ECE-255
Exam 3
April 8, 2015

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(Please print clearly)

Student ID: _____

INSTRUCTIONS

1) This is a closed book, closed notes exam.

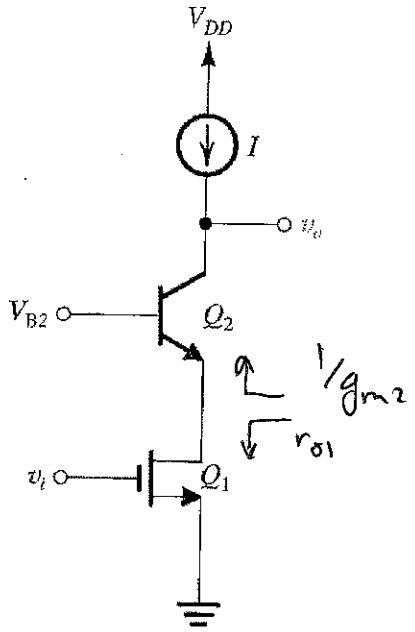
2) Clearly mark your multiple choice answers in the test booklet.

3) When the exam ends, all writing is to stop. This is not negotiable. No writing while turning in the exam/scantron or risk an F in the exam.

4) All students are expected to abide by the customary ethical standards of the university, i.e., your answers must reflect only your own knowledge and reasoning ability. As a reminder, at the very minimum, cheating will result in a zero on the exam and possibly an F in the course.

5) Communicating with any of your classmates, in any language, by any means, for any reason, at any time between the official start of the exam and the official end of the exam is grounds for immediate ejection from the exam site and loss of all credit for this exercise.

1) For the BJT-MOS cascode amplifier shown below what is the gain (vo/vi)? Assume I=1 mA, for BJT (β=100, V_A=100V) for MOS (k_n=100 μA/V^2, and λ=0). V_T=25 mA



(1) 1 (2) -90 **(3) -45** (4) -25 (5) -4000

(6) None of the above

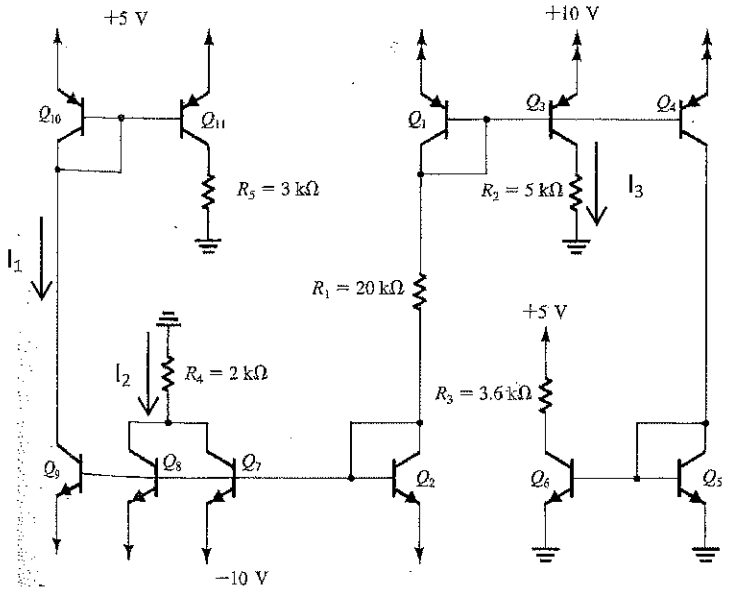
$$A_v = (-g_{m1} \cdot R_{L1})(g_{m2} R_{L2})$$

$$= \left(-g_{m1} \cdot \frac{1}{g_{m2}}\right)(g_{m2} \cdot r_{o2}) = -g_{m1} r_{o2}$$

$$g_m = \sqrt{2 k_n I_D} \qquad r_{o2} = V_A / I$$

$$\text{Gain} = -\sqrt{2 \times 100 \times 10^{-6} \times 10^{-3}} \cdot \frac{100}{10^{-3}} = -45$$

