Assignment 2 - The DFT and FFT

Due January 23, 1996

Question 1

You are given a DFT processor that can't be modified. What simple changes could you make to the input and output so the same processor would compute the inverse DFT? *Hint: make time go "backwards."*

Question 2

(a) Compute the values of W_4^k for $k = 0, 1, 2, 3, 4$.

(b) Certain DSP operations require that a signal be multiplied by a complex sinusoid. Can you see any advantages of choosing the frequency of this sinusoid to be $F_s/4$?

Question 3

Compute the DFT of the sequence $x(n) = \{1, 1, 0, 0\}$ by hand. Show your work.

Question 4

Using the previous result compute the DFTs of the following sequences: $a(n) = \{2, 2, 0, 0\}$, $b(n) = \{0, 2, 2, 0\}$.

Question 5

The results of the DFT of a sampled time-domain signal correspond to frequencies kF_s/N, $k = 0 \ldots N-1$. However, it's often more intuitive to plot spectra over the range $-F_s/2$ to $F_s/2$ rather than 0 to $F_s(N-1)/N$.

How would you arrange the output of an 8-point DFT so as to plot the frequency components from $-F_s/2$ to $F_s/2$? If the signal was sampled at 4 kHz what frequency would each value correspond to?

Question 6

Draw the signal flow graph for an 8-point decimation in time reordered-input radix-2 FFT. Assume the input is $x(n) = \{0, 1, 1, 1, 0, 1, 1, 1\}$ (in normal order). Use standard flow graph symbols instead of the special butterfly symbol used in the text. Label all nodes with their numerical values. Label branches that have twiddle factors with their numerical values.

Question 7

Find the indexes of the first 4 components in reordered (bit-reversed index) order for a 1024-point FFT.

Question 8

Briefly define the following terms as applied to FFT algorithms:

- in-place
- radix-2
- decimation in time
- reordered input
- butterfly
- twiddle factor