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610 Fall 2012 – Homework 2

1. For the circuit giving the semistate equations covered in the class notes of 09/06/12 replace the VCCS by an ideal op-amp (necessitating adding a branch 7 across C1); also add a resistor R1 in series with v_i as part of branch 1.

a) Give the new graph, the new cut-set and tie-set matrices, and the Av=Bi descriptions using as much of the graph used in class as possible.

b) From those give the semistate equations using v_t and i_l as components of the semistate x.

c) Indicate what problems are anticipated in using these equations if R1=0.

2. A circuit has the following semistate matrices:

$$E := \begin{pmatrix} 0 & 0 & 0 & 0 \\ C1 & 0 & 0 & 0 \\ 0 & 0 & 0 & L1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \quad A := \begin{pmatrix} 0 & g1 & 0 & 0 \\ -g1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ g1 & 0 & -1 & 0 \end{pmatrix} \quad B := \begin{pmatrix} 0 & 1 \\ 0 & 1 \\ 1 & 0 \\ 1 & 0 \end{pmatrix} \quad C := \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Assuming that C1, L1 and g1 are all positive

a) transform the system so that E is the direct sum of 1_2 and 0_2.

b) Eliminate the last two rows to obtain state variable equations.

b) Find the transfer function 2x2 matrix, $T(s)=C(sE-A)^{-1}B$, where E is the above 4x4 matrix.

3. Find the characteristic polynomial and the minimal polynomial for the 4x4 A matrix of problem 2 above.

4. Find a singular valued decomposition for the above E. for C1=2, L1=5. In MathCad this can be done with the following commands (after setting array origin to 1 in the tools, worksheet options, menu)

$$M := \mathrm{svd2}(E) \qquad M = \begin{pmatrix} \{4,1\} \\ \{4,4\} \\ \{4,4\} \end{pmatrix} \qquad s := M_1 \qquad sd := \mathrm{diag}(s) \qquad U := M_2 \qquad V := M_3$$

Note that U and V are orthogonal matrices and check by

$$E2 := U \cdot sd \cdot V$$