2) What are the value of currents I_1, I_2, and I_3 for the circuit shown below, assume all transistors have equal BE area. $V_{BE(ON)}$=0.7 V, V_T=25 mV



(1) I_1=0.93mA, I_2=1.86mA, I_3=0.93mA

(2) I_1=0.93mA, I_2=0.93mA, I_3=0.93mA

(3) I_1=1.86mA, I_2=1.86mA, I_3=0.93mA

(4) I_1=0.96mA, I_2=1.93mA, I_3=0.96mA

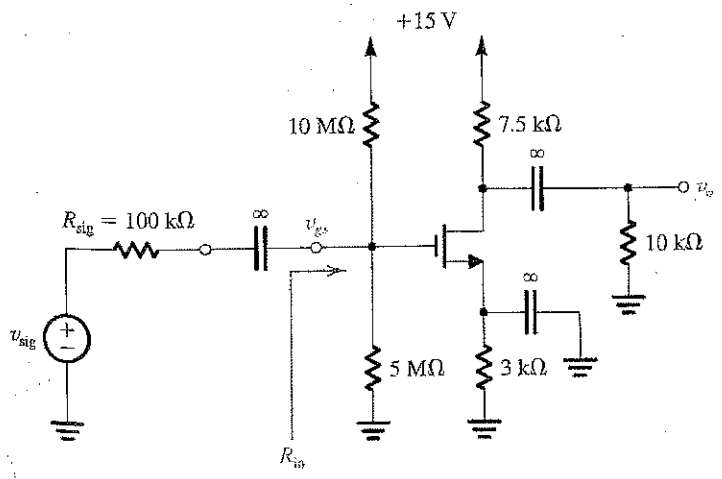
(5) I_1=0.93mA, I_2=1.86mA, I_3=1.86mA

(6) None of the above

$$I_{ref} = \frac{20 - 1.4}{20} = 0.93\ mA$$

$$\begin{cases} I_1 = 0.93\ mA \\ I_2 = 1.86\ " \\ I_3 = 0.93\ " \end{cases}$$

3) What is the input impedance of the common source amplifier shown below? Assume V_t=1V, K_t=1 mA/V^2, λ=0

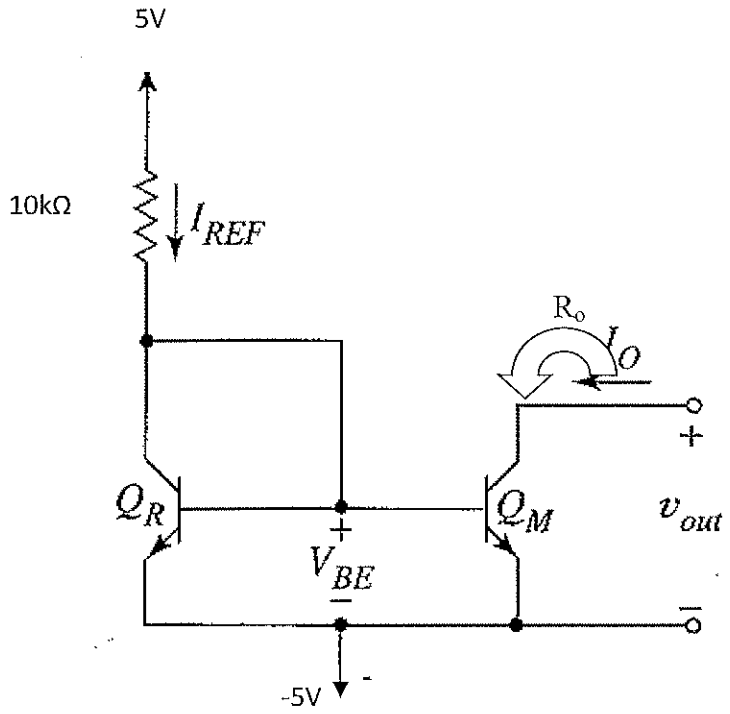


(1) ∞ (2) 5 MΩ (3) 3 kΩ (4) 3.3 MΩ (5) 10 MΩ

(6) None of the above

$R_{in} = 10^M \| 15^M = 3.3\ M\Omega$

4) What is the value of output impedance (R_o) for the current mirror shown below? Assume $\beta=\infty$, $V_{BE(ON)}=0.7V$, $V_A=100V$. Q_1 and Q_2 have the same BE areas.



