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610 Fall 2009 – Homework 5 Due ~~Th~~ ~~Tu~~ Th 10/~~15~~ ~~20~~ 22/09

1. [70 points] [semistate evaluation and design]

   For the following semistate equations all the coefficient matrix entries are real valued scalars

$$\begin{bmatrix} 0 & e_{12} \\ 0 & 0 \end{bmatrix} \frac{dx}{dt} = \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix} x + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} u$$

$$y = \begin{bmatrix} c_1 & c_2 \end{bmatrix} x$$

   a) Find the (scalar) transfer function, T(s), and show that there are some coefficient values for which T(s)=s and another set of coefficients for which T(s)=1.

   b) Show that the following set of equations can have the same transfer function, T(s)

$$\begin{bmatrix} E_{11} & 0 \\ 0 & 0 \end{bmatrix} \frac{dX}{dt} = \begin{bmatrix} 0 & A_{12} \\ A_{21} & 0 \end{bmatrix} X + \begin{bmatrix} B_1 \\ B_2 \end{bmatrix} u$$

$$y = \begin{bmatrix} C_1 & C_2 \end{bmatrix} X$$

   c) Writing these two equivalent semistate equations as

      edx/dt=ax+bu, y=cx

   and

      EdX/dt=AX+Bu, y=CX

   find the transformation pair, P and Q (both nonsingular), PaQ=A, to go between the two.

   d) In the case of T(s)=s with u=i (current) and y=v (voltage) draw an OTA-C circuit to give the semistate equations of b) above.

2. [30 points] [positive and bounded real conditions]

   For each of the following functions state a) if it is positive real and b) if it is bounded real as well as c) if it is lossless.

   a) $f(s) = \dfrac{s(s^2+9)(s^2+25)}{(s^2+4)(s^2+16)}$.

   b) $f(s) = \dfrac{as+b}{cs+d}$, $a > b > c > d > 0$ otherwise freely chosen (real).

   c) $f(s) = (\dfrac{s-2}{s+2})(\dfrac{s^2-4s+4}{s^2+4s+4})$