GEORGIA INSTITUTE OF TECHNOLOGY
School of Electrical and Computer Engineering

EE3230
Homework Assignment No. 9

Date Assigned: March 4, 1998
Date Due: March 13, 1998

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

Homework Assignment: Turn in for grading only Problems 9.4*, 9.5*, and 9.6*.

NOTICE: The final exam is Thursday, March 19, at 2:50 -5:40 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 9.1:

Work Problem 11.22 parts (a) and (c) in Oppenheim and Willsky.

Answers:

$$\text{(a)}\quad q(t) = te^{-2t}u(t)$$

$$\text{(c)}\quad q(t) = 0.5\sum_{k=0}^{\infty}(-0.5)^k\delta(t-k/3)$$

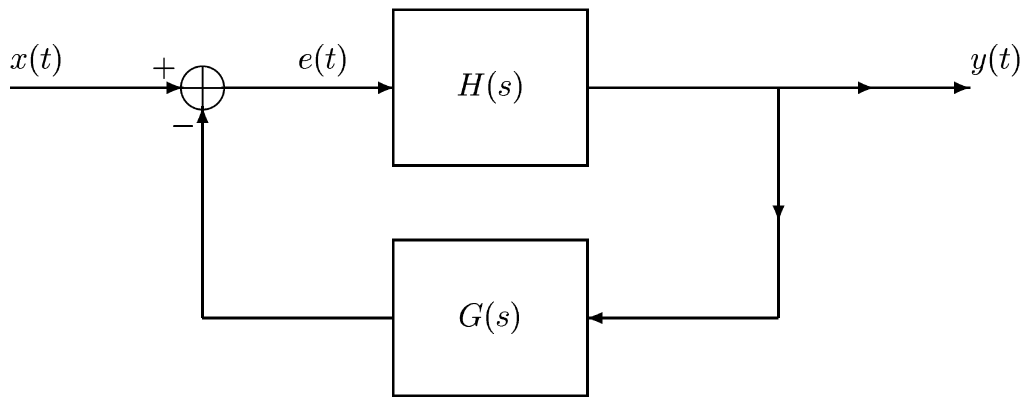
Problem 9.2:

Work Problem 11.2 in Oppenheim and Willsky.

Answer:

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

Problem 9.3:



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: $q(t) = [\cos(t) - \sin(t)]u(t)$.

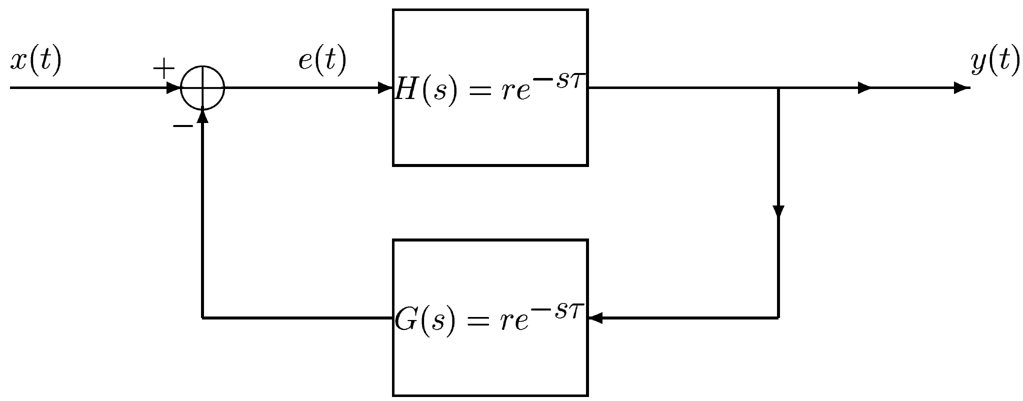
Problem 9.4*:

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

Problem 9.5*:

Work Problem 11.49 in Oppenheim and Willsky.

Problem 9.6*:



The above diagram is a model for reflections that occur on a transmission line when it is improperly terminated. Both the upper (forward) path and the feedback path have a gain of r and a delay of τ sec. The gain constant is such that $|r| < 1$.

(a) Show that the above diagram represents the equations

$$e(t) = x(t) - ry(t - \tau) \qquad\qquad y(t) = re(t - \tau)$$

(b) Find the system function $Q(s)$ of the overall system.

(c) Determine the poles and zeros of $Q(s)$. *Hint: The poles of $Q(s)$ are the values of s such that $G(s)H(s) = -1$.* Is the system stable for the values of r specified? For what values of r will the system be unstable?

(d) Find the impulse response of the overall system. *Hint: You may find the following result useful:*

$$\frac{1}{1-\alpha} = \sum_{k=0}^{\infty} \alpha^k \qquad \text{if } |\alpha| < 1$$

(e) Use the impulse response to determine an expression for $y(t)$ in terms of an infinite sum of delayed and scaled copies (echos) of $x(t)$.

(f) Determine the system function $H_i(s)$ and impulse response $h_i(t)$ of an echo removal system which, when cascaded with the above system (i.e., the echo removal system has $y(t)$ as input), will remove the echos producing an output $w(t) = x(t - \tau)$.