American University of Beirut
Department of Electrical and Computer Engineering
EECE 311 – Electronics II
Fall 2005 – 2006 (Section 2)
Quiz 2 – December 22, 2005
Closed Book – 90 minutes

NAME:_____ ID Number: _____

I have neither given nor received aid on this exam

SIGNATURE

Problem 1 [40 points]

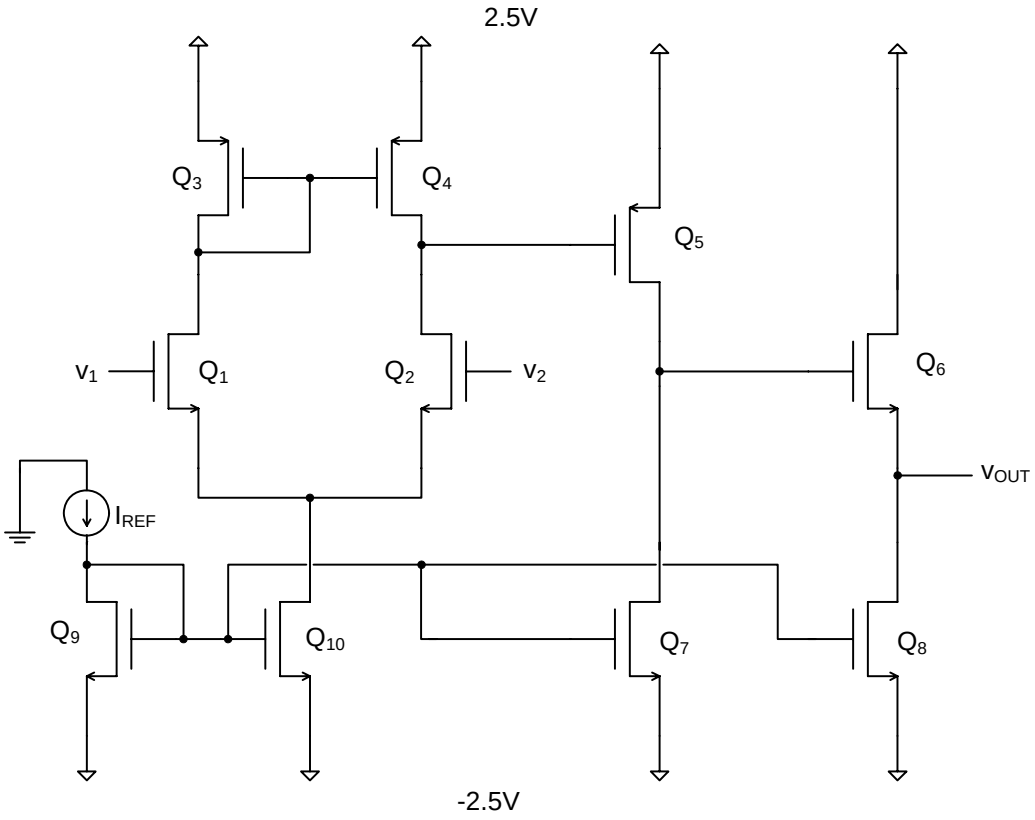

Figure 1

Refer to the MOSFET amplifier shown in Figure 1.

a) [5 points] How many stages are there? For each stage, identify the type of the stage, the amplifier transistor(s) and the load transistor(s).

Assume in the following that $k'_n = 250\ \mu A/V^2$, $V_{tn} = 0.5$ V, $\lambda_n = 0.05\ V^{-1}$, $k'_p = 100\ \mu A/V^2$, $V_{tp} = -0.6$ V, and $\lambda_p = 0.1\ V^{-1}$.

Assume I_{REF} = 100 μA, and that all MOSFETs have a (W/L) ratio equal to 20, except for of Q_5 which has (W/L) = 40.

Neglect channel length modulation in DC analyses.

b) [6 points] For each MOSFET, find the drain current and the overdrive voltage when $V_1 = V_2 = 0$. This condition ($V_1 = V_2 = 0$) results in $V_{OUT} = 0$. Show your results in the following format:

Transistor	Drain Current (μA)	Overdrive Voltage (V)
Q1		
Q2		
:		

c) **[4 points]** Find the total power dissipation in the circuit.

d) **[7 points]** Find the differential gain $A_d = v_{out}/(v_1 - v_2)$ by calculating $v_{d2}/(v_1 - v_2)$, v_{d5}/v_{d2}, and v_{out}/v_{d5}.

e) **[6 points]** Find the common-mode gain $A_{cm} = v_{out}/v_{icm}$ when $v_1 = v_2 = v_{icm}$. What is the common-mode rejection ratio of the amplifier (in dB)?

f) **[5 points]** Find the input common-mode range by calculating the maximum and minimum values of $V_1 = V_2 = V_{ICM}$ for which all MOSFETs are saturated.

g) **[2 points]** Find minimum output voltage V_{OUT} for which *all* MOSFETs remain saturated. What transistor determines this limit?

h) **[2 points]** Find the maximum output voltage V_{OUT} for which *all* MOSFETs remain saturated. What transistor determines this limit?

i) **[3 points]** A capacitor C_C is connected from the output node to the drain of Q_2. Neglecting all other capacitances in the circuit, find the frequency of the resulting zero and pole.

