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610 Fall 2018 – Homework 5 Due Th 10/18/18

1. (50 points, companion matrix design)
   Consider the scalar lossless PR admittance

   $$y(s)=[3s(s^2+4)]/[(s^2+1)(s^2+9)]$$

   a) Explain why this is PR and lossless.
   b) Give a state-variable realization in companion matrix form and from it find a (5-port) constant admittance coupling matrix Yc which when loaded in four capacitors gives y(s) at the remaining port.
   c) Discuss passivity of any circuit realizing Yc.

2. (40 points, PR & BR)
   For the following functions state which are PR and/or BR and where there is a parameter a, for which values of a the function is PR and/or BR.
   a) $f1(s)=[s^2+(2-a)s+1]/[s^2+s+a]$.
   b) $f2(s)=[(s^2+1)(s^2+4)]/[s(s^2+2)(s^2+3)]$
   c) $f3(s)=1/f1(s)$
   d) $f4(s)=[s^2-as+4]/[s^2+as+4]$

3. (10 points, tan and tanh)
   The partial fraction expansions for tan(s) and tanh(s) are

   $$\tan(s)=\sum_{(n=1 \text{ to } \infty)}[8s/[(2n-1)^2\pi^2 - 4s^2]$$

   $$\tanh(s)=\sum_{(n=1 \text{ to } \infty)}[8s/[(2n-1)^2\pi^2 + 4s^2]$$

   a) Discuss why one is positive-real and the other not.
   b) The infinite product expansions for sin and cos are

      $$\sin(\pi s)=\pi s\prod_{(n=1 \text{ to } \infty)}(1-(s/n)^2)$$

      $$\cos(\pi s)= \prod_{(n=1 \text{ to } \infty)}(1-(2s/\{2n-1\})^2)$$

      From these form the infinite product expansion for tan(s)=sin(s)/cos(s) and infer the infinite product expansion for tanh(s)=sinh(s)/cosh(s).