Digital Signal Processing I ECE 561
Fall 2004 Test 3

1. Given the function $f(x)$

$$f(x) = \begin{cases} \exp(40x) & x < 0 \\ \exp(-3x^2) & x \geq 0 \end{cases}$$

   Calculate and plot the following using the FFT and using direct functions (e.g. `convn`)

   (a) Plot the self convolution $(f(x) * f(x))$ of $f(x)$. (8 points)

   (b) Plot the autocorrelation of $f(x)$. (8 points).

2. Use the function $f(x)$ (assume x is seconds) to construct a periodic signal $p(x)$ of period 4 sec, and total length 30 cycles, sampled at 100 Hz. Note that the function $f(x)$ is defined over the domain $-2 < x < 2$.

   (a) Plot the first five cycles of the function $p(x)$. (4 points)

   (b) Plot the autocorrelation function of $p(x)$. (5 points)

3. Given the sound file `signal2004.wav`, consisting of a periodic signal buried in noise.

   (a) Find the period of the underlying signal. (5 points)

   (b) Extract and plot one cycle of the periodic component of the signal. (5 points)

4. Design a filter to remove a 60 Hz spurious component and its first harmonic (120 Hz) from a signal sampled at 8000 Hz. Your filter must attenuate these frequencies by a factor of 100, and must attenuate no more than 0.95 for frequencies 1.2 Hz above or below the target frequencies. Show a plot of the magnitude of the response vs. frequency for frequencies from 0 to 200 Hz. (10 points)

5. Identify four characteristics often used in biometrics for identification applications. (5 points)

6. Design a seventh-order low-pass Chebyshev type II filter with a cutoff frequency of 2000 Hz and attenuated below 30 dB in the stop band. Assume the signal is sampled at 8000 Hz.

   (a) Plot its pole-zero plot. (5 points)

   (b) Plot its magnitude response. Find the width of the transition band. (5 points)

   (c) Find the maximum group delay within the passband. (5 points)

   (d) Generate its State-Space representation. (5 points)

7. Design a FIR filter using a Kaiser window with the same basic specs as above.

   (a) Plot the impulse response. (5 points)

   (b) Plot the magnitude response. Find the width of the transition band. (5 points)

   (c) Find the maximum group delay within the passband. (5 points)

8. Design an FIR filter whose frequency response approximates a triangle function of the form

$$A(f) = \begin{cases} 1 - f/f_0 & f \leq f_0 \\ 0 & f > f_0 \end{cases}$$

   where f_0 is 3000 Hz and the sampling frequency is 8000 Hz. Plot the magnitude response of your filter. (15 points)