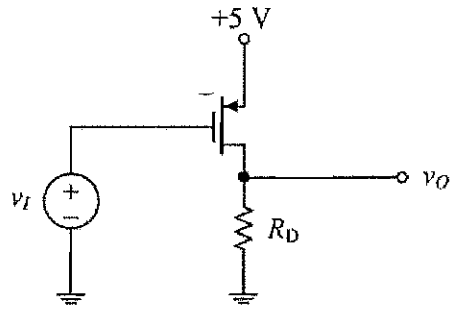
(1) ∞ (2) 232kΩ **(3) 107kΩ** (4) 0 (5) 116kΩ

(6) None of the above

$$I_{ref} = \frac{10 - 0.7}{10} = 0.93 \text{ mA}$$

$$r_o = V_A / I_o = \frac{100}{0.93 \times 10^{-3}} = 107 \text{ k}\Omega$$

5) For the MOSFET amplifier shown below, what is the gain? Assume R_D =10 kΩ



MOSFET Parameters:

$K_p = 0.25$ mA/V^2
$V_{TP} = -1$ V
$\lambda = 0$ V^{-1}

(1) -50 (2) -10 (3) -25
(4) -100 (5) -150 (6) None of the above

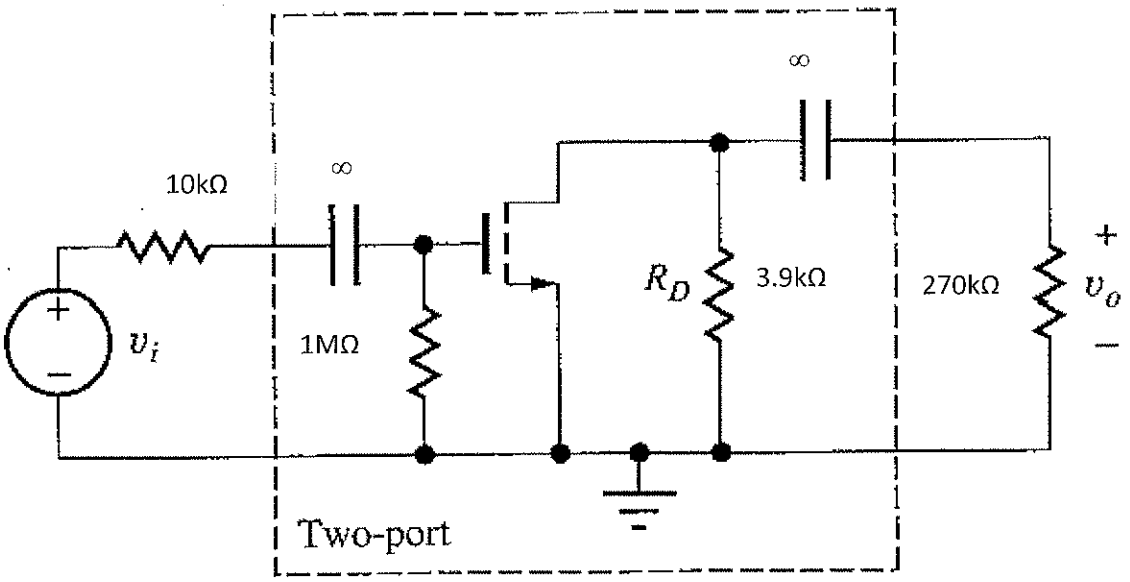
$V_{SGQ} = 5\,V \qquad I_D = \frac{K_p}{2}(V_{SGQ} - |V_{tp}|)^2$

