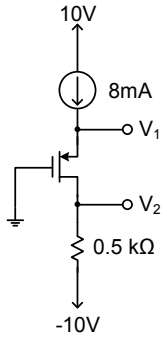
EECE 2412 – Homework 11 – Fall 2018

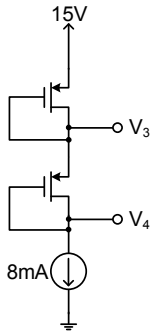
Due: Wednesday, November 28, 2018

1) Problem 5.34 on page 337 in the textbook. Make sure to submit print-outs of the schematic and all plots mentioned in the problem statement, as well as the schematic with annotated operating information in part c) together with the printed output file showing the GM and GDS values. Show the hand calculations used to obtain the requested values from the plots/operating point information. Use the MbreakN transistor model in PSPICE, and connect its bulk terminal to the source terminal: Select the MbreakN transistor in the schematic and choose "edit → PSPICE model" in the menu on the top. To specify its most relevant parameters, change the statement in the first line to:
   .model Mbreakn NMOS VTO=1,KP=50E-6,W=100E-6,L=2E-6,LAMBDA=0.1

2) The PMOS transistors in the circuits below have V_{to} = -1V, $\mu_p \cdot C_{ox} \cdot (W/L)$ = 1mA/V^2, and λ is small enough to be approximated as $\lambda \approx 0$. Find the labeled voltages $V_1 - V_4$.

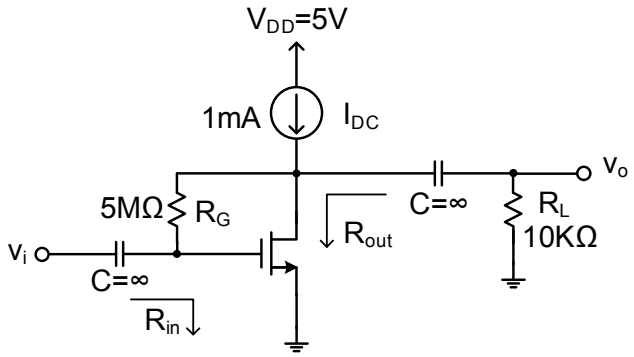


(a)



(b)

3) The NMOS transistor in the circuit below has the following parameters:
   V_{to} = 0.9V, K = (W/L)·(KP/2) = 826μA/V^2, and V_A = 50V.
   a. Calculate the drain-to-source resistance (r_{ds}) value. (Hint: $V_A = 1/\lambda$)
   b. What is the value of the transconductance (g_m)? (ignore λ ONLY for this part)
   c. What is the value of the DC voltage V_D? (ignore λ ONLY for this part)
   d. Draw the small-signal equivalent circuit (including r_{ds}).
   e. Find the equation of the small-signal voltage gain $A_v = v_o/v_i$. This equation should be in terms of the variables g_m, R_G, r_{ds}, and R_L. Make the appropriate parameter substitutions and calculations to obtain the value of A_v.
   f. Find the equation of the small-signal input resistance R_{in}. This equation should be in terms of the variables g_m, R_G, r_{ds}, R_L, and/or A_v. Make the appropriate parameter substitutions and calculations to obtain the value of R_{in}.
   g. Find the equation of the small-signal output resistance R_{out}. This equation should be in terms of the variables g_m, R_G, r_{ds}, R_L, and/or A_v. Make the appropriate parameter substitutions and calculations to obtain the value of R_{out}.



4) Setup the circuit from problem 3) in PSPICE to verify your result from part e) of the problem. Use the MbreakN transistor model, and connect its bulk terminal to the source terminal. Select the MbreakN transistor in the schematic and choose "edit → PSPICE model" in the menu on the top. To specify its most relevant parameters, change the statement in the first line to:

.model Mbreakn NMOS VTO=0.9,KP=82.6E-6,W=20E-6,L=1E-6,LAMBDA=0.02

Hint: Choosing C = 100μF ensures that the impedances of the blocking capacitors at the signal frequency of interest are much smaller than the resistances in the circuit.

a) Run a DC bias point simulation to verify that your operating point is correct (the V_D error should be less than 3% in this case), and submit the schematic that shows all DC voltages and currents.
b) Print the DC operating point information for the transistors after the simulation in part a). Notice that GDS parameter is equal to $1/r_{ds}$. What is the drain-source resistance value based on the operating point information?
c) Run an AC simulation to plot $A_v = v_o/v_i$. Label the midband gain in the plot before submitting it, and compare it to the hand calculation result.
d) Run a transient simulation with a sinusoidal input signal having an amplitude of 5mV and a frequency of 1MHz. Plot $v_i(t)$ and $v_o(t)$ vs. time. Mark the peak output voltages in the plot before printing it for submission. What is the voltage gain based on the transient simulation result?