ECE 304: Final Exam Fall 2000

1. Short questions <u>to be answered in words and diagrams (not equations)</u>:

1.1 List the advantages and disadvantages of feedback

1.2 What are the classifications of output amplifiers, what do they mean, and what are the advantages and disadvantages of each?

1.3 What are the advantages and disadvantages of a bypass capacitor?

1.4 What is a cascode circuit? Sketch one that uses bipolar transistors, and explain its advantages in words.

1.5 What is an active load, and what is its advantage over a resistor as load in a common source amplifier?

1.6 Sketch a MOSFET differential amplifier circuit using an active load.

1.7 What is a current mirror, and what is its advantage in a differential amplifier?

1.8 Sketch a circuit for a p-channel MOSFET current mirror.

1.9 For a transconductance amplifier, which type of feedback connection should be used in the input and which in the output? Explain your reasoning.

1.10 Would you model a transresistance amplifier as a Norton source or as a Thevenin source? Explain your answer.

1.11 Would you drive a transconductance amplifier with a Norton source or with a Thevenin source? Explain your answer.

1.12 Why would you use an emitter follower as an input stage?

1.13 Why would you use an emitter follower as an output stage?

1.14 What does the "mid-band region" of an amplifier mean?

1.15 What is the Miller effect? The Miller approximation?

1.16 What are the four types of amplifier considered in feedback theory? Imagine a two-port representation of the amplifier's feedback network. For each type of amplifier, specify the dependent source (*e.g.*, VCVS, CCCS, *etc.*) that provides the feedback signal. Explain your answers.

1.17 Sketch the circuit for a V_{BE}–multiplier power amplifier. Explain how the multiplier controls output waveform distortion, and why it is called a V_{BE}-multiplier.

1.18 Using a circuit diagram, explain the current flow patterns at the conditions of maximum and of minimum output voltage for the V_{BE} -multiplier power amplifier.

2. For the amplifier in Fig. 1.

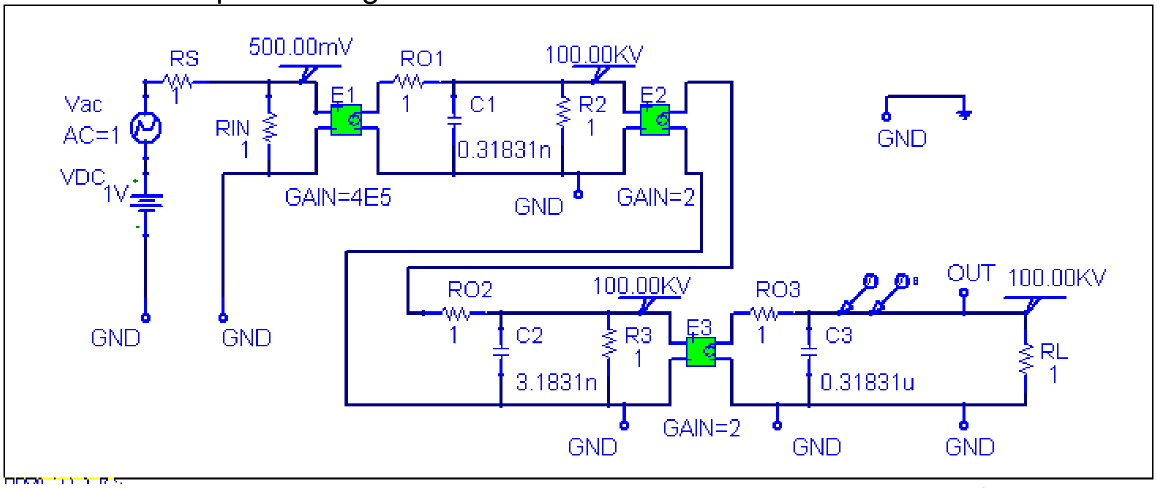

FIGURE 1: BLOCK DIAGRAM OF THREE-STAGE AMPLIFIER. TO ALLOW A CHECK ON YOUR WORK, THE DC VOLTAGES (ZERO FREQUENCY) ARE SHOWN AT SEVERAL POINTS USING Viewpoints.

2.1 Calculate the pole frequencies **in Hertz**. For numerical convenience, capacitor values all are proportional to $1/\pi$ and resistor values all are 1Ω.

2.2 Sketch the Bode phase and gain diagrams for V_{OUT}/V_{ac}. Label all slopes and break frequencies. The x-axis should be Hertz, not radians.

2.3 Determine the gain and phase margins when this amplifier is used for a feedback amplifier with feedback $\beta_{FB} = 10^{-2}$V/V

2.4 Add a pole to the open loop amplifier to realize a phase margin of 45° for feedback $\beta_{FB} = 10^{-2}$V/V. Sketch the Bode phase and gain plots of the compensated amplifier. Specify the frequency of the added pole, all slopes and break frequencies.

2.5 Indicate how your diagrams can be used to determine the gain and phase margins for the compensated amplifier and give their values.

3. With the amplifier circuit in Fig. 2,

3.1 Sketch a small-signal circuit valid at high frequencies.

3.2 Decide what limits the corner frequency. Is it the Miller effect? Why or why not?

3.3 Draw another high-frequency equivalent circuit like that above (Question 3.1), but simplified to apply for frequencies in the vicinity of the high-frequency corner. Simplify by leaving out unimportant elements based upon the Q-point values of Table 1 below, and by using your knowledge of how the circuit works. Justify your simplifications in words.

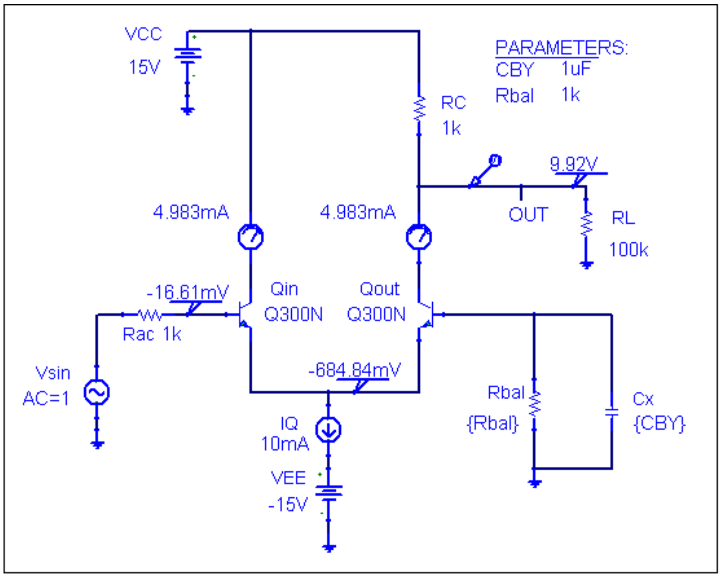

FIGURE 2: AMPLIFIER CIRCUIT FOR PROBLEM 3.

3.4 Generate a high-frequency block equivalent like that shown in Fig. 3 and provide formulas for all circuit components and the gain. To avoid a huge mess, take advantage of any approximations suggested by the Q-point data in Table 1, and also use your knowledge of which capacitors are likely to determine the corner frequency.

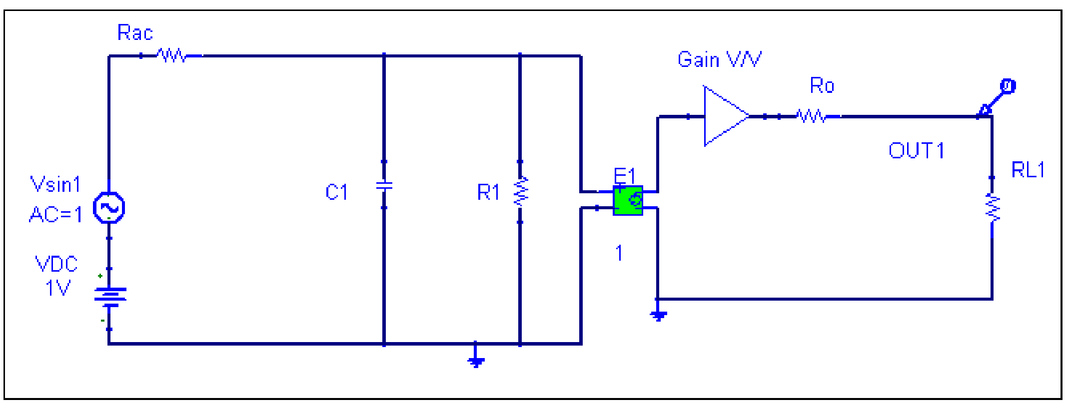

FIGURE 3: BLOCK DIAGRAM FOR HIGH-FREQUENCY EQUIVALENT CIRCUIT OF FIG. 2.

3.5 Evaluate the components and the gain for Fig. 3 using the Q-point data below.

TABLE 1: Q-POINT DATA FOR TRANSISTORS IN FIG. 1.

NAME	**Q_Qin**	**Q_Qout**
MODEL	**Q300N**	**Q300N**
IB	1.66E-05	1.66E-05
IC	4.98E-03	4.98E-03
VBE	6.68E-01	6.68E-01
VBC	-1.50E+01	-9.93E+00
VCE	1.57E+01	1.06E+01
BETADC	3.00E+02	3.00E+02
GM	**1.93E-01**	**1.93E-01**
RPI	**1.56E+03**	**1.56E+03**
RX	0.00E+00	0.00E+00
RO	**1.00E+12**	**1.00E+12**
CBE	**4.74E-11**	**4.74E-11**
CBC	**1.10E-12**	**1.25E-12**
CJS	0.00E+00	0.00E+00
BETAAC	**3.00E+02**	**3.00E+02**
CBX	0.00E+00	0.00E+00
FT	6.32E+08	6.30E+08

3.6 Using Fig. 3, find a formula for the corner frequency in terms of C_1, R_1, *etc.*

3.7 Evaluate your formula for the corner frequency. A Bode gain plot is shown below to check your results.

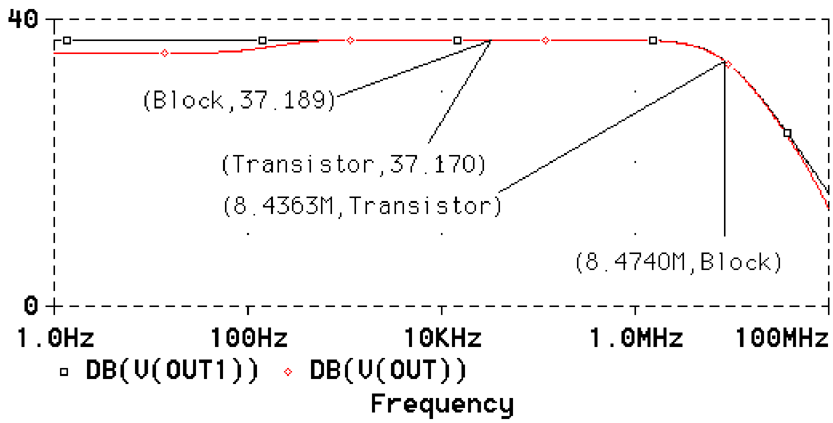

Figure 4: **Bode gain plots showing the corner frequency of Fig. 2 (Transistor) and of Fig. 3 (Block diagram).**