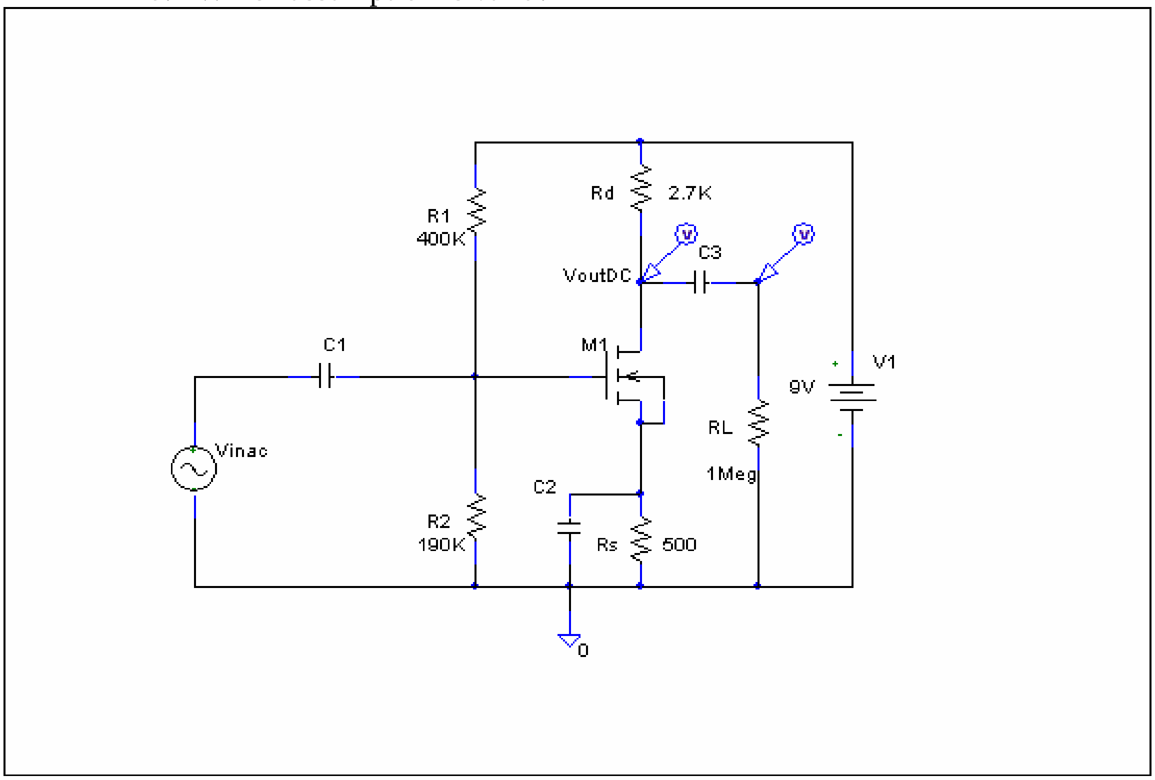
Homework 7

The transistors in this homework are to be implemented in 0.18 μm MOS technology so all dimensions must be a multiple of these numbers (we will approximate 5.04 as 5).

1. For the basic transistor circuit below, solve for the Q-point (all three currents and voltages on the transistor) assuming a V_{TNO} =+0.5V, $K_n' = \mu_n C_{ox} = 100\mu A/V^2$, W=5μm, L=0.18μm, a channel length modulation parameter, $\lambda = 0.0\ V^{-1}$, a body effect parameter, $\gamma = 0.0\ V^{1/2}$ and $\phi_F = 0.4V$.
   a. Assuming the transistor is biased in cutoff (neglect leakage currents).
   b. Assuming the transistor is biased in triode/linear.
   c. Assuming the transistor is biased in saturation.
   d. Which assumption is valid?

