ECE 584
Chapter 3 Homework

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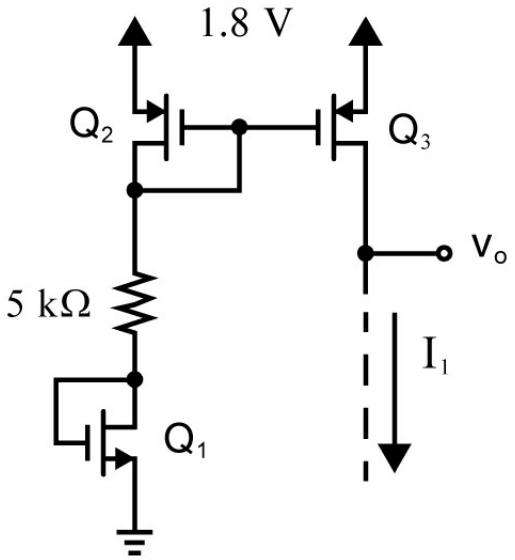
Due: Complete before Midterm Exam

Problem 1. (Current Source Design)

Consider the current source shown below. FETs Q_2 and Q_3 are matched. Rather than the 1.8 Volt supply pictured, assume $V_{DD} = 3.3$ Volts.



(a) Determine the shape factor of Q_1 so that V_{GS} is 1.0 Volts.

(b) Determine the shape factor of Q_2 and Q_3 so that V_{SG} for these devices is 1.0 Volts.

(c) What is the DC output current, I_1?

(d) Size all transistors so that the output resistance of the current source is at least 500 $k\Omega$.

(e) What is the compliance of the mirror?

(f) Clearly indicate the size (W, L, and m values) for all FETS on the Figure.

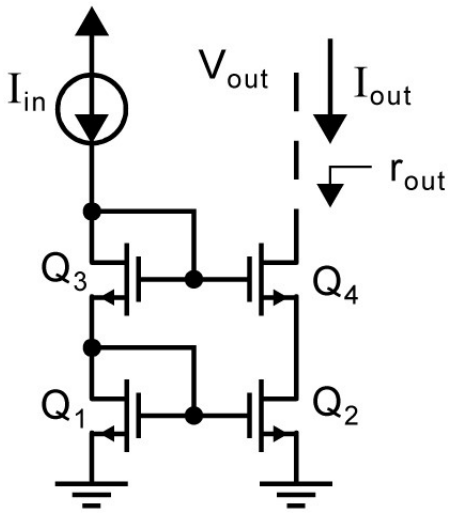
Problem 2. (Cascode Current Source Mirror)

Consider the cascode current source shown in the figure below. Assume that transistors Q_1 and Q_2 are matched. Also, assume that transistors Q_3 and Q_4 are matched. Please neglect any body effects.

(a) Draw a small-signal equivalent circuit.

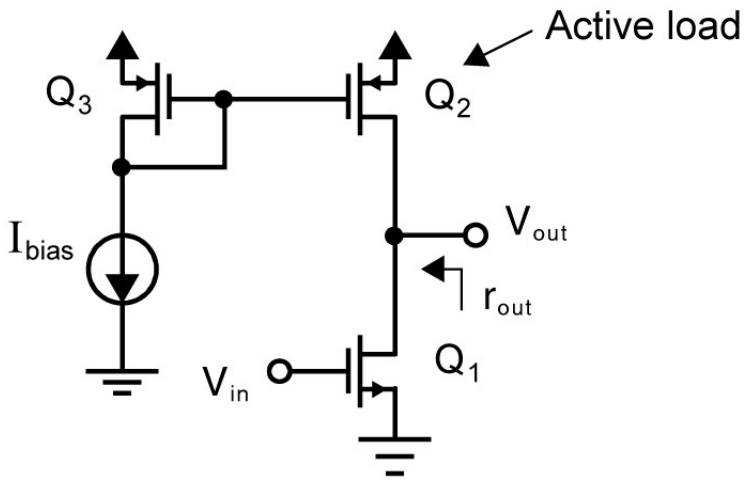
(b) Derive an expression for the small-signal output resistance of the circuit. Make any resonable approximations so as to simplify the resulting expression.

(c) What is the output compliance of the mirror?



Problem 3. (Design of a Common Source Amplifier)

Consider the common source amplifier with active load pictured below. Assume $V_{DD} = 3.3\ V$ and that I_{bias} is 15 μA. Moreover, assume Q_2 and Q_3 are matched. The length of all devices is 3 μm.



(a) Choose $\theta_1 = 3$ and compute the transconductance of transistor, Q_1.

(b) What is the saturation *i.e.* the effective voltage of transistor, Q_1?

(c) Determine the shape factor of Q_2 so that the effective voltage of the device is 400 mV.

(d) Determine the output resistance of the amplifier?

