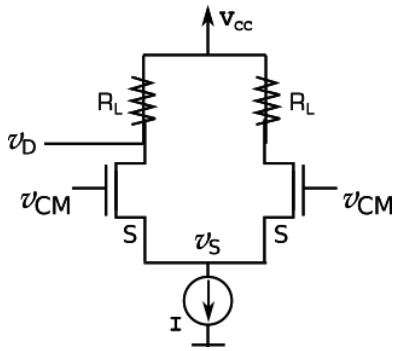
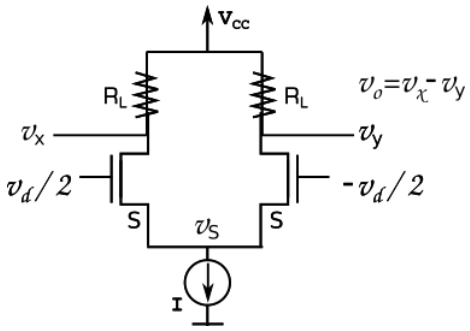
CSU0007 Basic Electronics, Homework 7

- Submit your work via Moodle before **5PM, Jan. 14th**. The solution will be available right after for you to prepare for the final exam on Jan. 15th.

1. (50 points) For the following difference amplifier, suppose that I=0.64mA, V_{CC}=3V, R_L=2kΩ, K=1mA/V^2, V_T=1V, and v_{CM}=2V.
    1. (40 points) Suppose that both MOSFET operates under the saturation discipline. Compute large signals v_D and v_S.
    2. (10 points) Determine the maximum possible v_{CM} for both MOSFET to remain in saturation.



2. (30 points) In class, we've shown that $A_d = \frac{v_o}{v_d} = -g_m R_L$ for a difference amplifier:

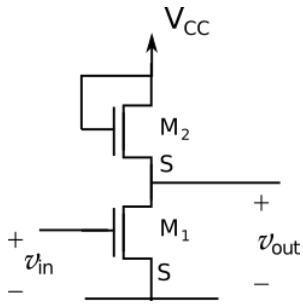


   Now, assuming both MOSFETs are identical, show that, approximately, $A_d = -R_L\sqrt{K}\sqrt{I}$.

   Hint: Consider that current $I/2 + \Delta i$ flowing through the left MOSFET and that current $I/2 - \Delta i$ flowing through the right MOSFET, where Δi is of a small quantity.

   This result gives us an insight: in order to improve the small-signal voltage gain, we may choose to increase I the biasing current. In this way we keep R_L the same, and thus the output resistance remains unchanged :)

3. (20 points) We've learned a way to wire a MOSFET for it to work like a resistor for a small-signal. Now, consider the following inverting amplifier, with the load resistor replaced by MOSFET M_2 (with parameter $K = K_2$). Suppose that M_1 (with parameter $K = K_1$) operates under the saturation discipline:



Show that the small-signal voltage gain, $\frac{v_{out}}{v_{in}}$, is equal to $-\sqrt{\frac{K_1}{K_2}}$.

Hint: The same amount of current should flow through both M_1 and M_2.

This result suggests a cool feature: recall that parameter K for a MOSFET is in portion to the geometric length (L) and width (W) of the channel between source and drain, i.e., $K = K'(\frac{W}{L})$. Assuming that the two MOSFETs have identical K' and L, then essentially, we may setup the voltage gain of this circuit by building the MOSFETs with the calculated relative channel widths :)