McGill

ECSE 304-334

ELECTRONIC CIRCUITS II

Final Examination
Dec. 13, 2005
2:00 PM - 5:00 PM

Examiner: Prof. G. Roberts GR
Associate Examiner: Prof. R. Khazaha

Name: ______________________________

Student No.: ______________________________

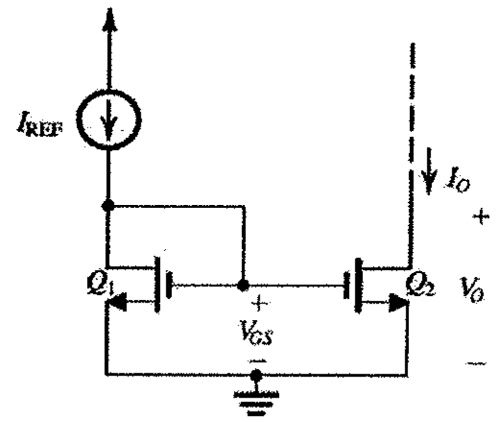
Special Notes:

- Answer all 5 questions.
- Questions have equal weight; Distribution is indicated in brackets.
- Answer directly on the question sheet provided. You may use the back of the sheet to continue your answer.
- Only the sheets provided will be marked.
- Closed-book exam; a one-sided crib sheet is allowed.
- Write your name and student number on the top of this sheet and on the top of each of the question sheets that you want marked.
- Closed-book exam.
- Only the faculty approved calculator is permitted.

Marking Scheme:

Q1 (10 points)	*Q2 (10 points)*	*Q3 (10 points)*	*Q4 (10 points)*	*Q5 (10 points)*	*Q6 (10 points)*	*TOTAL*

Question 1:



Consider the current-mirror circuit to the left with two transistors having equal channel lengths but with Q_2 having a width four times that of Q_1. Let $V_A = 25$ V.

(a) If I_{REF} is 20 μA and the transistors are operating at an overdrive voltage of 0.3 V, what I_o results? (2 points)

(b) What is the minimum allowable value of V_o for proper operation of the current source? (2 points)

(c) If V_t=0.5 V, at what value of V_o will the nominal value of I_o be obtained? (2 points)

(d) If V_o increases by 1 V, what is the corresponding increase in I_o? (2 points)

(e) Estimate the effective output resistance of this current mirror circuit. (2 points)

Question 2:

The high-frequency reponse of a direct-coupled amplifier having a dc gain of -100 V/V incorporates zeros at ∞ and 10^6 rad/s (one at each frequency) and poles at 10^5 rad/s and 10^7 rad/s (one at each frequency).

(a) Write an expression for the amplifier transfer function. (2 points).

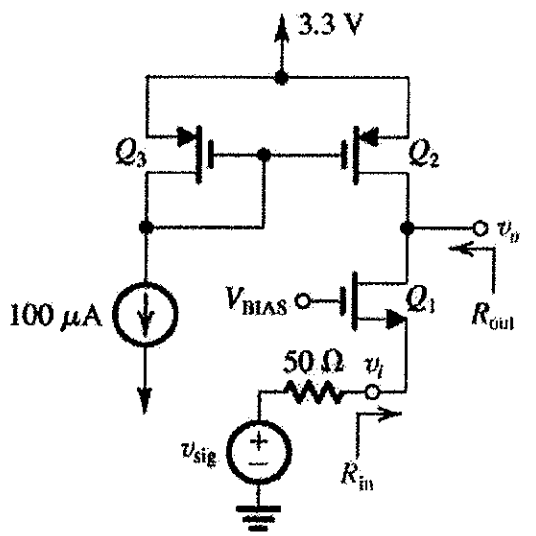
(b) Find ω_H using the dominant-pole approximation. (2 points).

(c) Find ω_H using the root-sum-of-squares approximation. (2 points).

(d) If a way is found to lower the frequency of the finite zero to 10^5 rad/s, what does the transfer function become? (2 points)

(e) For the condition specified in part (d) above, what is the 3-dB frequency (expressed in Hertz) of the resulting amplifier? (2 points).

Question 3:



In the common-gate amplifier circuit shown to the left, Q_1 and Q_2 are assumed to be matched with the following parameters:

$$\mu_n C_{OX}(W/L)_n = \mu_p C_{OX}(W/L)_p = 4\ mA/V^2$$

and all transistors have

$|V_t| = 0.8$ V,

$|V_A| = 20$ V.

Transistor Q_1 has $\chi = 0.2$.

The signal v_{sig} is a small sinusoidal signal wih no dc component.

Based on the information given above, answer the following questions.

(a) Neglecting the effect of V_A, find the dc drain current of Q_1 and the required value of V_{BIAS}. (2 points)

(b) Find the values of g_{m1} and g_{mb1} , and the output resistance r_o for all transistors. (2 points)

(c) Find the value of R_{in}. (1 point)

