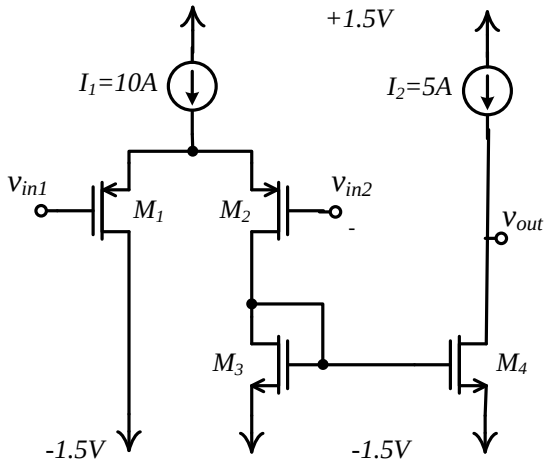
Student Name:

Student ID:

EHB262E Electronics II
Homework 3

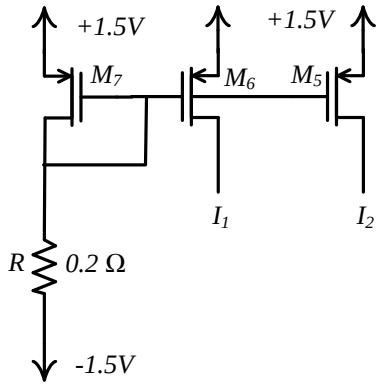
Deadline: 20/12/2012 (before the lecture)



Transistor	L (µm)	W (µm)
M_1	1	50
M_2	1	50
M_3	1	20
M_4	1	20

Differential Amplifier with Ideal Current Sources

Consider a differential amplifier shown above. Replace the ideal current sources with the transistor-level current sources shown below, so you have a differential amplifier with 7 transistors and a resistor. Answer all the following questions considering this amplifier.
Assume that all MOSFETs are operating in saturation region. Also assume that input and output DC operating points are all **zero**. Transistors have the following parameters: $k_p' = \mu_p c_{ox} = 45A/V^2$, $k_n' = \mu_n c_{ox} = 80A/V^2$, $V_{An}=500$, $V_{Ap}=50V$, $V_{T0,p}=-0.9V$, $V_{T0,n}=1V$.



Transistor	L (µm)	W (µm)
M_5	1	10
M_6	1	20
M_7	1	20

Current Sources in Transistor-level

a) Calculate the small signal differential gain $\boldsymbol{v_{out} / (v_{in1} - v_{in2})}$.
   - Assume that I_1=10A and I_2=5A.

b) Calculate the small signal common-mode gain $\boldsymbol{v_{out} / v_{in}}$ where $\boldsymbol{v_{in1} = v_{in2} = v_{in}}$.
   - Assume that I_1=10A and I_2=5A.

c) Calculate **CMRR**.

d) To verify your calculated result, find $v_{out} / (v_{in1} - v_{in2})$, v_{out} / v_{in}, and **CMRR** using SPICE.

- Use FDR840P and FDR6580 SPICE models for PMOS and NMOS transistors, respectively.
- To make the output DC operating point zero, apply a DC offset to v_{in1} (It should be around 7.8mV).
- Use a sine signal with 1mV peak-to-peak amplitude and 1kHz frequency as a small signal voltage source.

Grading: a) 20%, b) 20%, c)10%, d)50%

Note: *Do not forget to attach SPICE **output file** prints to your homework!*