ECE 3150: Microelectronics

Spring 2015

Homework 8   **Due on April 09, 2015 at 5:00 PM**

Suggested Readings:
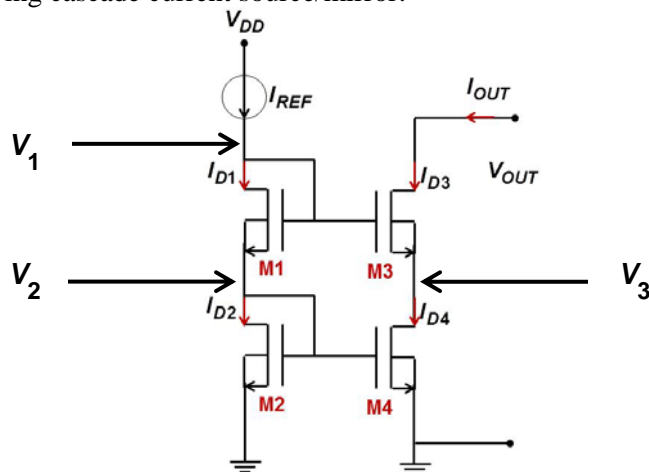
a) Lecture notes

Important Notes:
1) MAKE SURE THAT YOU INDICATE THE UNITS ASSOCIATED WITH YOUR NUMERICAL ANSWERS. OTHERWISE NO POINTS WILL BE AWARDED.
2) Unless noted otherwise, always assume room temperature.

Problem 8.1: (A cascode current source/mirror)

Consider the following cascade current source/mirror:

Assume that all NFETs are identical and their characteristics are given by:

$W = 10 \ \mu m$

$L = 1 \ \mu m$

$\mu_n C_{ox} = 200 \ \mu A/V^2$

$\lambda_n = 0.1 \, 1/V$

$V_{DD} = 5.0 \ V$

$V_{TN} = 0.5 \ V$

$I_{REF} = 1 \, mA$

a) Find the voltages V_1 and V_2.

b) What is the relationship between voltages V_3 and V_{OUT}?

It might be obvious that if $V_{OUT} = V_1$ then $I_{OUT} = I_{REF}$. However, when $V_{OUT} \neq V_1$ then $I_{OUT} \neq I_{REF}$.

c) What is the lowest value of V_{OUT} at which at least one NFET goes into the linear region? Which NFET?

d) Using the values of voltages V_1 and V_2 found in part (a), calculate and plot (not sketch) I_{OUT} vs V_{OUT} with V_{OUT} in the range 0 and 5 Volts.

e) Draw a small signal circuit of the current source when looking in from the output terminals.

f) Use the small signal circuit of part (e) to find and expression for the output resistance r_{oc} of the current source.

g) Assuming $V_{OUT} = V_1$, find the actual numerical value of the output resistance r_{oc} using the expression found in part (f).

Problem 8.2: (A common gate amplifier)

Consider the following FET common gate amplifier. The two current sources shown have output resistances equal to r_{oc}. In answering the following parts, DO NOT MAKE ANY APPROSIMATIONS.
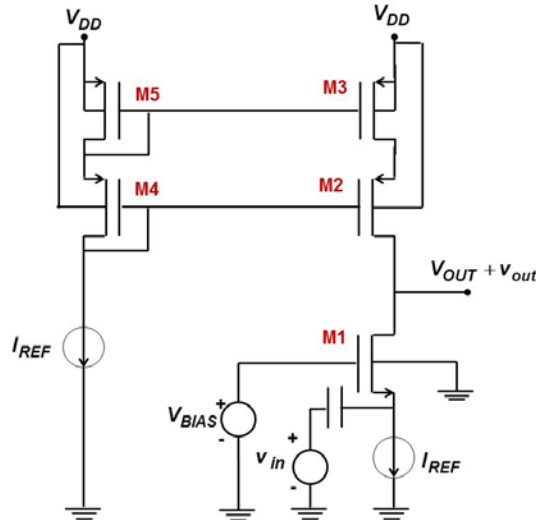

a) Find the open circuit voltage gain $A_v = v_{out}/v_{in}$.

b) Find the input resistance R_{in} assuming a load resistor R_L is connected at the output.

c) Find the output resistance R_{out} assuming that the input voltage source v_{in} is replaced by a voltage source v_s is in series with a resistor R_s.

## Problem 8.3: (Double Wilson BJT current source/mirror)

Consider the following BJT current source. All BJTs are identical and their V_{BE-ON} and V_{CE-SAT} are known.
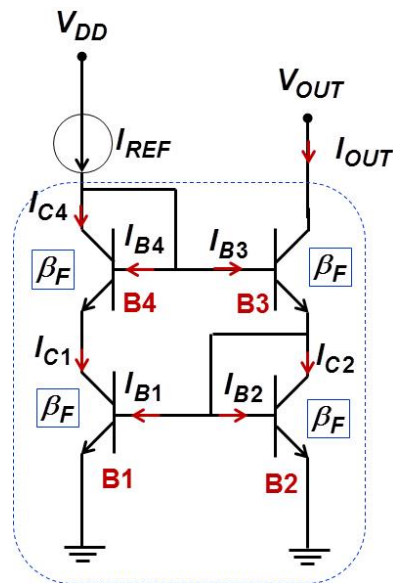
a) Find an expression for the small signal output resistance r_{oc} of the current source.

b) What is the lowest voltage value V_{OUT} can take before at least one of the BJTs goes into the saturation region?

Problem 8.4: (A BJT current source)

Consider the following BJT current source. All BJTs are identical and their V_{BE-ON} and V_{CE-SAT} are known.
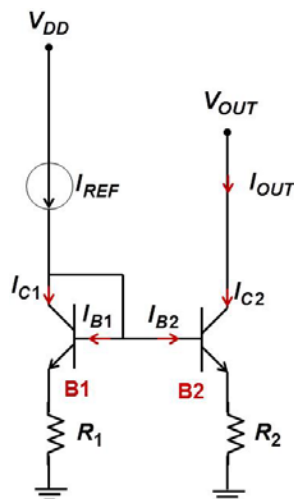
a) Find an expression for the small signal output resistance r_{oc} of the current source.

b) What is the lowest voltage value V_{OUT} can take before at least one of the BJTs goes into the saturation region (your answer could depend on I_{OUT})?