ECE 802-601 Homework 2
Spring 2008
Due February 7, 2008

1. Consider the following signal, $s(t) = 0.4e^{j10t} + e^{j20t}$.
   a. Find an expression for the instantaneous frequency of this signal. Plot your result for $0 < t < 5$. Does this result match your intuition? Why or why not?
   b. Compute the Wigner distribution of this signal.
   c. Write a MATLAB function that will compute the instantaneous frequency (average frequency) from the Wigner distribution. Include your code and results. Compare with the results found in part a.
   d. Apply the instantenous frequency code provided on the web page on the Wigner distribution. Compare your results to the ones obtained from parts a and d, and discuss the effect of cross-terms.

2. The pseudo-Wigner distribution is defined as

$$W_{PS}(t,\omega) = \int h(\tau)s(t+\frac{\tau}{2})s^*(t-\frac{\tau}{2})e^{-j\omega\tau}d\tau$$

   a. What is the kernel function for this distribution?
   b. Does this distribution satisfy the time and the frequency marginals? Show your work to verify your answers.
   c. Compare this distribution to the Wigner distribution in terms of resolution and cross-terms.

3. Load the crossing chirp signals from the web page.
   a) Compute the Wigner distribution using the 'wigner' command in the time-frequency toolbox.
   b) Compute the Choi-Williams distribution using the 'choiwil' command in the time-frequency toolbox. Use three different values of σ and comment on the effect of σ parameter on the distribution.
   c) Choose the best σ value from part b and compute:
      i. The time and frequency marginals directly from the distribution. Verify that the marginals are satisfied by plotting the marginals obtained from the distributions on top of the actual marginals.
      ii. Compute the initial and end frequencies from the distribution for the two chirp signals. Express your answers in terms of normalized frequency.

4. Consider the linear chirp signal $s(t) = e^{j\frac{\omega_0 t^2}{2}}$.

   a. Find the ambiguity function.

   b. If we have the sum of two linear chirp signals, $s(t) = e^{j\frac{\omega_1 t^2}{2}} + e^{j\frac{\omega_2 t^2}{2}}$, give an expression for the kernel function that will keep the auto-terms and get rid of the cross-terms.

   c. Using the results from part (b), design a kernel for s(t)=chirpsig(128,0,0.2)+chirpsig(128,0,0.8). First determine ω_1, ω_2, and then apply your kernel in the ambiguity domain to the ambiguity function of the signal. Use the 'dochange' command to transform the ambiguity domain to the time-frequency domain. Compare your result with the Wigner distribution of the same signal. You will need to use 'ambigu' command to compute the ambiguity function of the signal.