Chapter 6
MATLAB Problems

6.1 Consider the following signal: $x(t) = \cos 2\pi 20t + 0.5\cos 2\pi 25t$. It is sampled at a rate of $f_s = 2^6 = 64$ samples/sec, slightly (1.28X) above the Nyquist rate obtaining $x(t) \to x(kT_s)\big|_{Ts=1/64} \to x(k)$. Plot and compare $x(t)$ and $x(k)$. Assume $x(t)$ is approximated as a continuous function using a sampling rate of $2^{14} = 16{,}384$ samples /sec.

(a) Using zero padding in the frequency domain, upsample $x(k)$ by a factor of two so its effective sampling rate is 128 samples/sec. Plot the time and power spectral density (PSD) of the upsampled signal and compare with the continuous function.

(b) Repeat (a) except upsample $x(k)$ by a factor of eight so it's effective sampling rate is 512 samples/sec. Discuss your results and state any conclusions.

6.2 Repeat Prob. 6.1b, except use cubic spline interpolation in the time sequence domain to upsample $x(k)$ by a factor of eight. Comment on the results.

6.3 Consider an audio amplifier with a gain of two and has a passband of 30 to 15,000 Hz, Assume it is modeled as a 3rd order butterworth bandpass filter. Design and simulate a system that employs bipolar choppers to enable the amplifier to adequately process signals with significant DC content. The system should consist of the following: (1) chopper of Fig. 6.1-4, (2) amplifier, and (3) reconstruction stage. Assume the input is a gaussian shaped pulse defined as $x(t) = e^{-4(t-1.5)^2}$ and that the same bipolar signal is used for modulation and demodulation. Plot the input and output signals. Compare your results if you used the amplifier without chopper modulation.

6.4 In Prob. 6.3, the same bipolar chopper signal was used in the modulation and demodulation process. Let's now assume these two chopper signals are independent and therefore may not be synchronized (i.e. out of phase). Design a system to synchronize the receiver's chopper signal so it is in phase with the transmitter's chopper signal. Show your results with and without synchronization using some arbitrary value of phase error. Suggestions: (a) see the system in Fig. 15.4-1, (b) assume the system will be processing a series of chopped signals, and therefore if you synchronize the chopper signals using the first input and thus subsequent inputs will be optimally processed.

6.5 We sometimes think the Nyquist theorem requires that adequate sampling be done at a rate at least twice the highest frequency component in the signal. However, the Nyquist criterion only requires that $f_s \geq 2W$. With **quadrature sampling**, we can represent bandpass (BP) signals with bandwidth $B_T = 2W$ using a rate of $2W \leq f_s \ll f_c + W$, even if the center frequency $f_c \gg W$. This is done by extracting the quadrature components from the bandpass signal as shown in the diagram below.

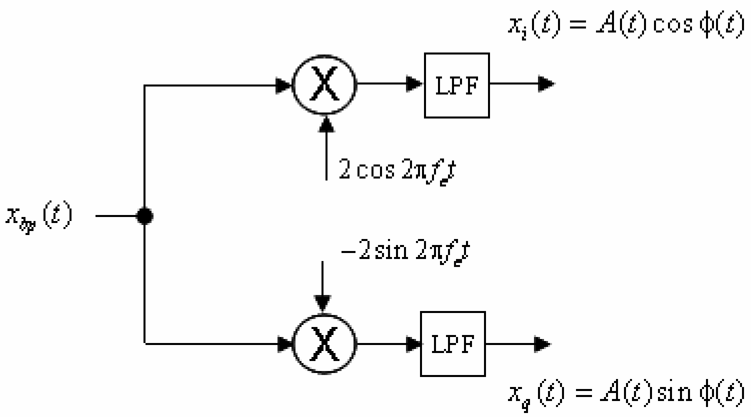

Figure P.6.4. Method for extracting quadrature components from a bandpass signal.

We then sample the functions $x_i(t)$ and $x_q(t)$ at a rate at least $f_s \geq 2W$.

Implement a quadrature sampling system to represent BP signal $x_c(t) = [0.25\cos 2\pi 20t + 0.5\cos 2\pi 30t]\cos\left(2\pi 1000t + \pi/6\right)$. Use $f_s = 64$ samples/second For comparison purposes, show your results are the same by direct sampling of the BP signal at $f_s = 4096$ samples/second. Consider using spectral plots to show quadrature sampling is adequate to represent BP signals. Comment on your results.