$I_D = \frac{0.25 \times 10^{-3}}{2}(5-1)^2 = \boxed{2}$ mA

$Gain = -g_m R_D = -\sqrt{2K_p I_D}\cdot R_D$

$Gain = \boxed{-10}$

6) What is the absolute value of the voltage gain ($|v_0/v_i|$) for the amplifier whose ac equivalent circuit is shown below? Assume the MOSFET Q points are (2mA, 7.5V), K_n=1mA/V^2, and λ=0



(1) 16 **(2) 8** (3) 540 (4) 25

(5) gain is zero since we ignored the channel length modulation

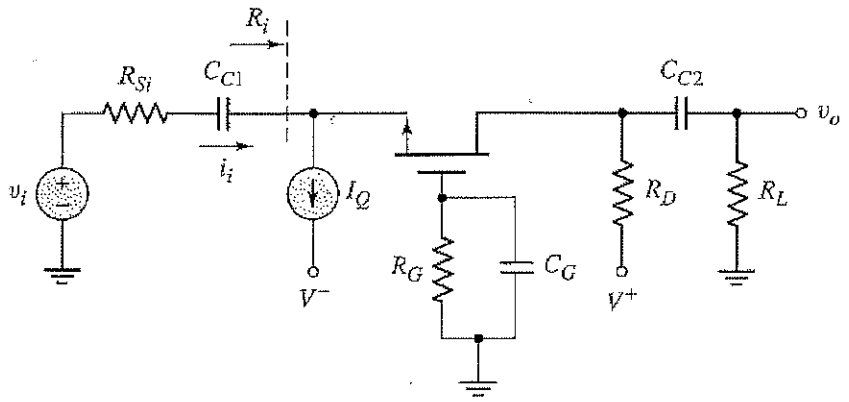
(6) None of the above

$$\frac{v_o}{v_i} = g_m R_D = \sqrt{2 K_n I_D} \cdot R_D$$

$$= \sqrt{2 \times 10^{-3} \times 2 \times 10^{-3}} \cdot 3.9 \times 10^{3} = 7.8$$

$$\sim 8$$

7) For the amplifier shown below, what is the configuration? What is the input impedance R_i? R_{si}= 50kΩ, R_G=200kΩ, R_D=10 kΩ, and R_L=1 kΩ. Assume I_Q=1mA, V_{TN}=1V, K_n=100 μA/V^2, λ=0



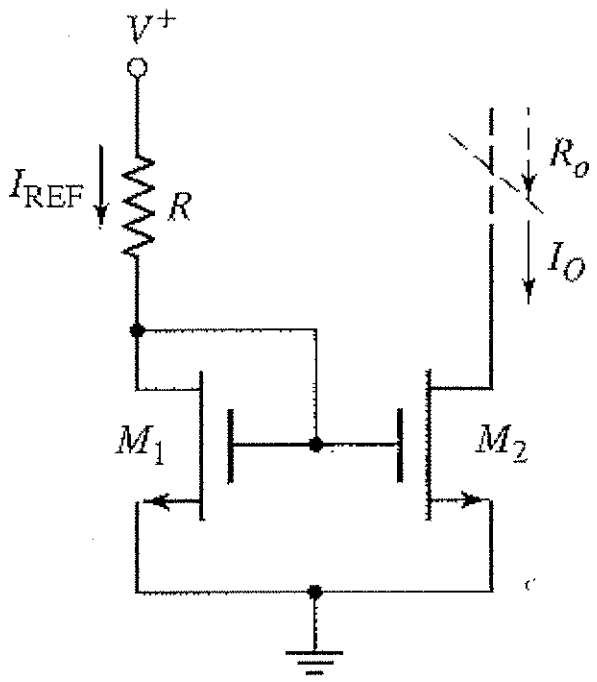
(1) ∞ **(2) 2.24 kΩ** (3) 200 kΩ (4) 100Ω

(5) 5 kΩ (6) none of the above

$$R_{in} = \frac{1}{g_m} = \frac{1}{\sqrt{2K_n I_D}} = \frac{1}{\sqrt{2 \times 100 \times 10^{-6} \times 10^{-3}}}$$

$$R_{in} = 2.24\ K\Omega$$

8) For the MOS current mirror shown below what is the value of Io? Assume V^+=2.5V, R=15 kΩ, V_t=0.5V, Kn'=80μA/V^2, $(W/L)_1$=10, $(W/L)_2$=30, λ=0.



