MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Electrical Engineering and Computer Science

6.301 Solid State Circuits

Fall Term 2007

Midterm Quiz 10/18/07

This is an **open book** test. Make sure to show your work on the exam booklet as partial credits are given. Don't forget to put your name on the exam booklet. You will have to make reasonable approximations to do the problems quickly. You only need to calculate about **within about 5%** of an accurate value. Failing to make such approximations will result in unnecessarily complicated equations, so you may not be able to complete all the problems in 120 minutes.

Problem 1(10 points):

The circuit in Fig. 1 is intended to be used as a follower.

For Q_1: V_{BE}=0.6, $V_{CE,SAT}$=0.2, $\beta_F=\beta_o$=100, $r_o=\infty$ ($V_A=\infty$), and r_b=0

For M_2: $I_{DS}=(k'/2)(V_{GS}-V_T)^2$ for $V_{GS}>V_T$, k'=1mA/V^2, V_T=0.6, $V_{DS,SAT}=V_{GS}-V_T$, $r_o=\infty$ (λ=0). Ignore the body (back-gate) effect.

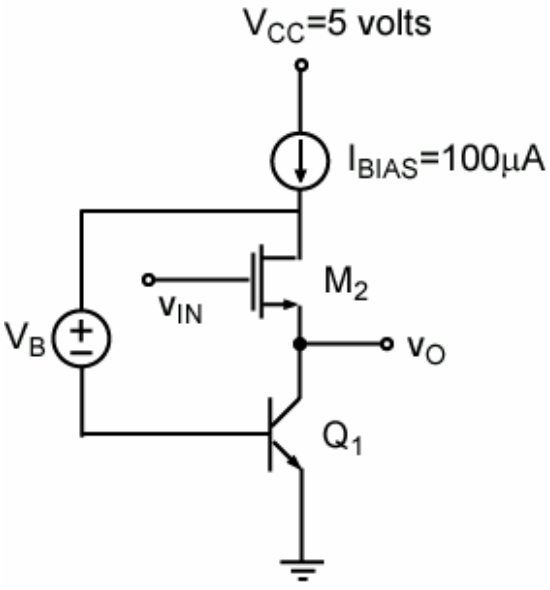

Fig. 1

a. Determine the DC output voltage V_O if V_{IN}=3 V.

b. Determine the range for V_B such that Q_1 operates in the forward active region, and M_2 in saturation.

c. Derive the Thevenin output resistance R_o in terms of incremental device parameters ($r_{\pi 1}$, g_{m1}, g_{m2}, etc.).

Problem 2(20 points):

The circuit in Fig. 2 is an amplifier circuit.

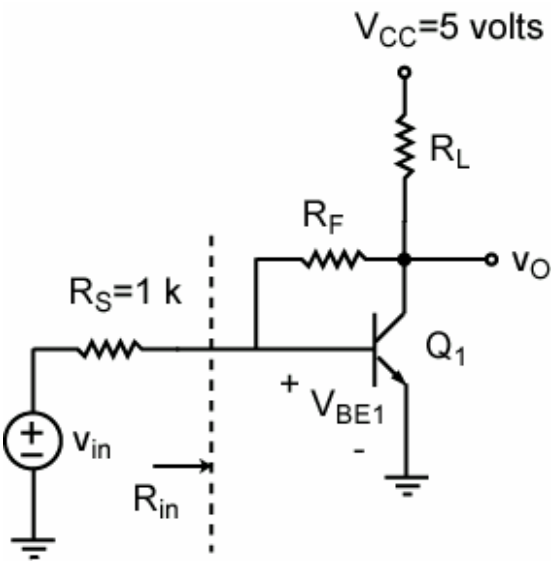

Fig. 2

Assume $\beta_F=\beta_o=100$, $r_o=\infty$ ($V_A=\infty$), and $r_b=0$, $C_\pi=20$pF, $C_\mu=1$pF, $C_{CS}=0$ for the transistor. Ignore any other transistor parasitic resistance or capacitance. The source v_{in} is an AC voltage source with DC voltage $V_{IN}=0$.

a. Find the DC output voltage V_O as a function of V_{BE1}, R_S, and R_F.

b. Determine the values of R_F and R_L such that the DC output voltage V_O=2.4 volts and I_C = 0.5 mA. Assume V_{BE1}=0.6 volt

b. Derive the expression for the input resistance R_{in} of the amplifier, then compute its numerical value.

c. Calculate open-circuit time constants.

Problem 3(20 points): Consider the following amplifier circuit.

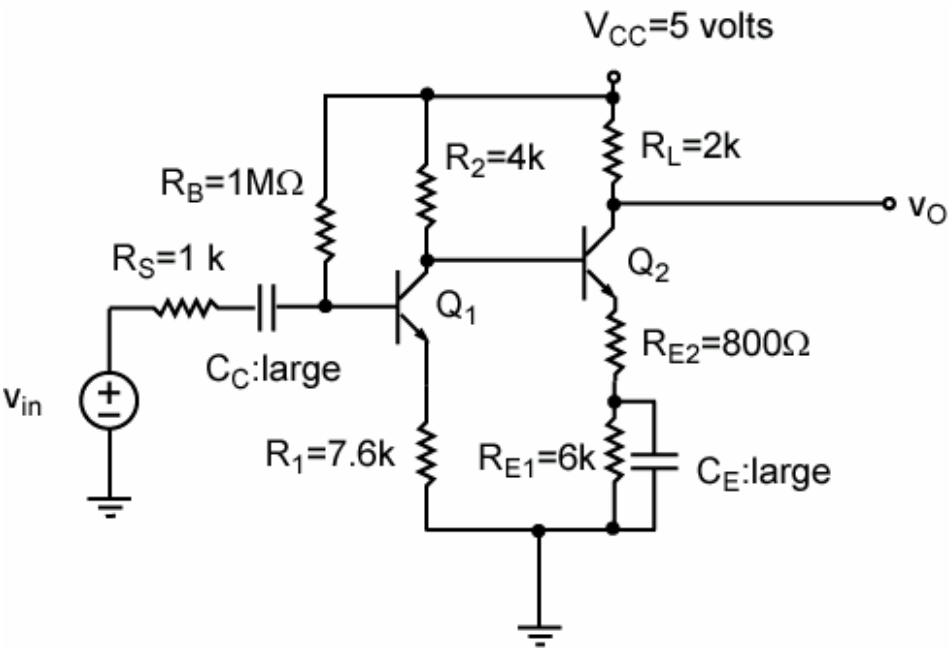

Fig. 3

$\beta_F=\beta_o=100$, $r_o=\infty$ ($V_A=\infty$), and $r_b=0$ for both transistors. Also, $C_\mu=1pF$, $C_\pi=20pF$ for all transistors. Ignore any other transistor parasitic resistance or capacitance. $V_{BE}=0.6$ volt for both transistors.

a. Find the DC currents and voltage I_{C1}, I_{C2} and V_O.

b. What is the midband gain of the amplifier? For this part, assume C_C and C_E are very large.

c. Compute open-circuit time constants for Q_1.

d. Compute open-circuit time constants for Q_2.

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