# EE140/240A Problem Set 4

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February 12, 2024

For all the problems in this exam, assume $\mu_n C_{ox} = 0.5\text{mA/V}^2$ , $V_{Tn} = 0.3\text{V}$, for the NMOS transistors, assume $\mu_p C_{ox} = 0.4\text{mA/V}^2$ , $V_{Tp} = 0.4\text{V}$, for the PMOS transistors. Also, assume that the channel length modulation parameter $\lambda = 0$, unless otherwise mentioned. Numbers adjacent to the MOS transistors indicate the (W/L) ratio of the transistors. Assume all capacitors and inductors are infinite.

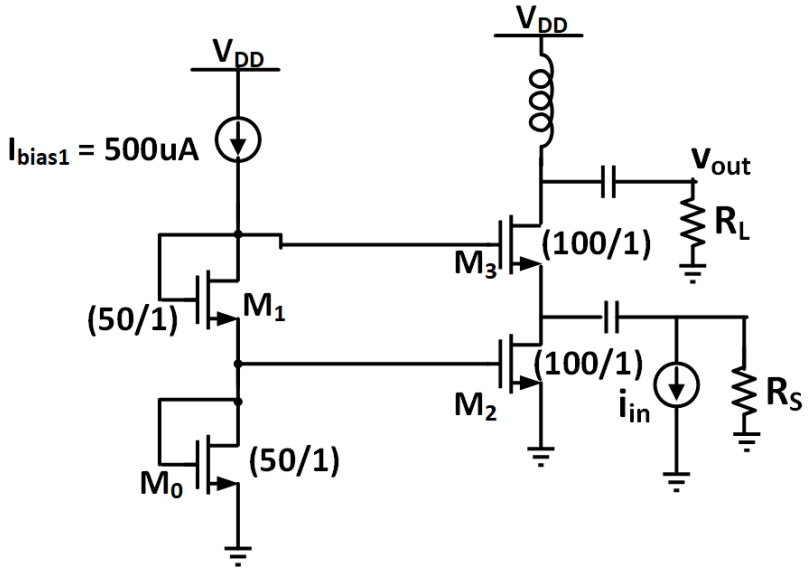


Figure 1: Problem 1

**Problem 1.** (a) The current source $I_{bias1}$ needs a minimum headroom of 0.3V. With this constraint, what is the minimum possible $V_{DD}$? Use this calculated value of $V_{DD}$ for subsequent parts.

(b) Assume $R_S = 100\Omega$, $R_L = 400\Omega$ for this part and the next part. Compute the small-signal gain $v_{out}/i_{in}$.

(c) Assume $i_{in}$ is a sinusoid of the for $A\sin(\omega_0 t)$. What is the maximum amplitude $A$ such that all transistors remain in saturation?

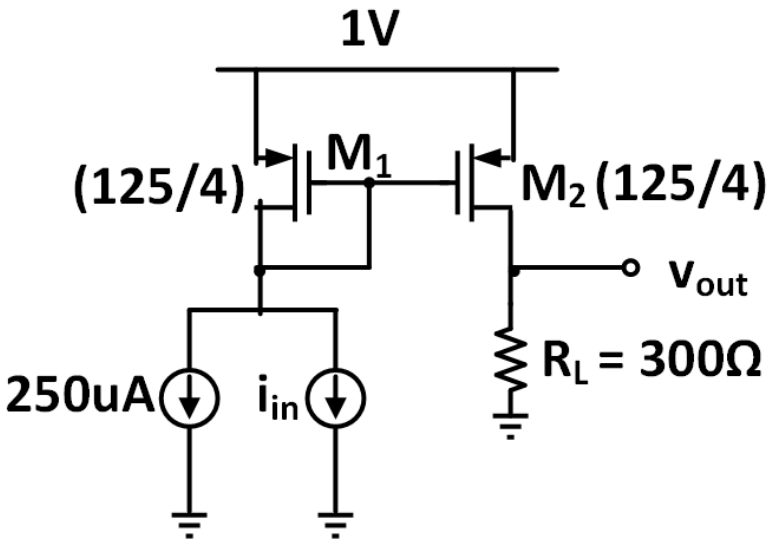


Figure 2: Problem 2

**Problem 2.** 1. Compute the DC operating point of the circuit in Fig. 2, that is, compute the gate voltage of the transistors $M_1/M_2$, and the drain current of $M_2$.

2. Compute the small-signal gain $v_{out}/i_{in}$.

3. Assume $i_{in}$ is a sinusoid of the for $A\sin(\omega_0 t)$. What is the maximum amplitude $A$ such that all transistors remain in saturation?

**Problem 3.** (a) Compute the DC operating point of the circuit in Fig. 2, that is, compute the drain of the transistors $M_1/M_2$, and the DC voltage at node $v_{out}$.

(b) In parts (b) and (c), assume $v_{in2} = 0$. Compute the small-signal gain $v_{out}/v_{in}$. What kind of amplifier/controlled source is this?