(1) 1mA (2) 0.1 mA (3) 3 mA (4) 6 mA

(5) 0.3 mA (6) None of the above

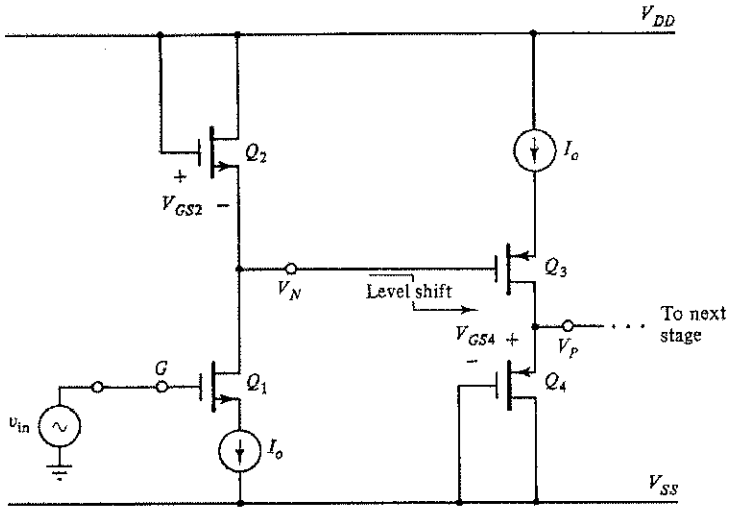
$$2.5 = R I_{ref} + V_{GS1} = R \frac{K_n}{2} (V_{GS1} - V_T)^2 + V_{GS1}$$

$$\Rightarrow \text{Solve for } V_{GS1} = V_{GS2} = 1\ V$$

$$I_{ref} = \frac{2.5 - 1}{15 \times 10^3} = 0.1\ mA$$

$$I_o = 3 I_{ref} = 0.3\ mA$$

9) What is the configuration of the two stage MOS amplifier shown below?



(1) Common source-common drain

(2) Common source-common source

(3) Common drain-Common Source

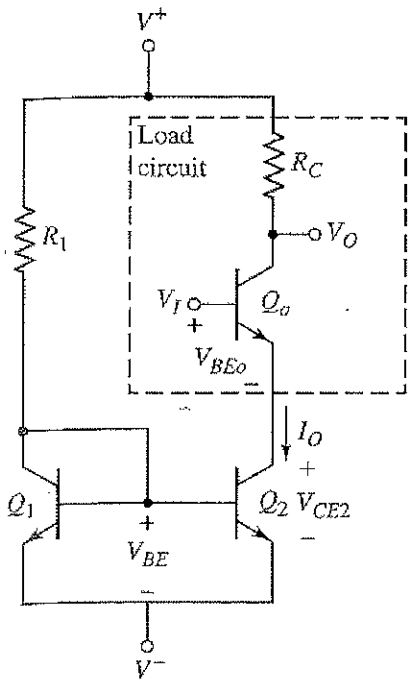
(4) Common drain-Common drain

(5) Common source-Common gate

(6) None of the above

10) The common emitter amplifier below is biased by a current source. What is the amplifier gain? Assume V+=5V, V-=-5V, R_1=9.3 kΩ, R_C=10 kΩ.

All transistors are identical and β=50, V_A=∞, $V_{BE(ON)}$=0.7V, V_T=25mV.



(1) -1 (2) -200 (3) 540 (4) -400

(5) -50 (6) None of the above

$$I_{ref} = \frac{10 - 0.7}{9.3} = 1 \text{ mA} = I_o$$

$$G_{oin} = -g_m R_c = -\frac{I_o}{V_T} \cdot R_c = -\frac{1}{25} \times 10^4$$

$$G_{oin} = -400$$