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?

$N = 64$

$\frac{50\,kHz}{64} \sim 781\,Hz$

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?

I need to do a DFT ($N=64$) every $64 \times \frac{1}{50\times10^3}$ s

$64 \log_2 64 = 64 \times 6 = 384$ multiplies per DFT

$\frac{384 \text{ multiplies}}{64} \times 50 \times 10^3 = 3 \times 10^5$ 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? Goertzel algorithm?

Direct computation: $N \times M = 64 \times 8$

FFT $N \log_2 N = 64 \times 6$ ← FFT would be faster!