

MIT OpenCourseWare  
<http://ocw.mit.edu>

2.161 Signal Processing: Continuous and Discrete  
Fall 2008

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
DEPARTMENT OF MECHANICAL ENGINEERING

2.161 Signal Processing - Continuous and Discrete  
Fall Term 2008

**Problem Set 5: The Discrete Fourier Transform**

**Assigned:** October 16, 2008

**Due:** October 23, 2008

**Problem 1:** A 128 millisecond portion of an analog signal is sampled at a rate of 8 kHz and the resulting  $L$  samples are saved for further processing. What is  $L$ ? The 256 point DFT of these samples is computed. What is the frequency spacing in Hz of the computed DFT values? What is the total number of required multiplications

(a) if the computations are done using the DFT directly, and

(b) if the computations are done using a FFT?

What is the scale factor relating frequency domain samples  $F_m$  in the FFT to the value of the Fourier transform  $F(j\omega)$  at the same frequency?

**Problem 2:** A 10 kHz sinusoidal signal is sampled at 80 KHz. A total of 64 samples are collected and used to compute the DFT of the signal. At what DFT indices,  $k = 0, 1, \dots, N - 1$  would you expect to see any peaks in the DFT?

**Problem 3:** Compute the 8 point FFT of the 8 sample sequence.

$$\{x\} = [5, -1, -3, -1, 5, -1, -3, -1]$$

(Show your decomposition and recombination.) Verify your answers using Matlab's FFT function.

Noting that these samples are the first 8 samples of  $x(n) = 4 \cos(\pi n/2) + \cos(\pi n)$ , discuss whether the 8-point FFT values represent the expected spectrum of  $\{x_n\}$ . What FFT indices correspond to the two frequencies of the cosinusoids?

**Problem 4:** (Proakis & Manolakis – Prob. 7.1)

**Problem 5:** (Proakis & Manolakis – Prob. 7.3)

**Problem 6:** Use Matlab to explore off-line filtering of data by manipulation of the FFT of a noisy signal as follows:

(a) Create a “noisy” signal of length 1024 in Matlab as follows:

```
t=[0:.01:10.23];  
f = exp(-t).*sin(10*t);  
noise=rand(1,1024);  
signal = f + noise;
```

- (b) Look at `f` and `signal` with a `plot` command.
- (c) Your task is to “clean up” the noisy signal by shaping the spectrum of the contaminated signal, using the FFT function. (Note that you will not be able to do a perfect job.) You can do this by setting parts of the FFT to zero and taking the IFFT. Do the best you can and hand in plots of the contaminated signal and your filtered signal. Tell us what you did to filter it.