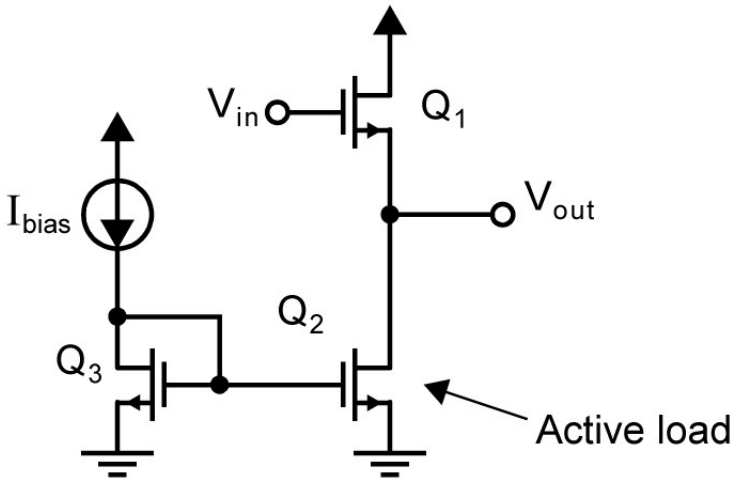
(e) What is the low-frequency gain of this CS amplifier?

(f) What is the amplifier's maximum voltage swing?

(g) Clearly indicate the size (W, L, and m values) for all FETS on the Figure.

Problem 4. (Design of a Source Follower)

Consider the source follower pictured below. Assume $V_{DD} = 3.3\ V$ and that I_{bias} is 15 μA. Moreover, assume Q_2 and Q_3 are matched. The length of all devices is 3 μm. The NFET, Q_1 does suffer from the body effect since the source of the device will be at ground potential.



(a) Choose $\theta_1 = 3$ and compute the transconductance of transistor, Q_1.

(b) What is the saturation *i.e.* effective voltage of transistor, Q_1?

(c) Determine the shape factor of Q_2 so that the saturation voltage of the device is 400 mV.

(d) Determine the output resistance of the amplifier?

(e) What is the low-frequency gain of this source-follower circuit?

(f) What is the amplifier's maximum voltage swing?

(g) Clearly indicate the size (W, L, and m values) for all FETS on the Figure.

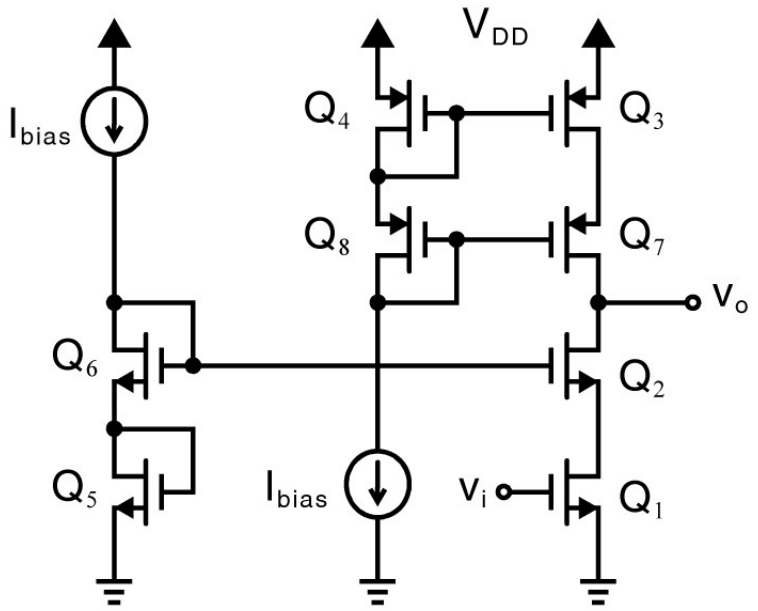
Problem 5. (Single-Ended Cascode Amplifier)

Consider the cascode amplifier depicted on the following page. Assume $V_{DD} = 3.3\ V$ and that I_{bias} is 15 μA. Transistors Q_3, Q_4 are matched as well as Q_7, and Q_8. Moreover, assume transistors Q_2, Q_5 and Q_6 are matched. The length of all devices is 3 μm.

(a) Choose $\theta_1 = 3$ and compute the transconductance of transistor, Q_1.

(b) What is the saturation *i.e.* effective voltage of transistor, Q_1?

(c) Determine the shape factor of Q_2 so that the saturation voltage of the device is 250 mV.



(d) Determine the shape factor of Q_3 so that the saturation voltage of the device is 250 mV.

(e) Determine the shape factor of Q_7 so that the saturation voltage of the device is 250 mV.

(f) Determine the output resistance of the amplfier?

(g) What is the low-frequency gain of the cascode amplfier?

(h) What is the amplifier's maximum voltage swing?

(i) Clearly indicate the size (W, L, and m values) for all FETS on the Figure.