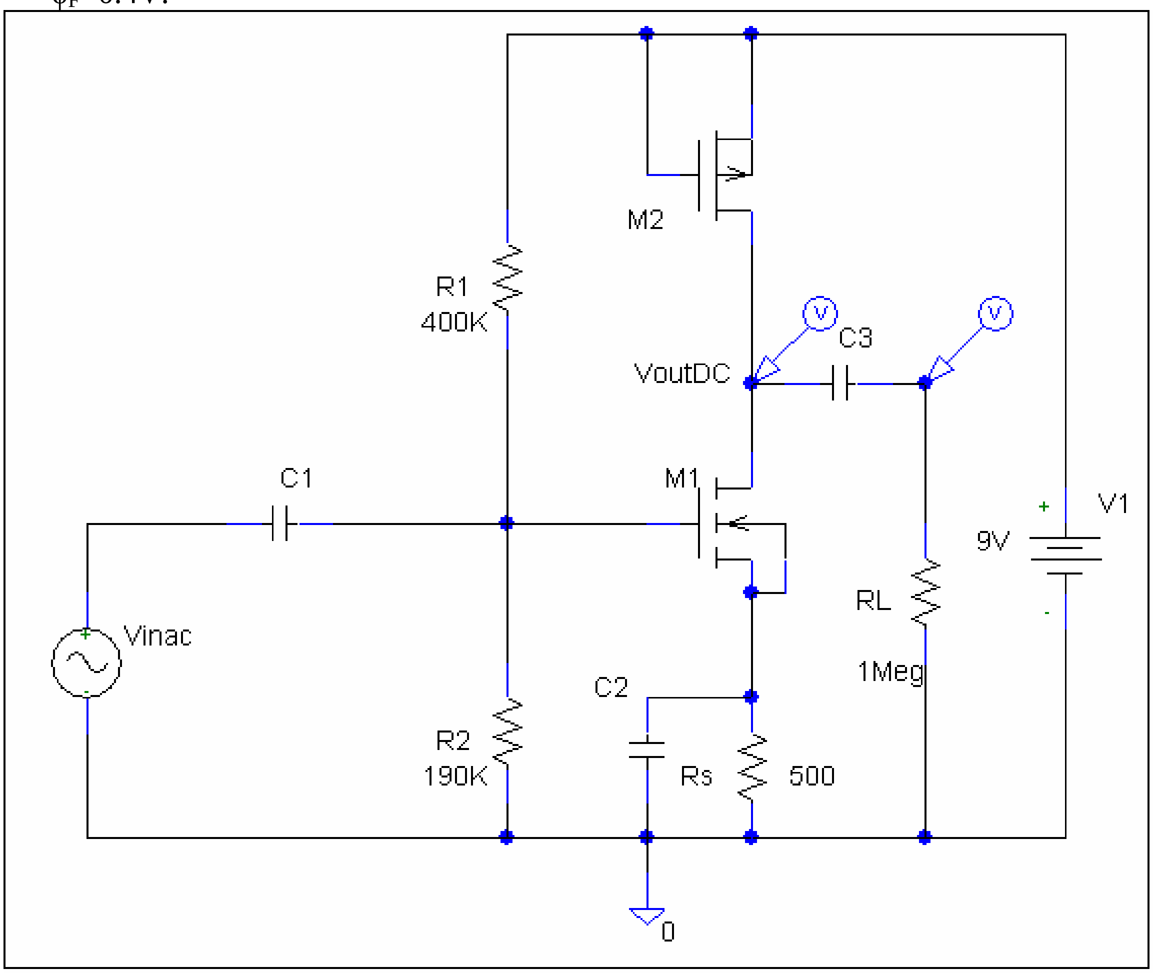


   e. Repeat part c for $\lambda = 0.1\ V^{-1}$.
   f. For $\lambda = 0.1\ V^{-1}$, (part e answers) determine the voltage gain VoutAC/VinAC
   g. What is the maximum allowable VoutDC signal swing without distortion.
   h. Note: While I am not asking for it herein, you should be able to determine, all relevant transistor parameters from their respective material parameters.

2. For the circuit below, similar to that from problem 1f, a) calculate the voltage gain. This configuration uses a current source as a load instead of the resistor, Rd. b) Why is the body of the PMOS transistor tied to the source/highest potential? c) If the PMOS transistor could be made with arbitrary dimensions such that W/L=2.81, what would be the new gain? d) Given the dimensions must be a multiple of 0.18 um, how could we best approximate this value so as to get the benefits of the higher gain you should have found in part c but stay within the limits of the 0.18 um technology? In an integrated circuit, this transistor load (or "active" load as opposed to the "passive" resistor load) results in huge space savings making complex analog circuits very compact and thus cheaper and higher performance.

   For M1, V_{TNO} =+0.5V, $K_n' = \mu_n C_{ox}$=100μA/V^2, W=5μm, L=0.18μm, a channel length modulation parameter, λ=0.0 V^{-1}, a body effect parameter, γ=0.0 $V^{1/2}$ and ϕ_F=0.4V.

   For M2, V_{TPO} =+4V, $K_p' = \mu_n C_{ox}$=100μA/V^2, W=0.54μm, L=0.18μm, a channel length modulation parameter, λ=0.0 V^{-1}, a body effect parameter, γ=0.0 $V^{1/2}$ and ϕ_F=0.4V.



3. For the source follower circuit below, and the same parameters as in problem 1f a) calculate the voltage gain. b) what is the phase of the circuit. c) Assume that instead of the gm you found, gm was allowed to be infinite, what is the voltage gain for this "ideal" case? Note: for this problem, you can take the DC solution from part 1f so you do not have to re-solve it but for the ac solution, use λ=0 V^{-1} to make the AC solutions easier.