Problem 2 [10 points]

For a BJT differential amplifier, the value of β for the transistors varies between 100 and 140, around a mean value of 120. The transistors are biased using a 100 μA current source.

a) [4 points] Find the input bias and the input offset currents.

b) [2 points] The circuit uses collector resistors, each equal to 10KΩ, and emitter resistors, each equal to 150 Ω. Show the circuit diagram.

c) [4 points] Find the range of values for the differential input resistance.

Problem 3 [20 points]

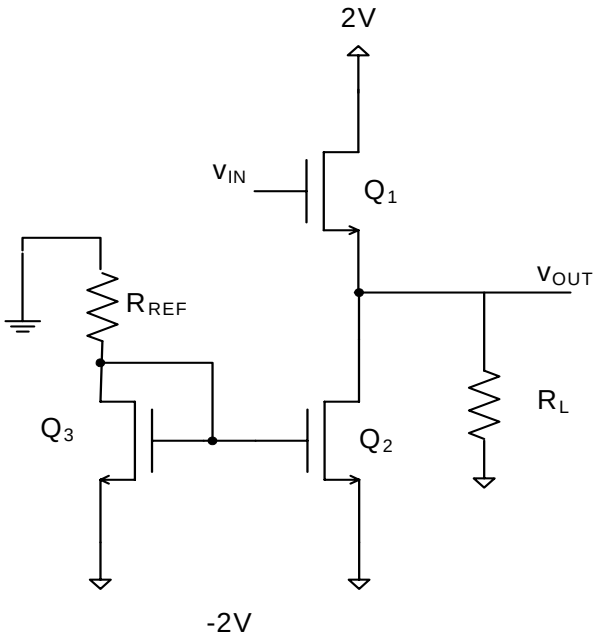

Figure 2

Refer to the circuit shown in Figure 2. The load resistor is R_L = 500 Ω. The MOSFETs have k'_n = 200 μA/V^2 and V_{tn} = 0.5 V.

a) [3 points] What type of output stage is this circuit?

b) [10 points] Calculate the values of R_{REF} and the (W/L) ratios for the MOSFETs so that the output ranges from –1.0 to 1.0 volts with the highest efficiency and smallest area. All MOSFETs should be in saturation over the range of operation. Assume that Q_2 and Q_3 are matched.

c) [7 points] Calculate the sine wave efficiency (power_into_load / total_power) for a sine wave output with an amplitude of 1 V. The total_power should include the power dissipated *in all circuit elements*.

Problem 4 [30 points]

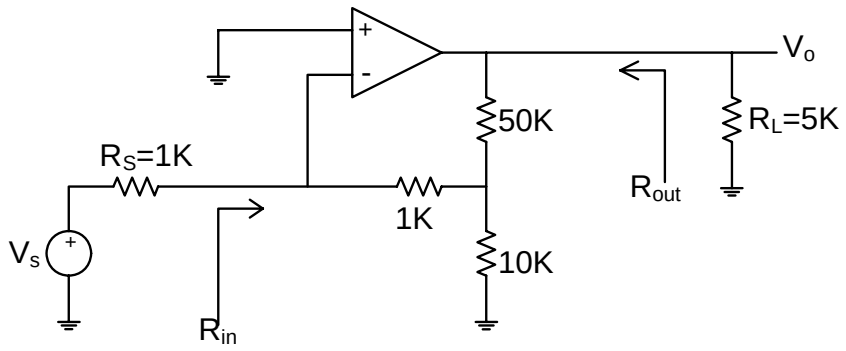

Figure 3

Consider the op-amp circuit shown in Figure 3.

a) [3 points] Determine the type of feedback used.

b) [10 points] The op-amp is modeled by a differential input resistance R_{id} = 100 KΩ, an open-circuit voltage gain of 5000, and an output resistance of 1 KΩ. Using feedback techniques, find the open-loop gain A. What are the units of A?

c) [4 points] Find the feedback factor β. What are the units of β?

d) [3 points] Find the closed-loop gain A_f.

e) [5 points] Using feedback techniques, find the input resistance R_{in}.

f) [5 points] Using feedback techniques, find the output resistance R_{out}.