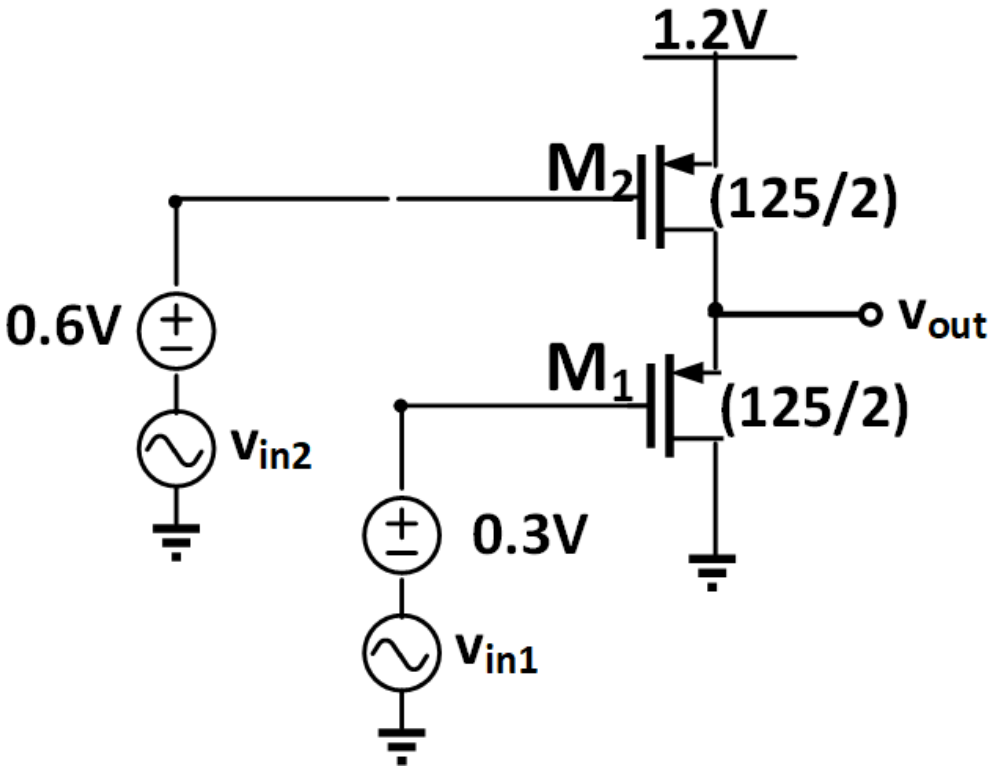


Figure 3: Problem 3

(c) Assume $v_{in1}$ is a sinusoid of the for $A\sin(\omega_0 t)$. What is the maximum amplitude $A$ such that all transistors remain in saturation?

(d) In parts (b) and (c), assume $v_{in1} = 0$. Compute the small-signal gain $v_{out}/v_{in}$. What kind of amplifier/controlled source is this?

(e) Assume $v_{in2}$ is a sinusoid of the for $A\sin(\omega_0 t)$. What is the maximum amplitude $A$ such that all transistors remain in saturation?

**Problem 4.** Assume a finite $r_o$ for the transistors in this question.

(a) What is the output resistance $R_{out}$ for the circuit in Fig. 4(a). Give your answer symbolically in terms of $r_{o1}$, $g_{m1}$, the small-signal parameters of $M_1$, and also the resistor $R_S$.

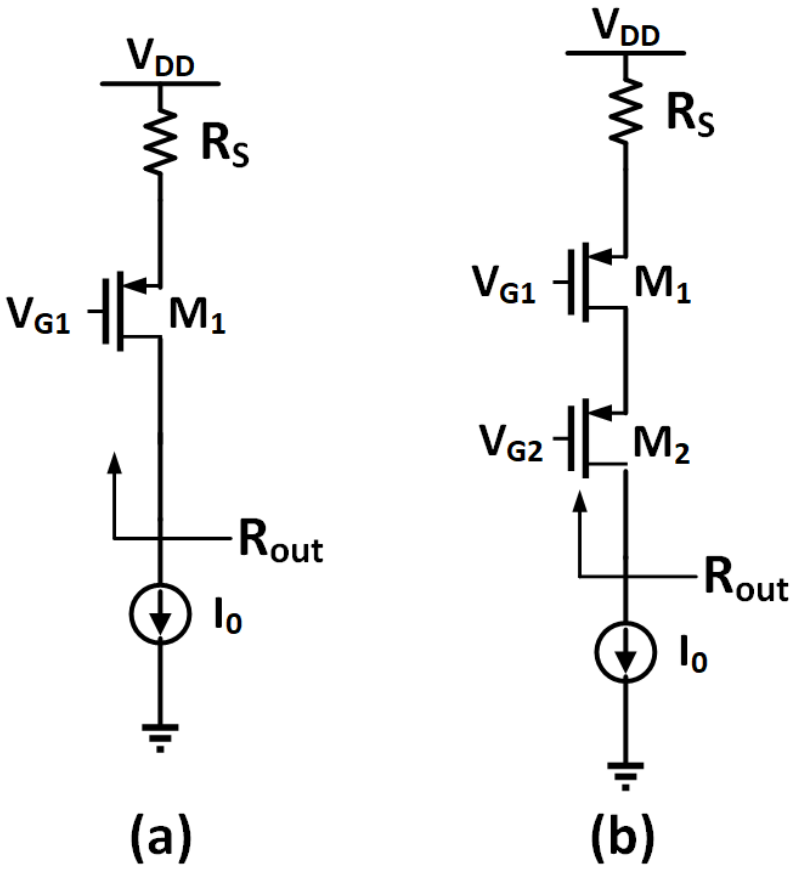


Figure 4: Problem 4

(b) What is the output resistance $R_{out}$ for the circuit in Fig. 4(b). Give your answer symbolically in terms of $r_{o1}$, $g_{m1}$, $r_{o2}$, $g_{m2}$, the small-signal parameters of $M_1$ and $M_2$, respectively, and also the resistor $R_S$.