ECEn 487 - Introduction to Digital Signal Processing
Winter 2013

Quiz 7 (Preparing for Midterm)

\[ X[k] = \sum_{n=0}^{N-1} x[n] W_N^{kn} \]

1. (2 pts) Suppose I take \( L = 1000 \) samples at a frequency of 50 kHz. I then want to compute the FFT of this data. If I want the effective frequency spacing to be less than 1 kHz and I want to use a radix-2 FFT, what should my \( N \) be to achieve this resolution?

\[
N = 64
\]

\[
\frac{50 \text{ kHz}}{64} \sim 781 \text{ Hz}
\]

2. (2 pts) Suppose I have the \( N \) from problem 1 above for my radix-2 FFT. How many “butterfly stages” would I need to make this computation?

\[
64 = 2^6
\]

so, you need 6 stages.

3. (3 pts) If my DFT takes \( O(N \log_2 N) \) multiplications, how many multiplications per second would I need on a processor to compute the DFT fast enough for this application to operate in real-time?

\[
\text{I need to do a DFT } (N=64) \text{ every } 64 \times \frac{1}{50 \times 10^3} \text{ s}
\]

\[
64 \log_2 64 = 64 \times 6 = 384 \text{ multiplies per DFT}
\]

\[
\frac{384 \text{ multiplies}}{64} \times 50 \times 10^3 = 3 \times 10^5 \text{ multiplies/second}
\]

4. (3 pts) If I only needed 8 frequencies out of the \( N \) frequencies, would it be more efficient to use the FFT or direct computation?

\[
\text{Direct computation: } N \times M = 64 \times 8
\]

\[
\text{FFT: } N \log_2 N = 64 \times 6 \text{ -- FFT would be faster!}
\]