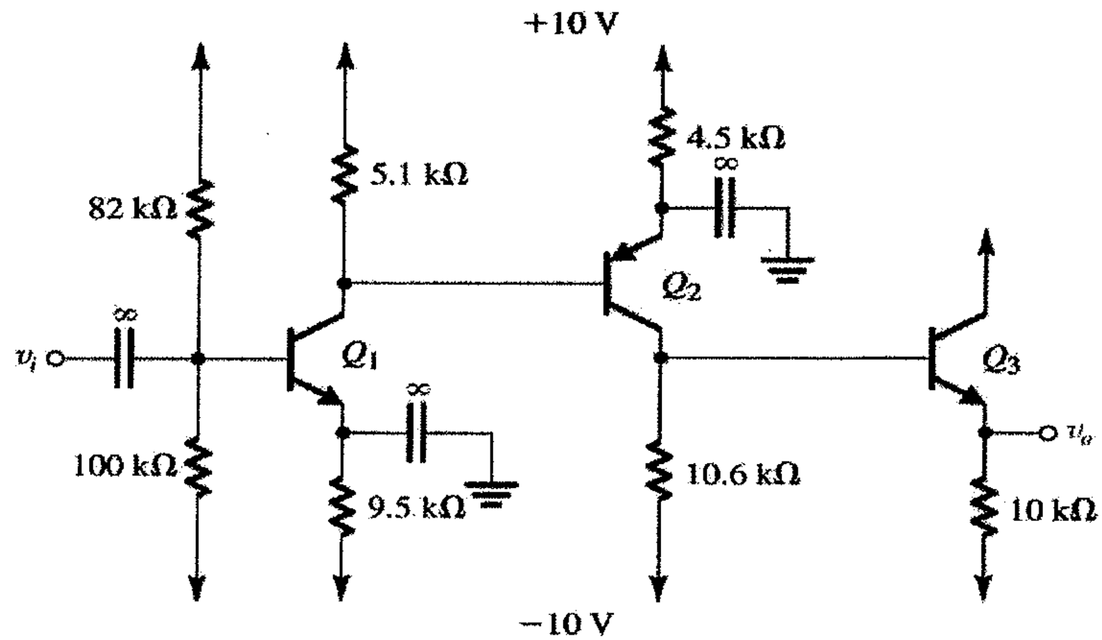
(d) Find the value of R_{out}. (1 point)

(e) Calculate the voltage gains v_o/v_i and v_o/v_{sig}. (2 points)

(f) How large can v_{sig} be (peak-to-peak) while maintaining saturation-mode operation for Q_1 and Q_2? (2 points)

Question 4:

The circuit on the left shows a circuit for a three-stage amplifier in which the stages are directly coupled. The amplifier, however, utilizes bypass capacitors, and, as such, its frequency response falls off at low frequencies. For our purposes here, we shall assume that the capacitors are large enough to act as perfect short circuits at all signal frequencies of interest. Assume $|V_{BE}| = 0.7$ V, $\beta=100$ and neglect Early effect. Also, neglect the base current in all DC bias calculations.



(a) Find the dc bias current in each of the three transistors. (2 points).

(b) Determine the dc voltage at the output. (1 point).

(c) Find the input and output resistance. (1 point)

(d) Compute the overall voltage gain v_o/v_i. (4 points)

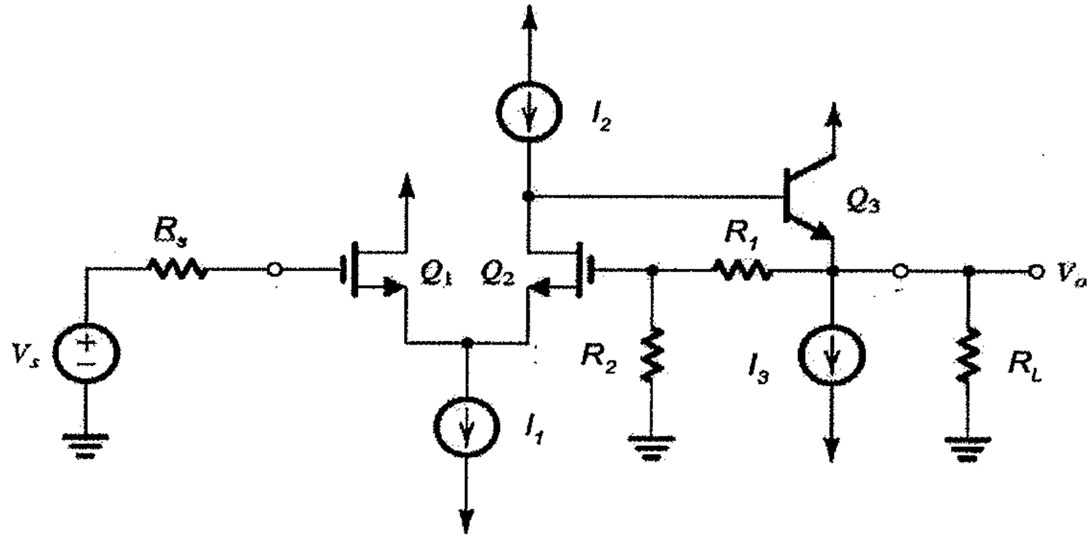
(e) Find the frequency of the high-frequency pole formed at the interface between the first and second stages. Assume that $C_{\mu2}$=2 pF and $C_{\pi2}$=10 pF. (2 points)

Question 5:

(a) Draw the block diagram of a single-loop negative feedback system. Label critical signals. (2 points)

(b) Provide four (4) advantages of incorporating negative feedback in an electronic circuit? (2 points)

(c) Assuming a single-loop negative feedback system, determine the corresponding parameters A, β and α, and its product Aβ for the following circuit. Draw the corresponding block diagram for this amplifier. Identify in the circuit above the location of the error signal used in your analysis. (5 points)



(d) What is the closed-loop gain A_f? (1 point)