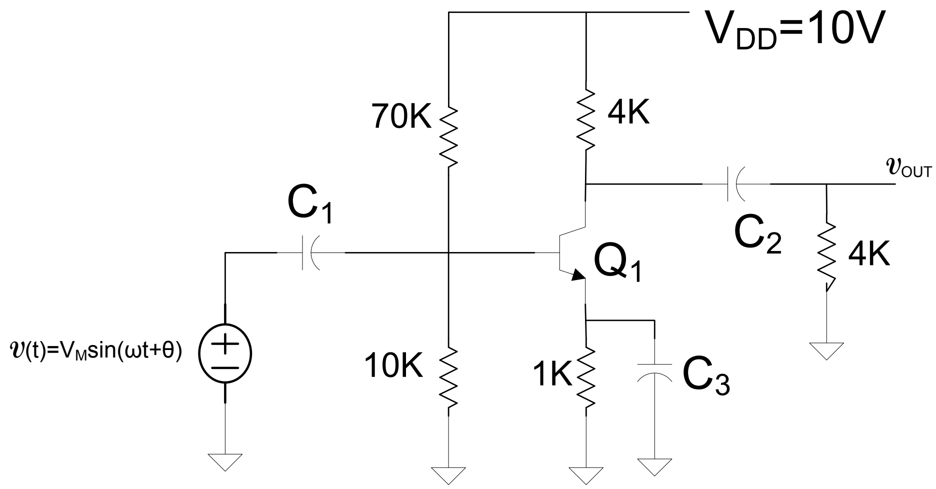
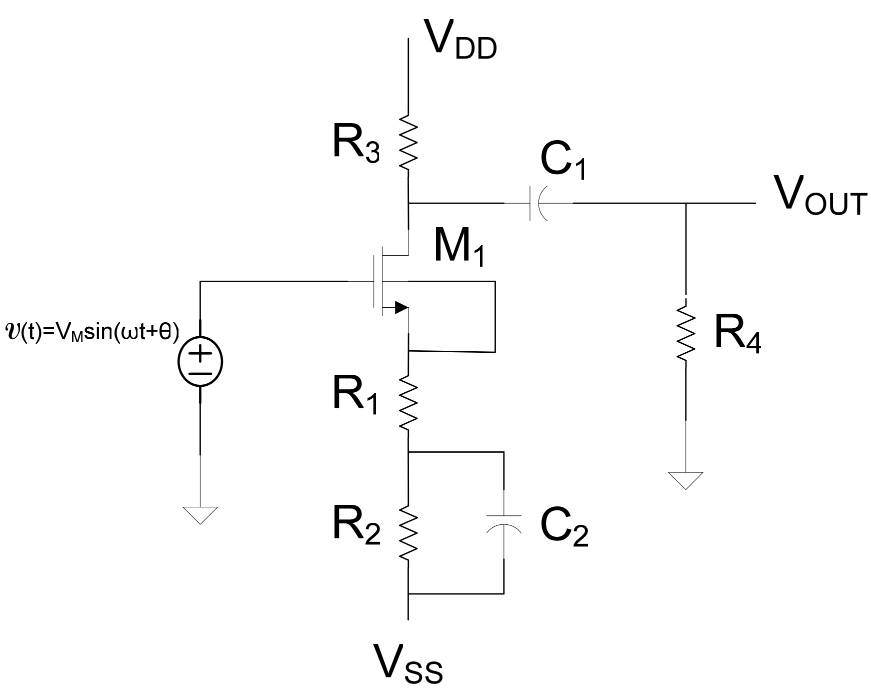
EE 230
Homework 11
Spring 2010

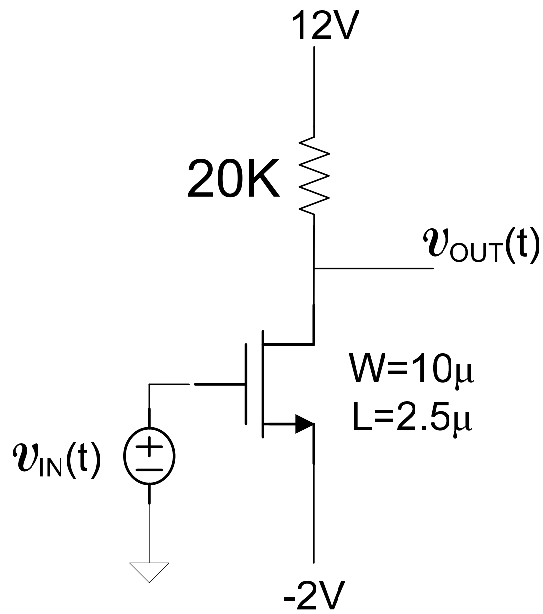
Assume all MOS transistors have model parameters $\mu_n C_{OX}$=100μA/V^2 , V_{Tn}=1V, and λ=0. Correspondingly, assume all BJT transistors have model parameters $J_S A$= 10^{-12}A , β=100, and V_{AF}=∞.

Problem 1 Draw the small signal equivalent circuits. Assume M_1 and Q_1 are in Saturation and Forward Active respectively and that all capacitors are large. Do not solve the circuit.

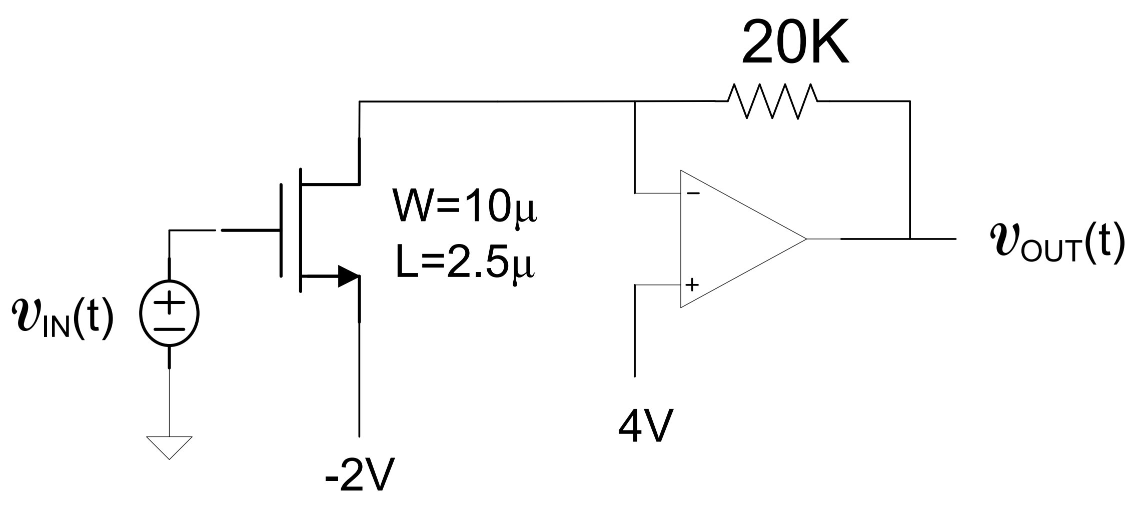




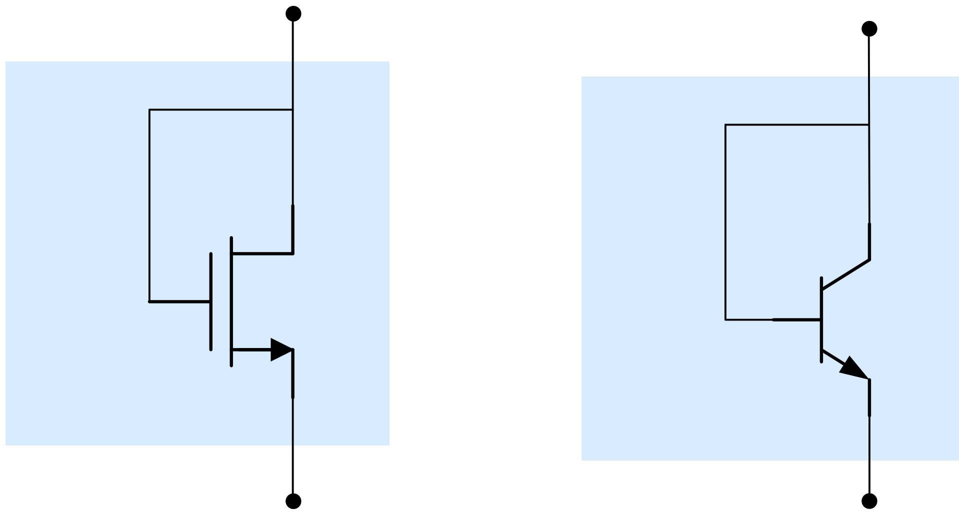
Problem 2 Obtain the quiescent output voltage and the small signal voltage gain.



Problem 3 Determine the small signal output voltage if the small signal input voltage is a sinusoidal 1KHz signal with 0-P amplitude of 100mV.



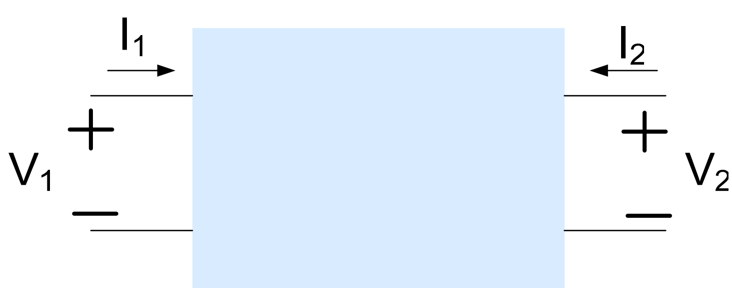
Problem 4 Obtain the small signal impedance between the two terminals exiting the box. Assume the MOSFET is operating in the Saturation region and the BJT in the Forward Active region and that the quiescent currents are both 1mA. The dimensions of the MOSFET are W=20μ and L=2 μ . The area of the emitter of the BJT is $A_E = 100\ \mu^2$.



Problem 5

Consider a device characterized by the equations

$$I_1 = V_1 V_2^{\,3}$$
$$I_2 = 0.1e^{0.2V_2}$$



a. Determine the small signal model for a two-terminal device characterized by the equations given above

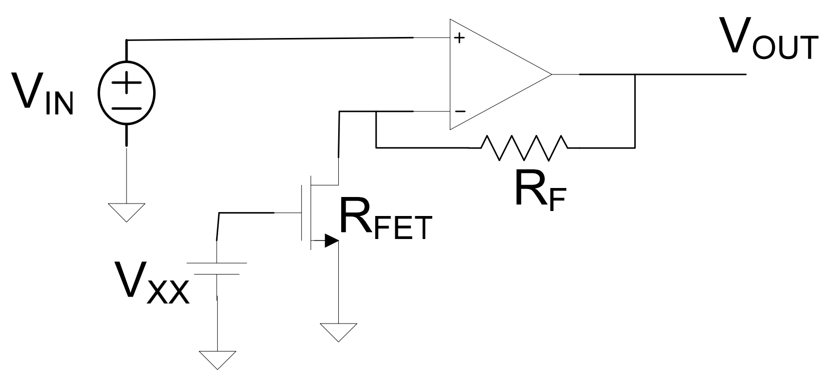
b. Determine the numerical values for the small signal model parameters if the quiescent value of the port voltages are V_2=1V, V_1=5V.

c. Determine the quiescent currents at the Q-point established in part b.

d. Determine the small signal currents i_1 and i_2 if the small signal voltages v_1 and v_2 were measured to be $1mV_{RMS}$ and $2mV_{RMS}$ respectively. Assume the same Q-point as established in part b.

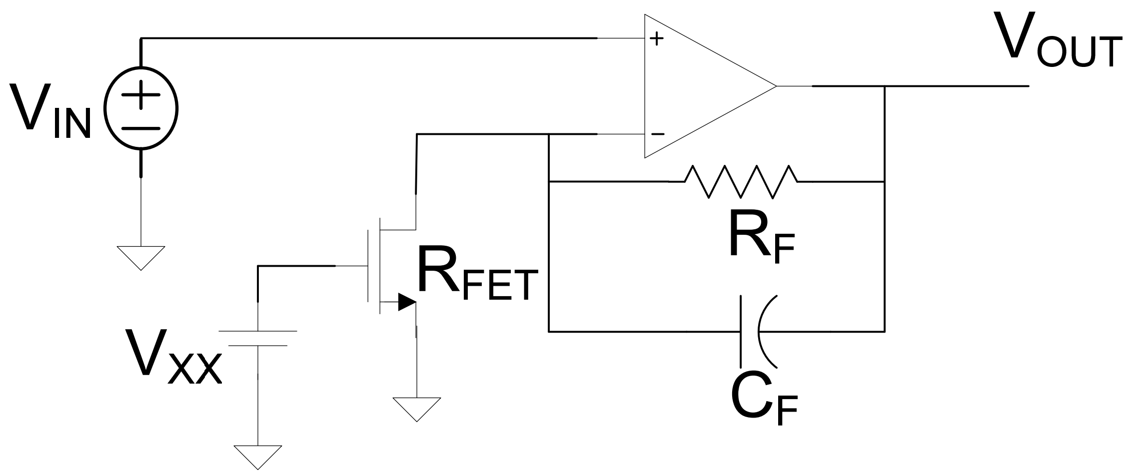
Problem 6 Assume V_{IN} is a low frequency nearly sinusoidal waveform that is below 50mV 0-P and that W=16μm, L=1μm for the MOSFET.

a) Determine the voltage gain of this circuit if V_{XX}=2V.
b) How does the voltage gain change if V_{XX} is swept between 1.5V and 4V?



Problem 7 In the circuit shown, R_F=10K, C_F=0.1uF and the MOSFET has dimensions W=16μm, L=2μm. Assume the op amp is ideal.

a) Determine the sinusoidal steady state response if V_{XX}=1.5V and V_{IN}=0.02sin1000t.
b) On the same axis, plot the transfer function V_{OUT}/V_{IN} for V_{XX}=1.5V, 14, and 4V.
c) Obtain an expression for the poles and zeros of the transfer function as a function of V_{XX} and plot as V_{XX} varies between 1.5V and 4V.



Problem 8 Assume the population P that a landmass of area A can support is dependent upon the annual rainfall R (in meters/year) and is given by the relationship

$$P=\frac{KAR}{1+R^2}$$

where K is a constant. Assume the landmass area, A, is fixed.

a) Determine the "Quisecent" population if R=1m/year.
b) Obtain an expression for the population if R varies sinusoidal around the value given in part a) with a period of 30 years with a peak-to-peak variation of .2m/year
c) Develop a small-signal model for the population around the "Quiescent" point of part A
d) Determine the population gain dP/dR from the small signal model and compare with the results derived in part b)
e) Give a small-signal "equivalent circuit" for the population at the "Quiescent" point. Describe what the elements are in your equivalent circuit.

Problem 9 Obtain the quiescent output voltage and the small signal voltage gain. Assume V_{XX} is set so that the quiescent current is 200μA.