ECE 304: Final Exam Fall '01

PROBLEM 1 (25 POINTS)

1. Define *gain margin* and *phase margin* using Bode plots for a three-pole amplifier as an example.
2. State the *rate-of-closure rule* and illustrate with a Bode plot.
3. Using a Bode gain plot, identify the *midband* region of an amplifier. Indicate in what regions you would use the *short-circuit time constant method* and the *open-circuit time constant method* to find the corner frequencies. Write a formula for each region expressing the corner frequencies as a function of the time constants.
4. Describe a situation where using a voltage follower could increase the bandwidth of an amplifier. Sketch the circuit.
5. Sketch the circuit for a *cascode* amplifier. Explain its advantages and how they are achieved.

PROBLEM 2 (25 POINTS)

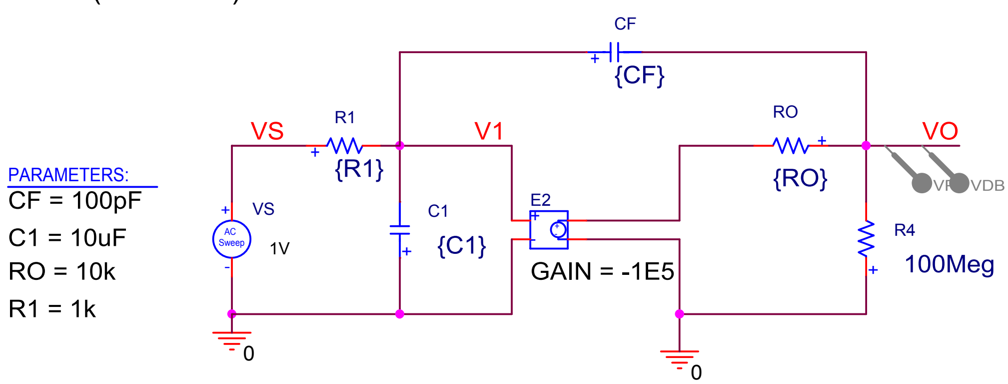

FIGURE 1:

Macromodel of two-pole amplifier using the VCVS PSPICE part E; gain is -10^5V/V.

For the <u>double-pole</u> amplifier of Figure 1,

- Derive a formula for the exact (no approximations) frequency dependence of the gain, V_O/V_S. Treat R_4 as infinite.
- Derive approximate formulas for the two pole frequencies assuming wide separation.
- Using the given parameter values, make a Bode phase and Bode dB gain plot vs. frequency in Hz over the range 1Hz $\leq$ f $\leq$ 100 MHz. Mark values and frequencies for each break point and mark slopes/decade of frequency.
- Define the Miller approximation and discuss its validity for the corner frequency of this example.

PROBLEM 3 (25 POINTS)

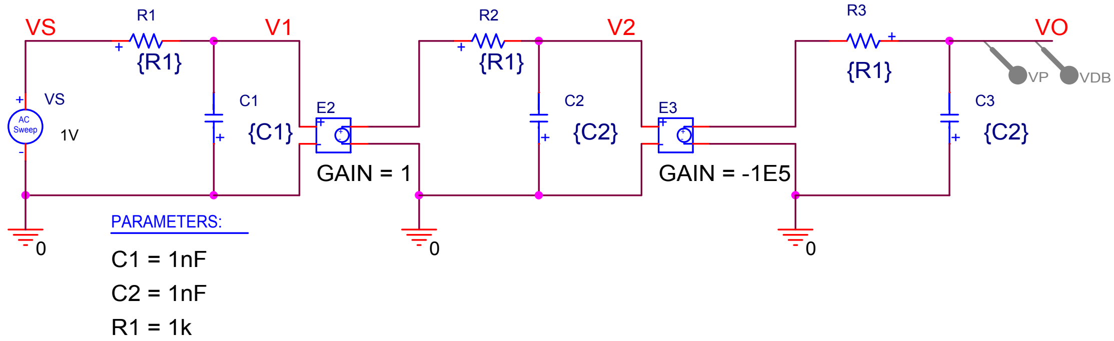

FIGURE 2:

Macromodel of <u>triple-pole</u> amplifier using two VCVS PSPICE parts E; first-stage gain is 1V/V; second-stage gain is -10^5V/V.

