GEORGIA INSTITUTE OF TECHNOLOGY
School of Electrical and Computer Engineering

EE3230
Homework Assignment No. 7

Date Assigned: May 29, 1998
Date Due: June 5, 1998

Reading Assignment: In Oppenheim and Willsky, study pp. 816-836.

Homework Assignment: Turn in for grading only Problems 7.4*, 7.5*, and 7.6*.

NOTICE: The final exam is Tuesday, June 9, at 11:30 - 2:20 pm. It will cover the entire course. You may use one 8.5 by 11 inch sheet (both sides) of notes and a calculator.

Problem 7.1:

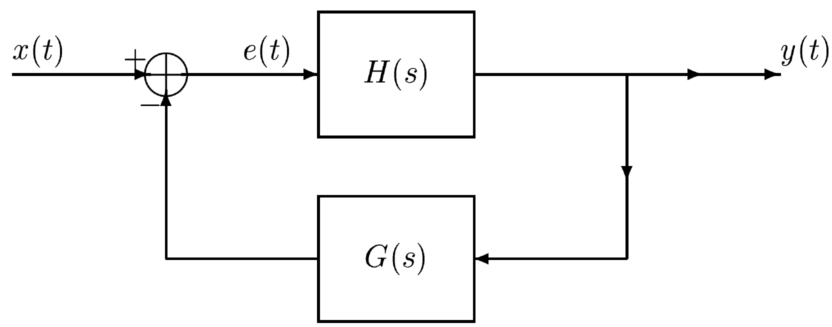
Work Problem 11.2 in Oppenheim and Willsky.

$$\textit{Answer:} \quad Q(s) = \frac{H_1(s)H_2(s)}{1 + H_1(s)H_2(s)G_2 + H_1(s)G_1(s)}$$

Problem 7.2:

Work Problem 9.25 parts (a), (b), (c), and (d) in Oppenheim and Willsky.

Problem 7.3:



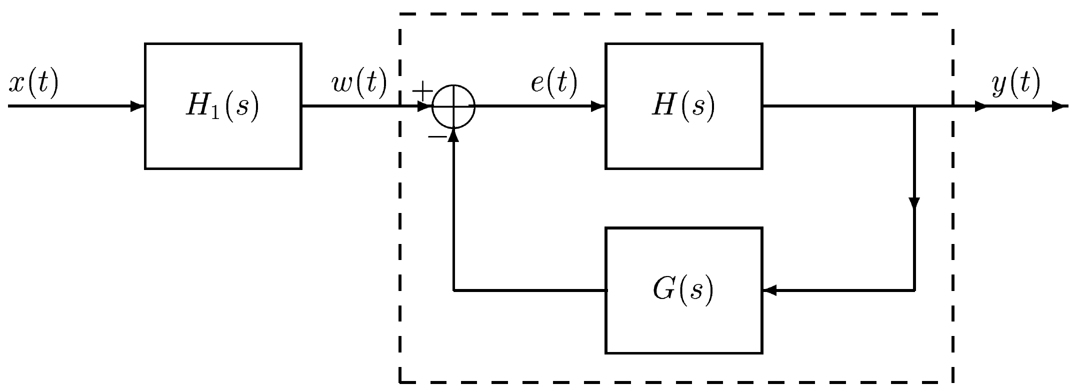
In the above system, $G(s) = K$ and

$$H(s) = \frac{s-1}{s(s+1)}$$

(a) Find the value of K such that the system function $Q(s)$ of the overall system has all its poles on the $j\omega$ axis.

(b) Find the impulse response of the system for the value of K found in part (a).
Answer: $q(t) = [\cos(t) - \sin(t)]u(t)$.

Problem 7.4*:



(a) Suppose that $w(t) = x(t) + \alpha x(t - t_d)$. Determine the system function $H_1(s)$.

(b) If $H(s) = 1$, determine the system function $G(s)$ so that the feedback system inside the dashed box is the inverse system for $H_1(s)$; i.e., so that $y(t) = x(t)$.

(c) If $G(s)$ is a causal system, for what values of α will the overall feedback system be stable?

(d) Determine the impulse response of the feedback system, $q(t)$, defined by $y(t) = w(t) * q(t)$.

Problem 7.5*:

A discrete-time signal is synthesized by the following MATLAB statements:

```
n1=0:399;
n2=400:799;
Ts=1/2000;
f0=200;
x=[cos(2*pi*f0*n1*Ts),cos(2*pi*3*f0*n2*Ts)];
```

(a) Write an equation for the sequence of samples represented by the MATLAB vector `x`. Plug in the numbers. Your equation should be in the form

$$x[n] = \begin{cases} ??? & ?? < n < ?? \\ ??? & ?? < n < ?? \end{cases}$$

(b) Sketch the spectrogram of the signal. Label the frequency and time axes appropriately for the sampling rate of the signal. *Assume that the spectrum analysis filter is a moving average filter of length* $M = 100$.

