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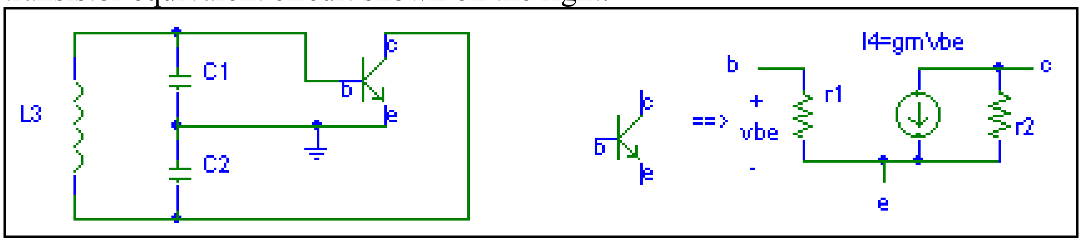
ENEE 610 Final Exam; 12/19/05

Open book & notes. Only signed work, which designates all the work is your own, will be graded.

1. (50 points)

For the following small signal version of a Colpitts oscillator, use the BJT transistor equivalent circuit shown on the right.



a. Draw an oriented graph numbering branches as per the element numbering and nodes 0=e=ground, 1=b, 2=c; orient all branches to point toward the lower numbered node. For this include C1 and r1 together in branch 1, so y1(s)=g1+sC1, and C2 and r2 in branch 2 as y2(s)=g2+sC2.

b. Choose branches 1 and 2 for the tree and give the cut set and tie set matrices.

c. Give the branch by branch admittance and use the cut set matrix to find the (2x2) nodal admittance matrix, Y(s). Check by finding the (3x3) indefinite admittance Yind(s) and then grounding the e node (chosen as node 3 prior to becoming 0 when grounding).

d. Give the even and odd parts of det[Y(s)]. For the circuit to be an oscillator both of these should be 0 at the oscillation frequency $s=j\omega_o$.

e. The two equations of part d determine a bias collector current, Ic, since $gm=Ic/V_T$, $g1=(1/r1)=g_\pi=Ic/(\alpha V_T)$, $g2=(1/r2)=g_o=Ic/V_A$. Determine Ic in terms of α, VT, VA, L, C1 and C2. [the normal $g_\pi=Ic/(\{\beta+1\}V_T)$ but for this problem $Ic/(\alpha V_T)$ is used].

f. Choose $\alpha=0.999$, $V_A=100$, $V_T=0.026$, L3=5nHy, C1=5pFd with $0.01<(C2/C1)<100$, and make reasonable approximations to determine for which C2 the circuit will oscillate and find Ic and ω_o for those C2.

2. (50 points)

a. For what values of the real parameters a and b is the admittance $y(s)=[(s^2+a)(s^2+b)/[as(s^2+1)]$ positive-real?

b. For b=1/a determine for which a this y(s) is lossless and give a second Foster synthesis with a as a parameter. Give also a first Cauer synthesis of this y(s) when b=1/a

c. Using the second Foster expansion show that any rational lossless driving point admittance satisfies $y_{LC}(s)=sf(s^2)$ and exhibit f(s) [not $f(s^2)$] as a partial fraction expansion. In a lossless second Foster synthesis of $y_{LC}(s)$, if each inductor is replaced by a resistor then we obtain an RC second Foster synthesis of $y_{RC}(s)$. Give $y_{RC}(s)$ in terms of f(s) and from that give a partial fraction type expansion for $y_{RC}(s)$ and then in turn an RC synthesis.

d. Give the necessary and sufficient conditions that a rational y(s) (with real coefficients) is the driving point admittance of an RC circuit.

e. For such a $y_{RC}(s)$ determine the location of its even part, $Ev[y_{RC}(s)]$, poles and the relation to them of the even part zeros. Sketch $Ev[y_{RC}(s)]$ for real s {hint; look at dEv[y]/ds}