For the <u>triple-pole</u> amplifier of Figure 2,

- Draw the open-loop Bode plots. Label all corners and slopes.
- Move one pole to obtain zero phase margin if the amplifier is used in a non-inverting amplifier with feedback β=1 V/V. Use Bode plots for a first guess and use formulas to make any needed adjustments.
- Draw the open-loop Bode plots with the new pole for frequencies from 1 mHz to the unity loop-gain frequency f_1. Label all corners and slopes.
- Find the value of capacitance C_1 that will result in the new pole frequency.

PROBLEM 4 (35 POINTS)

Parts for Problem 1 are shown in Figure 3 They are to be connected to form a feedback amplifier that provides a specified AC current to the load resistor R_L.

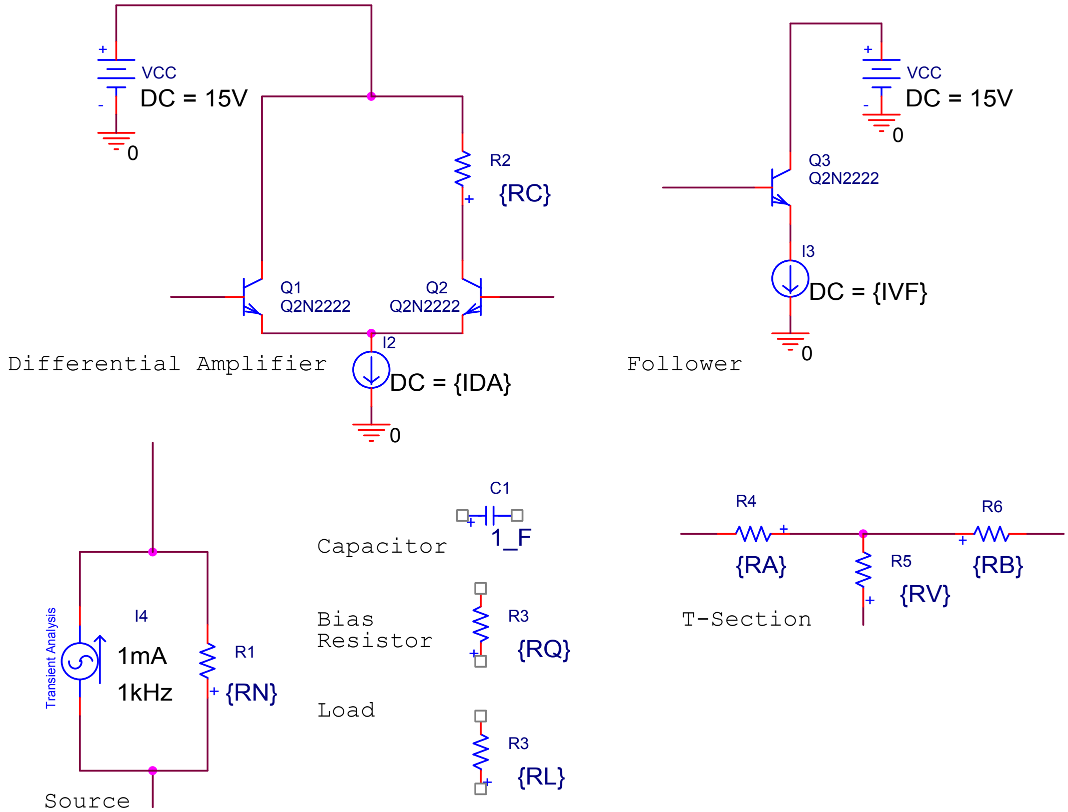

FIGURE 3:

Parts available are <u>one</u> each of diff amp, follower, source, load, bias resistor, capacitor, and T-section

Given only the parts shown in Figure 3, make a schematic showing how to connect them to provide a specified current into load R_L. The following specifications are given:

1. $R_L = 100\Omega$, $R_N = 1\ k\Omega$
2. AC load current is 20 mA amplitude with no clipping for 1 mA AC input
3. Diff amp to have maximum difference-mode gain consistent with specifications 1 & 2.
4. Voltage follower to have minimum DC bias current consistent with specifications 1 & 2
5. T-section resistor values should be determined. Zero values are OK if desirable.