Problem 7.6*:

The spectrogram in Figure 1 and the spectral slices in Figure 2 are for an unknown signal $x(t)$ that was sampled with sampling rate $f_s = 4000$ samples/sec. The spectrogram was computed using the equation

$$X[k,n] = \sum_{m=0}^{N-1} x[n-m]e^{-j(2\pi/N)k(n-m)} = \sum_{m=n-N}^{n} x[m]e^{-j(2\pi/N)km}$$

(a) By considering the sampling rate and Figure 1, determine the length, N, of the spectrum analysis window.

(b) Explain the appearance of the spectrogram in Figure 1. Specifically, what accounts for the "smeared regions" around 50, 150, and 200 msec.? From your result in part (a) and the two figures, write an equation for the signal $x(t)$.

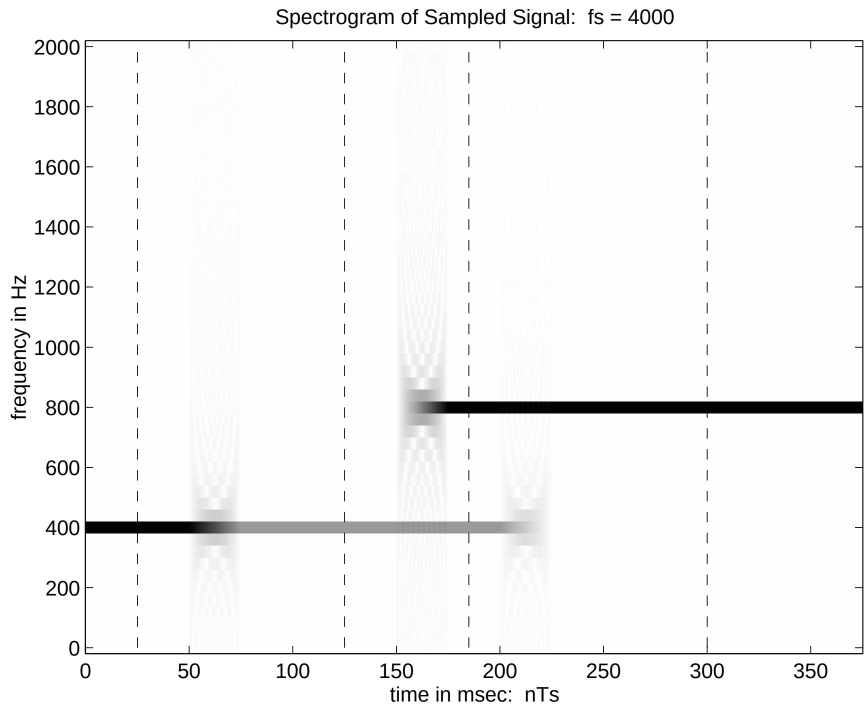


Figure 0.1: Spectrogram of unknown signal.

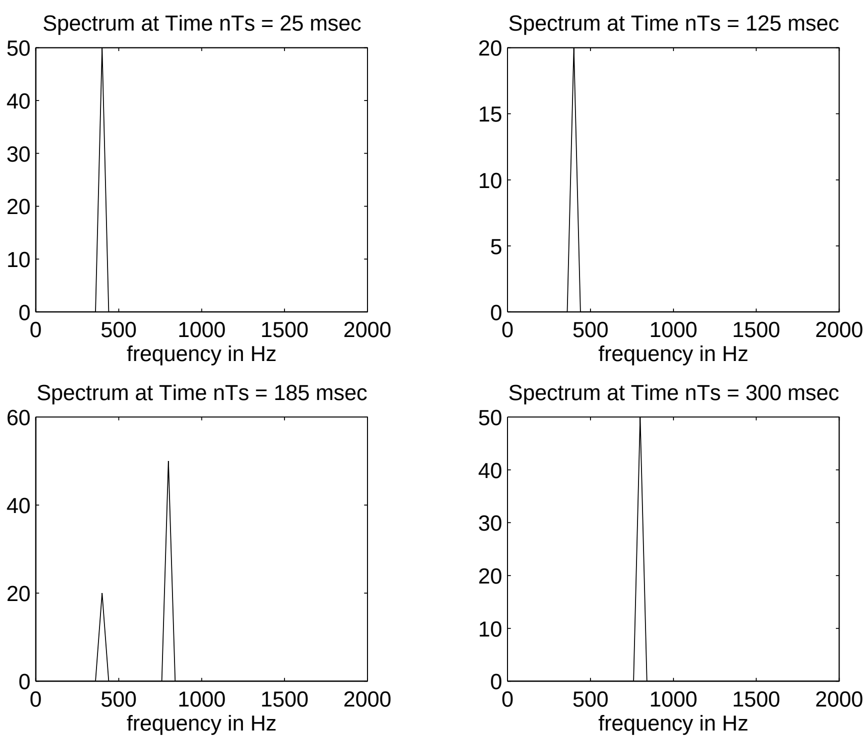


Figure 0.2: Spectral slices for unknown signal.