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ENEE 610
Homework Problems for Grading, Set 4 (100 points)
Due at class M 10/25/04
State, lossless synthesis

1. (25 points)

Determine if the following is true for a real-rational driving-point impedance z(s):

A non-zero z(s) is lossless and positive-real if and only if

a) z(1) is positive and

b) All poles and zeros are simple and on the imaginary axis and

c) Poles and zeros alternate

2. (25) points

a) Determine those constants a, b, c such that the following z(s) is lossless positive-real.

$$z(s) = \frac{s^2(s^2+b)}{(s+a)(s^2+c)}$$

b) For one set of the values of a, b, c found in part a) give a partial fraction synthesis of z(s), a synthesis by partial fractions of y(s)=1/z(s) and one using the Richards' function with the gyrator-inductor 2-port coupling structures.

3. (50) points

A movable MEMS plate similar to, but somewhat different from, the one discussed in class has the describing equations:

$$m\frac{d^2x}{dt^2} = -b\frac{dx}{dt} - k(Lo - x) + \frac{q^2}{2A\varepsilon}$$

$$v = r\cdot i + v_c,\quad q = Cv_c,\quad C = \frac{\varepsilon A}{Lo - x},\quad i = \frac{dq}{dt}$$

Assume the plates are square and 100uM on a side and made of gold, the top movable one being 2uM thick. Assume k=3.9x10^{-9}Newtons/M, b=1.1x10^{-15}Newton-sec/M and the mass-density of gold =19.3x10^{3}Kgram/M^{3}. Take r=50 Ohms and ϵ=8.85x10^{-12}Farad/M.

a) Assume a DC voltage Vdc of 2Volts, v=Vdc=2, to give Lo for x=0. What is the value of Lo and of the steady state charge q=Qdc?

b) Set up the state equations using [x, dx/dt, q]^{T} as the state and implement with a PSpice schematic using capacitors, resistors, a voltage source and Gvalue components.

c) Using Spice solve the state equations for the state vector when v=Vdc+vp where vp is a 1millisec pulse of 1milli Volt amplitude.

d) Linearize at the DC operating point and find the transfer function X(s)/V(s).