ECE 137 A Mid-Term Exam

February 7, 2007

Do not open exam until instructed to.

Closed book: Crib sheet and 1 page personal notes permitted

There are 2 problems on this exam, and you have 50 minutes.

Use any and all reasonable approximations (5% accuracy is fine.), AFTER STATING and approximately Justifying them.

Name: _______________________

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Problem 1, 70 points

You will be working on the circuit below:

Q1:
\( \beta = 100, \ V_A = \infty \) V

Q2:
Use square-law model, \( V_{th} = 0.4 \) V, \( 1/\lambda = 20 \) V, \( \mu C_{ox} W_g / 2L_g = 2(mA/V^2) \cdot (W_g / 1 \mu m) \)

Cin, Cout, and Cee are very big and have negligible AC impedance.
Vee is +3 V, Vss is -3 V.
RL is 10 kOhm, Rgen is 10 kOhm.
Reac1 is 100 Ohms.
Part a, 7 points

DC bias.
The source of Q2 is to be biased at zero volts DC.
The drain current of Q2 is to be 2 mA.
Vgs of Q2 is to be 0.7 Volts
Q1 is to be biased at 1 mA
The base of Q1 is to be biased at +1 V.
The DC current in Rb2 is to be 20 times larger than the base current of Q1.

Find the following:
Rss2=_________  Wg (gate width of Q2)=______________  Rc1=__________
Ree1=_________  Rb1=_____________  Rb2=__________________
Part b, 7 points

DC bias

On the circuit diagram above, label the DC voltages at ALL nodes and the DC currents through ALL resistors.
Part c, 6 points

Find the small signal parameters of Q1 and Q2.

Transistor Q1:  \( \text{gm=} \underline{\text{______}} \quad R_{ce=} \underline{\text{________}} \quad R_{be=} \underline{\text{______}} \)

Transistor Q2:  \( \text{gm=} \underline{\text{______}} \quad R_{ds=} \underline{\text{______}} \)
Part d, 15 points.

Find the small signal voltage gain \((V_{s2}/V_{g2})\) of Q2 and Q2’s small-signal input resistance.

\[
V_{s2}/V_{g2} = ______________________
\]

\[
R_{in,q2} = ______________________
\]
Part e, 15 points

Find the small signal voltage gain ($V_{c1}/V_{b1}$) of Q1 and the **amplifier** input resistance.

$V_{c1}/V_{b1} =$ ______________________

$R_{in,amplifier} =$_____________________

Part f, 6 points

Find (Vout/Vin), (Vin/Vgen) and (Vout/Vgen)

(Vout/Vin) = ______________________________
(Vin/Vgen) = ______________________________
(Vout/Vgen) = ______________________________
Part g, 14 points

Now you must find the maximum signal swings. Find the output voltage due to saturation and cutoff in Q2. To save time, we are going to ignore saturation and cutoff of Q1, even though it might be important. Give the sign (+ or -) in your answers below.

Cutoff of Q2; Maximum $\Delta V_{out}$ resulting $=$ ______________________

Knee voltage of Q2; Maximum $\Delta V_{out}$ resulting $=$ ______________________
Problem 2, 30 points

You will be working on the circuit to the left.

Ignore DC bias analysis. You don’t need it.

Transistor 1 has transconductance $gm_1$. Transistor 2 has transconductance $gm_2$.

The drain-source resistances $R_{ds}$ of both transistors are infinity (so you don’t need to draw it!)

Part a, 12 points

Draw the small-signal equivalent circuit
Part b. 13 points

Find, by nodal analysis, a small-signal expression for Vout/Vin.

Vout/Vin = __________________
Part c, 5 points

gm1 = 10 mS  gm2 = 20 mS
Give a numerical value for Vout/Vin.

Vout/Vin = __________________