Carnegie Mellon DSP-I Electrical & Computer ENGINEERING

Digital Signal Processing I (18-791)
Fall Semester, 2005

18-791 PROBLEM SET 8

Issued: 10/27/05

Due: 11/3/05

Reminder: Quiz 2 is scheduled for November 17.

Reading: During the past week we discussed fast Fourier transforms (FFTs), covering the material on Secs. 9.0 to 9.1 and 9.3 to 9.5 of the text. We are also distributing some additional notes from the original Oppenheim and Schafer published in 1975 which describe the computation of non-radix-2 FFTs. Next week begin looking at implementation procedures for discrete-time systems, following OSB Secs.6.1-6.5. (The last two problems on this problem set are related to filter implementation; you might want to defer them until after the Tuesday lecture.)

Problem 8.1: Problem 9.3 in OSB, except in part (b), let $x[n] = (-W_N e^{j\pi/4})^n$. You must explain your reasoning to get full credit for your answers to these problems, as the answers are in the back of the book..

Problem 8.2: Problem 9.38 in OSB

Problem 8.3: Problem 9.51 in OSB, part (a) only. **Note:** In this problem we consider the FFT operation as a matrix factorization process. Some courses (and textbooks, such as the one by Roberts and Mullis) consider DSP in general as a form of linear algebra.

Problem 8.4:

(a) Draw a flow graph for a 12-point decimation-in-time FFT algorithm using 4 DFTs of size 3 in the first column of the flowgraph, 6 DFTs of size 2 in the second, and 6 DFTs of size 2 in the third.

((b) How many complex multiplications by powers of W_N that are not equal to ± 1 or $\pm j$ are needed to compute the DFT? How does the compare to the number of complex multiplications by powers of W_N that are not equal to ± 1 or $\pm j$ that would have been needed if the DFT were obtained by direct computation?

(c) Is it possible to use in-place computation for this FFT structure?

Problem 8.5: Problem 6.3 in OSB. (Again, you must show your work to receive full credit as the answers are in the back of the book.) **Note:** The filter structure developed in part (b) is called the *coupled-form oscillator* and has some properties that are useful in reducing the effects of coefficient quantization.

Problem 8.6: Problem 6.6 in OSB. (Again, please show your work.)