ECE 8440 Spring 2017
Homework 2: Due February 20

4.37
4.59 with 44.1 KHz sampling rate then again with 44 KHz
2.81
2.89
5.38a
5.40

4.37. Suppose that you obtained a sequence $s[n]$ by filtering a speech signal $s_c(t)$ with a continuous-time lowpass filter with a cutoff frequency of 5 kHz and then sampling the resulting output at a 10-kHz rate, as shown in Figure P4.37-1. Unfortunately, the speech signal $s_c(t)$ was destroyed once the sequence $s[n]$ was stored on magnetic tape. Later, you find that what you should have done is followed the process shown in Figure P4.37-2. Develop a method to obtain $s_1[n]$ from $s[n]$ using discrete-time processing. Your method may require a very large amount of computation, but should *not* require a C/D or D/C converter. If your method uses a discrete-time filter, you should specify the frequency response of the filter.

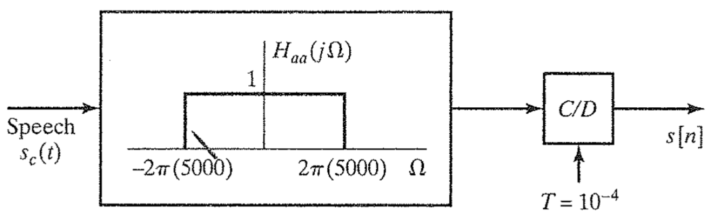

Figure P4.37-1

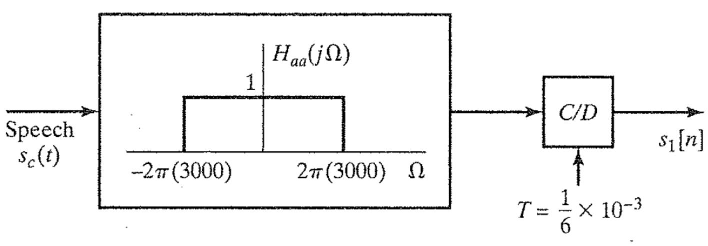

Figure P4.37-2

4.59. Suppose $s_c(t)$ is a speech signal with the continuous-time Fourier transform $S_c(j\Omega)$ shown in Figure P4.59-1. We obtain a discrete-time sequence $s_r[n]$ from the system shown in Figure P4.59-2, where $H(e^{j\omega})$ is an ideal discrete-time lowpass filter with cutoff frequency ω_c and a gain of L throughout the passband, as shown in Figure 4.28(b). The signal $s_r[n]$ will be used as an input to a speech coder, which operates correctly only on discrete-time samples representing speech sampled at an 8-kHz rate. Choose values of L, M, and ω_c that produce the correct input signal $s_r[n]$ for the speech coder.

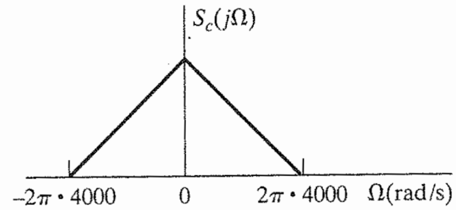

Figure P4.59-1

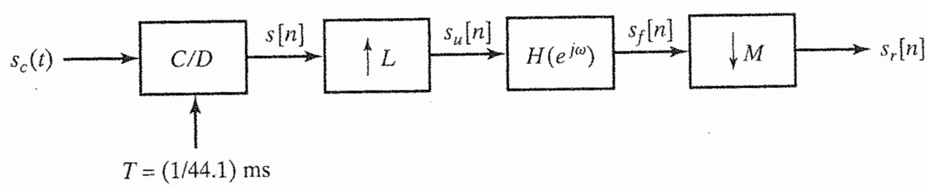

Figure P4.59-2

2.81. Let $e[n]$ denote a white-noise sequence, and let $s[n]$ denote a sequence that is uncorrelated with $e[n]$. Show that the sequence

$$y[n] = s[n]e[n]$$

is white, i.e., that

$$E\{y[n]y[n+m]\} = A\delta[m],$$

where A is a constant.

2.89. Consider a random process $x[n]$ that is the response of the linear time-invariant system shown in Figure P2.89-1. In the figure, $w[n]$ represents a real zero-mean stationary white-noise process with $E\{w^2[n]\} = \sigma_w^2$.

