EE 438 Digital Signal Processing with Applications
Homework #7 due 3/29/99

1. Draw the flow diagram for a 16 point decimation in time FFT. Determine the number of complex multiplies required to implement the algorithm. Do not count multiplies +1, -1, j or -j.

2. Derive a decimation-in-time FFT algorithm for a 12-point DFT, and draw a complete flow diagram for the algorithm. (Hint: Use four 3-point DFT's to implement the 12-point DFT.) How many complex multiplies are required?

3. An analog speech signal has a bandwidth of 3kHz and can be modeled as a stationary random process with a marginal probability density that is Gaussian with mean zero and varianced 1. You are asked to design a system to sample, quantize and store the speech signal on a computer.
   a) Compute the Nyquist samplin rate for the data.
   b) Choose a quantizer range so that the probability of overload is approximately 0.02. (**Hint:** You will need to use a table for the cumulative distribution function of a Gaussian random variable.)
   c) Assuming that the quantization noise may be modeled as a random variable uniformly distributed between $[-\Delta/2, \Delta/2]$, and a B bit quantizer is used, determine an expression for the average signal-to-noise power ratio in dB defined as

$$SNR = 10\log_{10}\frac{E\{(y(n))^2\}}{E\{(\varepsilon(n))^2\}}$$

   where $y(n)$ are the samples of the speech signal before quantization, and $\varepsilon(n)$ are the quantization errors.
   d) Find the minimum number of bits so that SNR ≥ 30.
   e) Using the result of d) and a) find the number of bits/second required to digitize the speech data.