<u>Marks are based on your detailed answers to the following questions</u>. Your design calculations should be keyed to these questions so I can locate where and how you executed your decisions.

Explain the following parts of your design choices <u>in words</u>:

1. How did you select the type of feedback?
2. How did you determine the T-section resistor values (R_A, R_B, R_V)?
3. How did you decide the follower DC bias current (I_{VF})?
4. How did you decide the diff amp DC bias current (I_{DA})?
5. How did you determine the value of R_C?
6. Explain your use (or not) of the coupling capacitor C1.
7. Explain your use (or not) and sizing of the bias resistor R_Q.

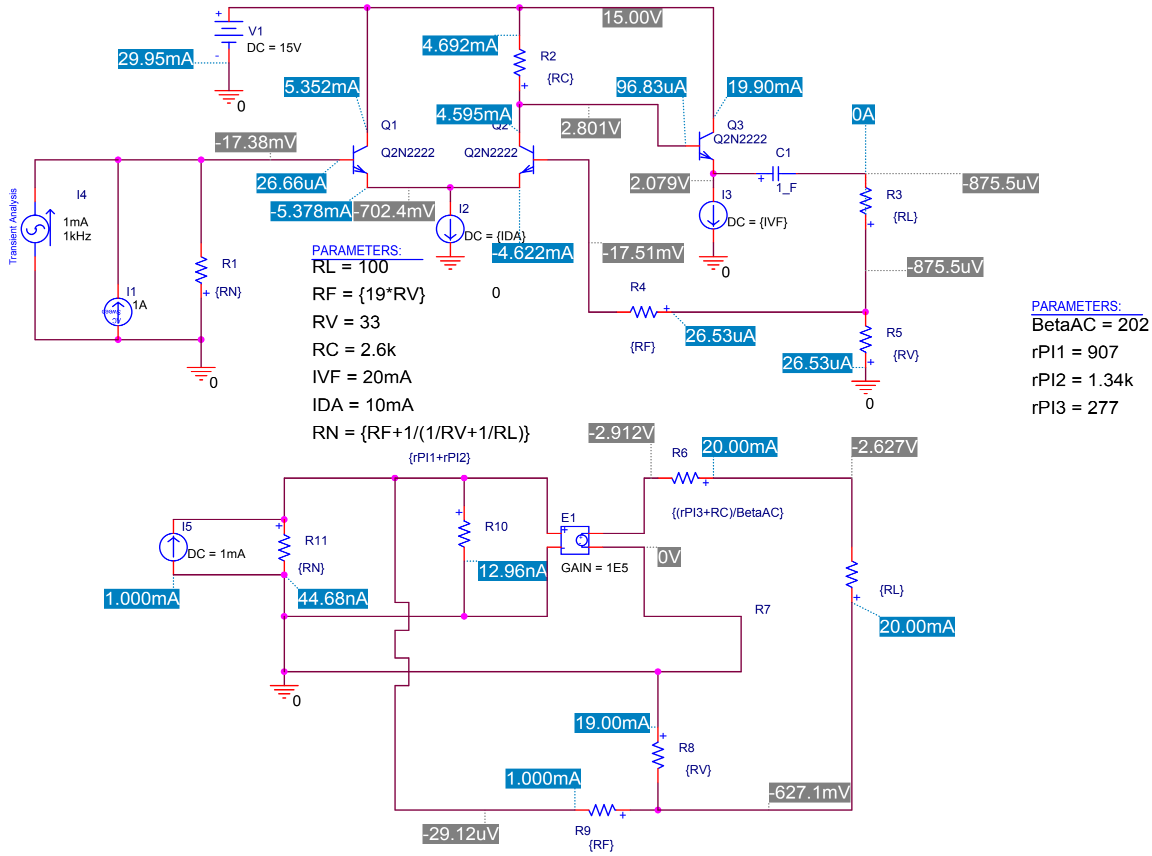

FIGURE 4:

Solution for last problem