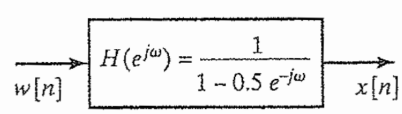

Figure P2.89-1

(a) Express $\mathcal{E}\{x^2[n]\}$ in terms of $\phi_{xx}[n]$ or $\Phi_{xx}(e^{j\omega})$.
(b) Determine $\Phi_{xx}(e^{j\omega})$, the power density spectrum of $x[n]$.
(c) Determine $\phi_{xx}[n]$, the correlation function of $x[n]$.

part a only

5.38. Consider the linear time-invariant system whose system function is

$$H(z) = (1 - 0.9e^{j0.6\pi}z^{-1})(1 - 0.9e^{-j0.6\pi}z^{-1})(1 - 1.25e^{j0.8\pi}z^{-1})(1 - 1.25e^{-j0.8\pi}z^{-1}).$$

(a) Find all causal system functions that result in the same frequency-response magnitude as $H(z)$ and for which the impulse responses are real valued and of the same length as the impulse response associated with $H(z)$. (There are four different such system functions.) Identify which system function is minimum phase and which, to within a time shift, is maximum phase.

(b) Find the impulse responses for the system functions in Part (a).

(c) For each of the sequences in Part (b), compute and plot the quantity

$$E[n] = \sum_{m=0}^{n} (h[m])^2$$

5.40. Each of the pole–zero plots in Figure P5.40-1, together with the specification of the region of convergence, describes a linear time-invariant system with system function $H(z)$. In each case, determine whether any of the following statements are true. Justify your answer with a brief statement or a counterexample.

(a) The system is a zero-phase or a generalized linear-phase system.

(b) The system has a stable inverse $H_i(z)$.

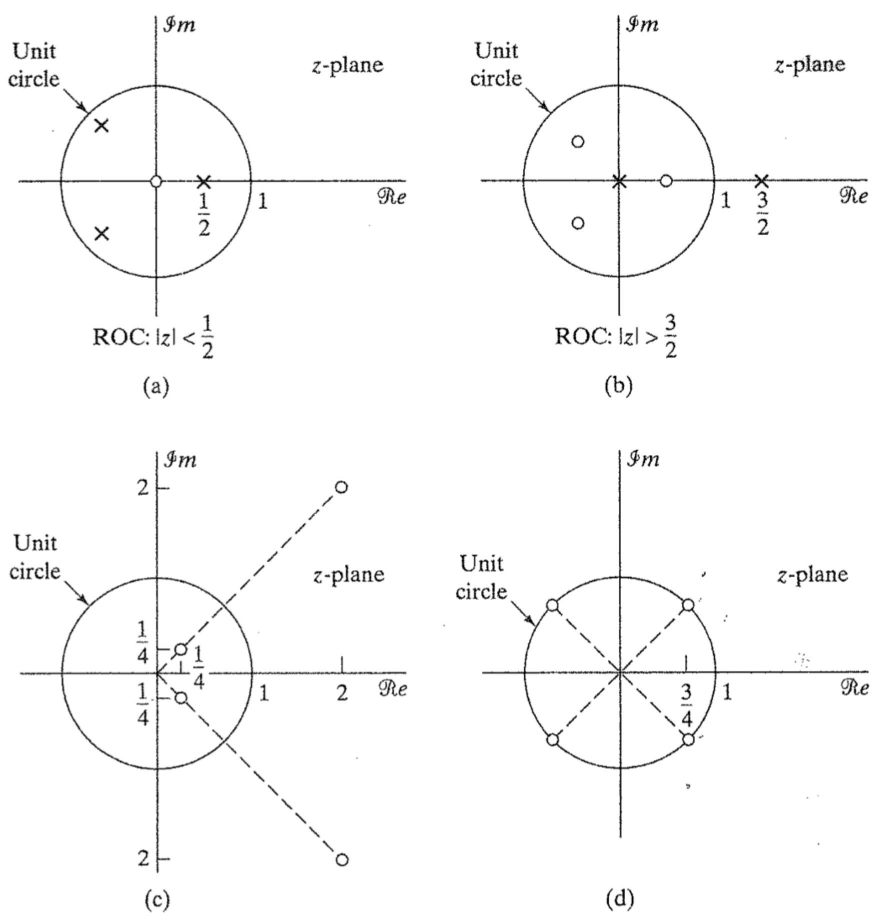

Figure P5.40-1