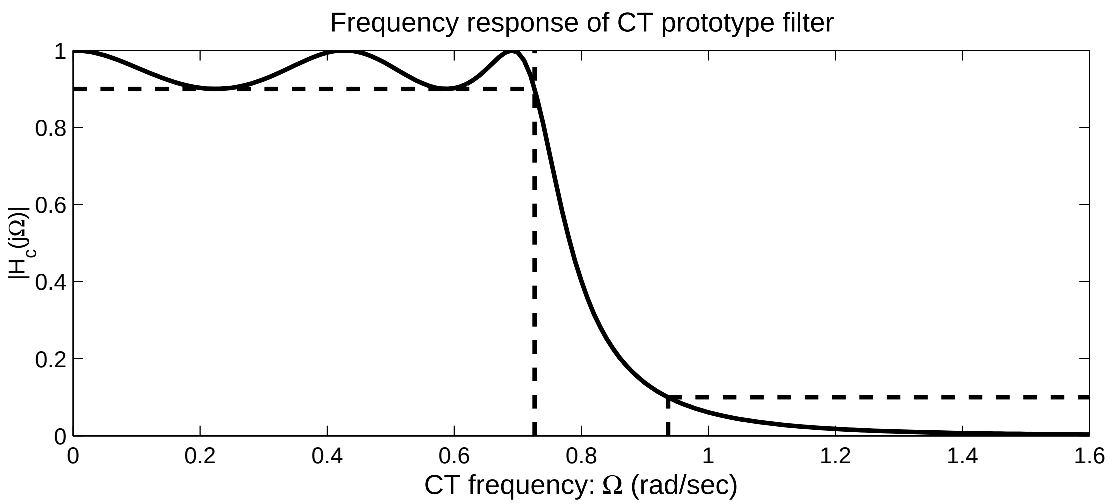

Figure 1: Frequency response of the CT prototype filter used in Problem 7.

Unfortunately, after Susan completed the designs, her computer crashed. She had saved the two sets of filter coefficients onto a disk, but they got mixed in with the coefficients for two other filters. Thus she has 4 filters (numbered 1 through 4). Susan plotted the frequency response magnitudes for these 4 filters using `freqz`. These frequency responses are shown in Figure 2. Can you help Susan decide which two filters correspond to her impulse invariance design (Filter A) and her bilinear transformation design (Filter B)?

For each of the 4 filters, indicate whether it corresponds to the impulse invariance design ($T_d = 2$) or the bilinear transformation design ($T_d = 2$) or neither. **Justify your answers!**

Summarize your results using the form on the last page.

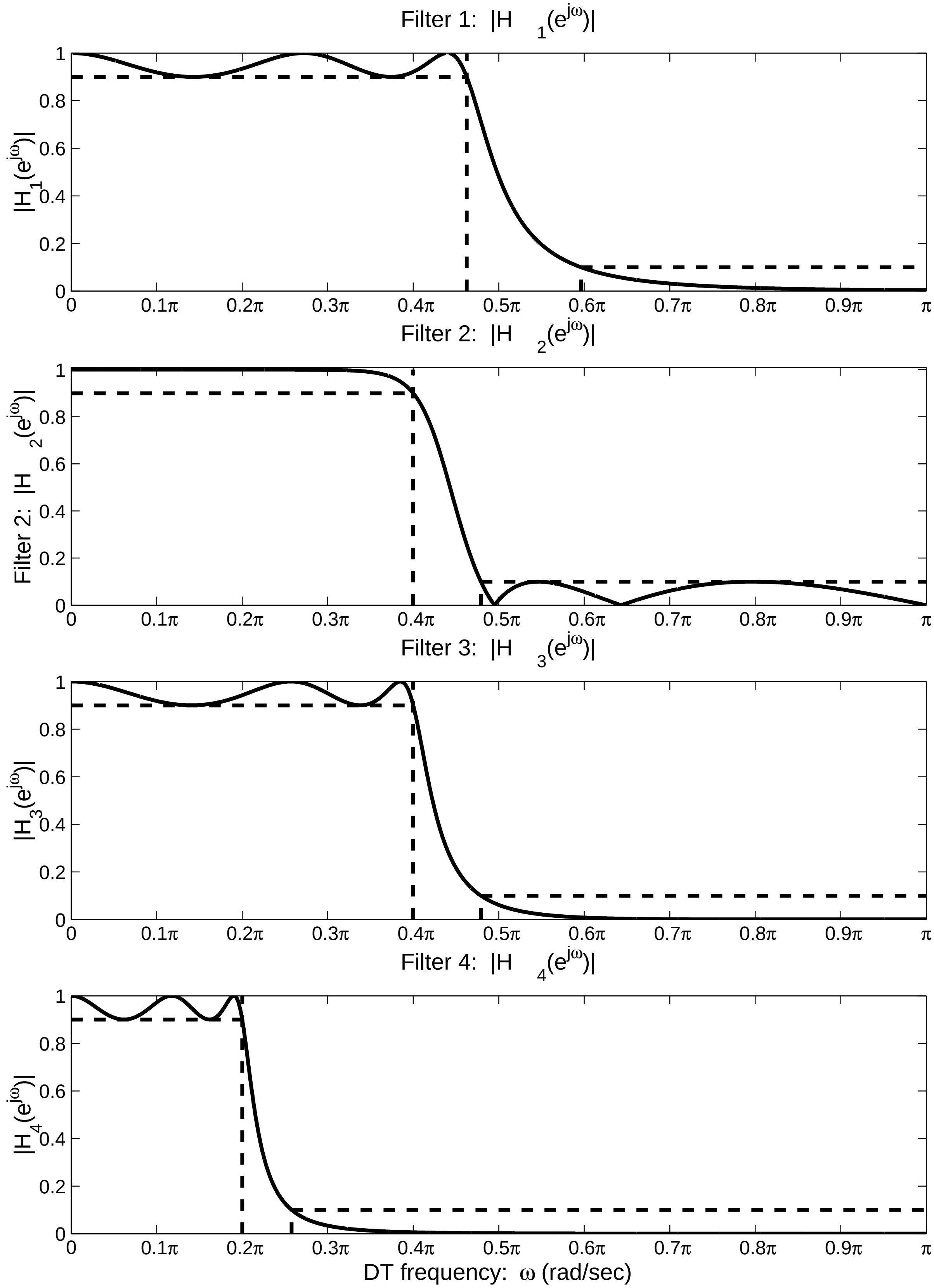

Figure 2: Frequency response magnitudes for filters 1-4 in Problem 7. The dashed lines indicate the 0.9 to 1.0 tolerance for the passband and the 0 to 0.1 tolerance for the stopband.

Filter 1: impulse invariance design? bilinear transformation design? neither?
Justification:

Filter 2: impulse invariance design? bilinear transformation design? neither?
Justification:

Filter 3: impulse invariance design? bilinear transformation design? neither?
Justification:

Filter 4: impulse invariance design? bilinear transformation design? neither?
Justification: