Calculators required, closed book; Wednesday, December 15, 8 AM – 10 AM

ECE 304 Fall '04 Final Exam

NOTE: IN ALL CASES

1. Put your answer first, and
2. Follow up with an <u>outline</u> of your solution. Each major step in the outline should
   2.1. Begin with a heading that describes the objective of that step, and should
   2.2. Have a body where actual work is done, not just hand waving, and should
   2.3. Conclude with a quantitative statement of the <u>major result</u> for that step (a number or formula or both).

For all problems take the thermal voltage as V_{TH} = 25.864 mV.

Problem 1: Current mirror

Follow the outline procedure at the top of the exam with headings for each major step in the solution. **No points for answer without an outline of the solution. A mish-mash of calculations is not an acceptable outline.**

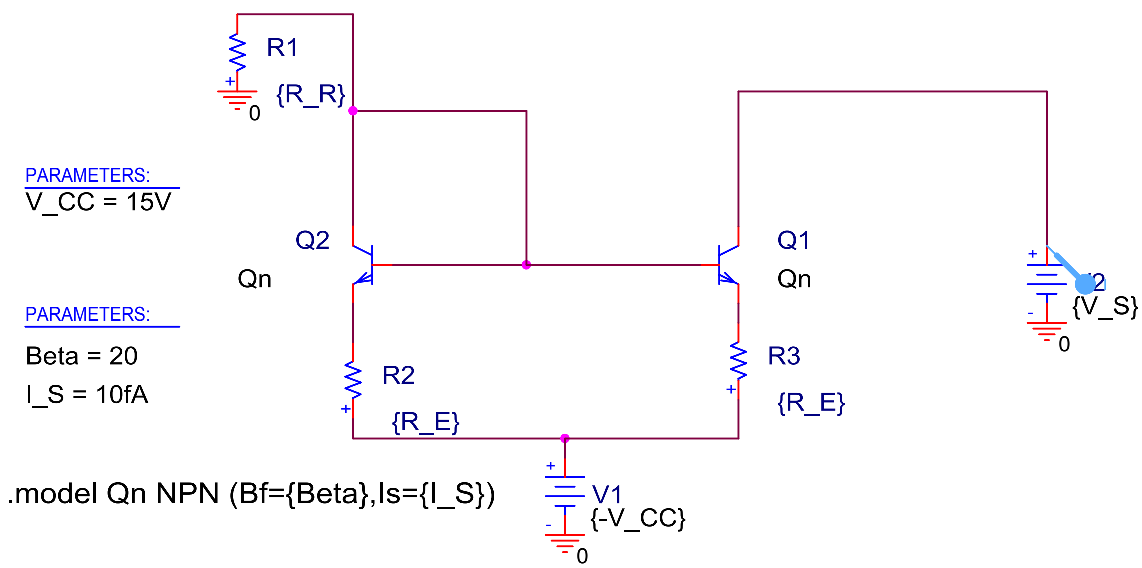

FIGURE 1
Current mirror for Problem 1

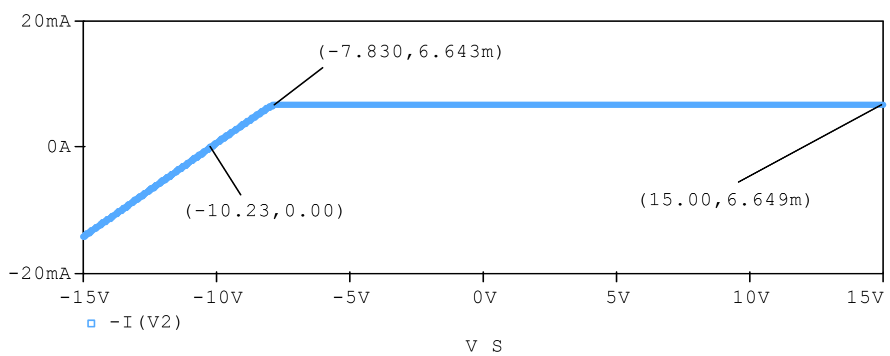

FIGURE 2
Current vs. DC voltage for current mirror of Figure 1

Select values of R_R and R_E so the mirror will have the *I-V* behavior seen in Figure 2. Assume the maximum forward CB bias in saturation is $V_{CB} = -V_{SAT} = -500$ mV. Note that all transistors have infinite Early voltages.

Problem 2: Differential amplifier

Follow the outline procedure at the top of the exam with headings for each major step in the solution. **No points for answer without an outline of the solution. A mish-mash of calculations is not an acceptable outline.**

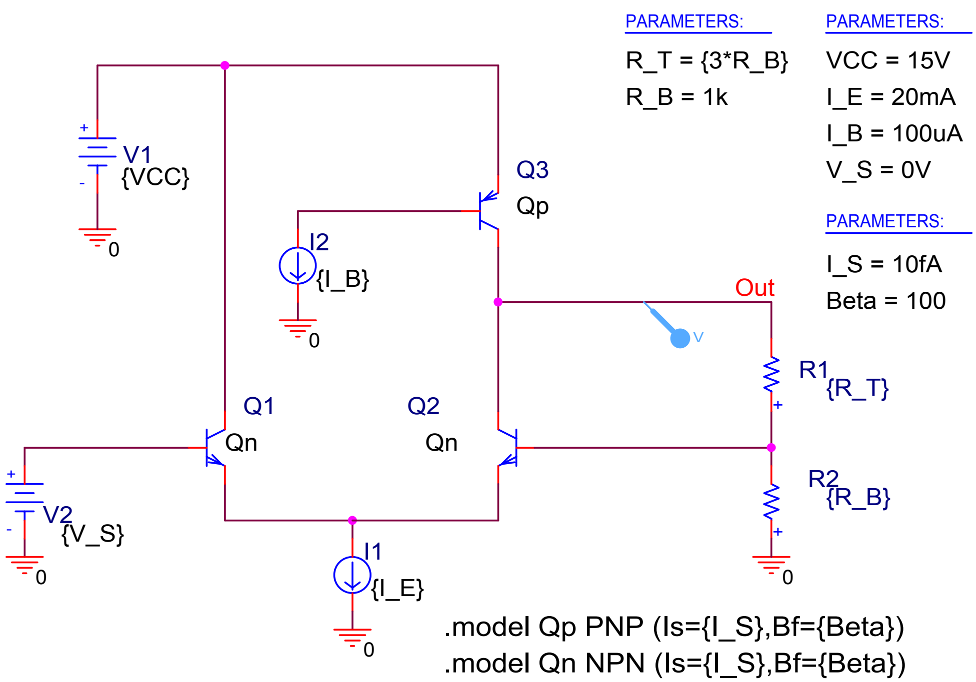

FIGURE 3

Differential amplifier hooked up as a noninverting op amp

For the amplifier in Figure 3

1. Sketch four schematics, one for each of the cases V_S = 10V, 2.5V, –5V and –15V. On each schematic label the modes of all transistors and the value of V_{OUT}.
2. Sketch the transfer curve V_{OUT} vs. V_S for $-15V \le V_S \le 15V$.
   2.1. Label all key break points with V_S- and V_{OUT}-coordinates.
   2.2. Label the slopes of all segments.
   2.3. Label the modes of all transistors in each segment of the transfer curve.

Assume the thermal voltage is V_{TH} = 25.864 mV. Assume the maximum forward CB bias is V_{CB}(npn) = V_{BC}(pnp) = $-V_{SAT}$ = 0 V, and that in active mode V_{BE}(npn)= V_{EB}(pnp) = 700mV. Note that all transistors have infinite Early voltages.

Problem 3: Feedback

Follow the outline procedure at the top of the exam with headings for each major step in the solution. **No points for answer without an outline of the solution. A mish-mash of calculations is not an acceptable outline.**

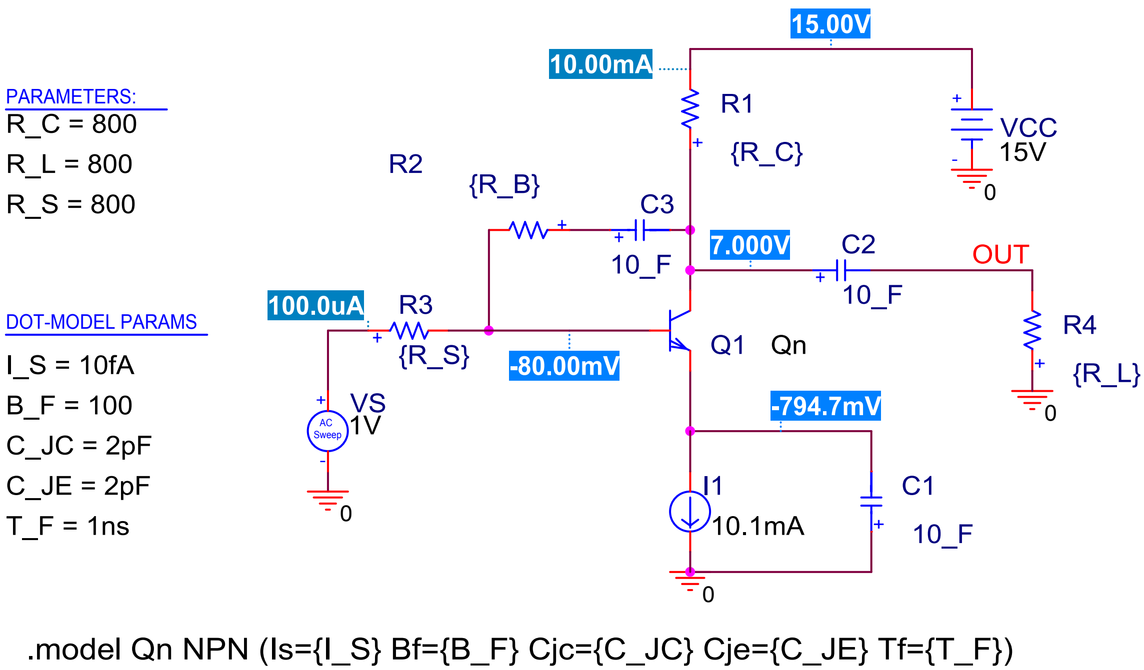

Figure 4

Common emitter amplifier

Select the value of resistor R_B to obtain a bandwidth of 6 MHz. Assume V_{TH} = 25.864 mV. Note that the transistor has infinite Early voltage.

Problem 4: Stability

Follow the outline procedure at the top of the exam with headings for each major step in the solution. **No points for answer without an outline of the solution. A mish-mash of calculations is not an acceptable outline.**

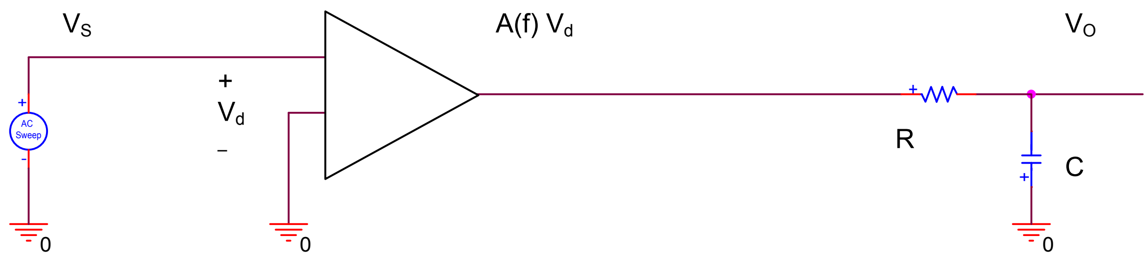

FIGURE 5

Open-loop amplifier; the op amp has infinite input resistance and zero output resistance

The amplifier of Figure 5 contains an RC-network to adjust its frequency response. For the amplifier of Figure 5, select C to make a feedback voltage amplifier using this open-loop amplifier exhibit a 30° phase margin when β_{FB} has a value of $1/\beta_{FB}$ = 30 dB. Use Bode plots to do your design. Assume the op amp has a gain function given by

EQ. 1

$$A(f) = \frac{A_0}{\left(1 + j\frac{f}{f_1}\right)\left(1 + j\frac{f}{f_2}\right)\left(1 + j\frac{f}{f_3}\right)},$$

with $A_0 = 10^5$V/V, $f_1 = 10^5$Hz, $f_2 = 10^6$Hz, and $f_3 = 10^7$Hz, and assume that the value of R = 10 MΩ. The op amp has infinite input resistance and zero output resistance