**EE Quals Problem**
January 22-26, 2007
Julius Smith

Consider the following second-order system:

$$\begin{aligned} x_1(n+1) &= x_1(n) - \epsilon\, x_2(n) + u(n) \\ x_2(n+1) &= \epsilon\, x_1(n+1) + x_2(n) \\ y(n) &= x_1(n) + x_2(n) \end{aligned}$$

where $u(n)$ and $y(n)$ are the input and output signals at time $n$, respectively, and $x_1(n)$ and $x_2(n)$ denote the two *state variables* at time $n$. Assume all signals and states are zero for $n < 0$, and that typically $|\epsilon| \ll 1$.

1. Derive the *state-space description* for this system. That is, find matrices (A,B,C,D) such that $\underline{x}(n+1) = A\underline{x}(n) + Bu(n)$ and $y(n) = C\underline{x}(n)$, where $\underline{x}(n) = [x_1(n), x_2(n)]^T$ denotes the *state vector* at time $n$.
2. Write down or derive an expression for the system *transfer function* in terms of the state-space description.
3. Give a formula that can be solved to find the *poles* of the system.
4. Find the product of the poles of the system.
5. Give a formula for *diagonalizing* this state-space description, if possible.
6. Write an expression for the *maximum decay time-constant* in the impulse response, assuming the system is stable.
7. If time remains, work to find the impulse response in closed form. Otherwise, state how this should be carried out.

Qualifying Exam for the Electrical Engineering PhD program, Stanford University, January 2007

Olav Solgaard

Questions:

1) What is this? (Showing the student a co-axial cable.)

2) How is it constructed?

3) How is information transferred along the cable?

4) What is the speed of information transfer?

5) How can you model the information transfer on a co-axial cable using lumped-circuit elements?

6) What is the bandwidth of the ideal loss-less transmission line?

7) What effects will degrade the signal quality as it propagates on real transmission lines?

8) How is signal propagation on an optical fiber different from signal propagation on a co-axial cable?

9) What effects degrade signals that propagate on optical fibers?

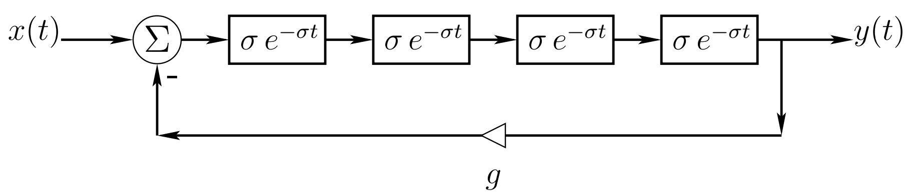
10) How can you mitigate dispersion on single-mode optical fibers?

**EE Quals Problem**

January 10-14, 2011

Julius Smith

Consider the following system:




1. Where are the *open-loop poles and zeros?*
2. What values of $\sigma$ yield a *stable open-loop system?*
3. Find the *transfer function* of the system from its input $x$ to its output $y$.
4. Sketch the *root locus* of the system as $g$ grows positively from zero.
5. What is the range of $g \geq 0$ for which the system is stable?
6. What is the resonance frequency $\omega_0$ at the stability limit?
7. Describe how to *digitize* this system, assuming $\sigma$ and $g$ will be used as variable controls.