

EE 330

Homework 9

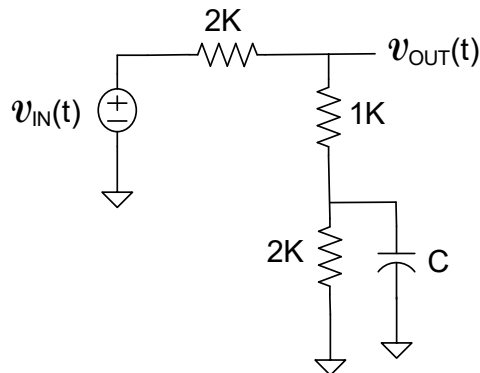
Fall 2025

Due Wednesday October 22 at noon (no late submissions will be accepted this week).

Unless specified to the contrary, assume all n-channel MOS transistors have model parameters $\mu_n C_{OX} = 250 \mu\text{A}/\text{V}^2$ and $V_{Tn} = 0.4\text{V}$, all p-channel transistors have model parameters $\mu_p C_{OX} = \mu_n C_{OX} / 3$ and $V_{Tp} = -0.4\text{V}$. Correspondingly, assume all npn BJT transistors have model parameters $J_S = 10^{-14} \text{A}/\mu^2$ and $\beta = 100$ and all pnp BJT transistors have model parameters $J_S = 10^{-14} \text{A}/\mu^2$ and $\beta = 25$. If the emitter area of a transistor is not given, assume it is $100 \mu^2$. Assume all diodes are characterized by the model parameters $J_{SX} = 0.5 \text{A}/\mu\text{m}^2$, $V_{G0} = 1.17\text{V}$, and $m = 2.3$.

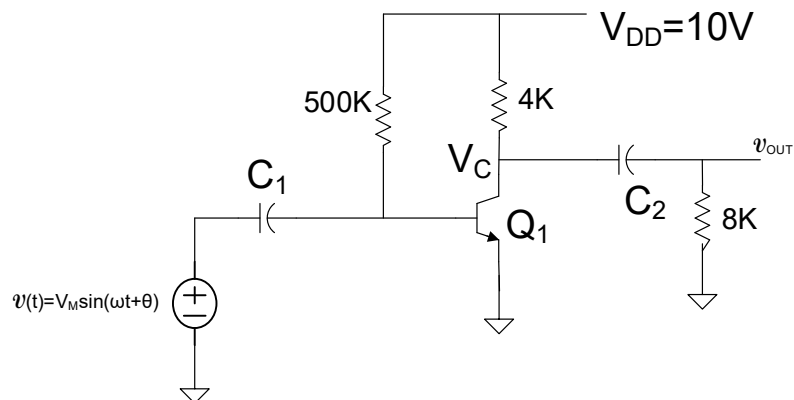
Problem 1 Assume the capacitor C is very large.

- Draw the small-signal equivalent circuit
- Determine the quiescent output voltage
- Determine the small-signal voltage gain.
- Determine the output voltage if $v_{IN}(t) = 2\sin 500t$

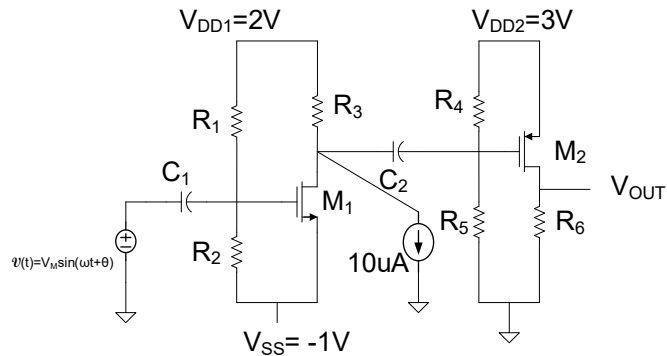


Problem 2 Assume the capacitors are very large, the emitter area of Q_1 is $20 \mu\text{m}^2$, and V_M is small.

- Draw the small signal equivalent circuit for the amplifier shown
- Determine the quiescent value of V_C and V_{OUT}

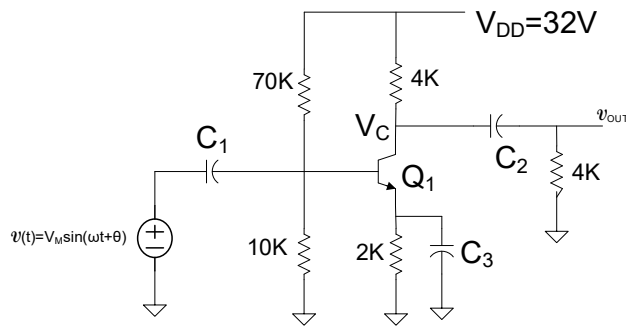


Problem 3 Obtain the small signal equivalent circuit for the following network. Assume the transistors are operating in the saturation region, all capacitors are large, and V_M is small. You do not need not solve the circuit for the output voltage.



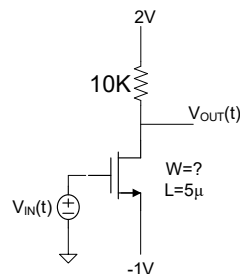
Problem 4 Assume the capacitors are all very large, $A_E = 10 \mu\text{m}^2$, and V_m is small.

- Draw the small signal equivalent circuit for the amplifier shown
- Determine the quiescent value of V_C and V_{OUT}



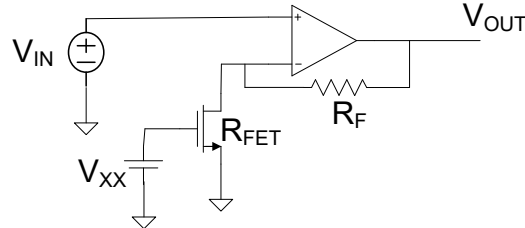
Problem 5 Consider the following circuit

- Determine the width W so that the quiescent drain current is 0.1mA
- Draw the small-signal equivalent circuit
- With the drain current specified in part a), determine the small-signal voltage gain (do not use small-signal device models to solve this part of the problem)
- Determine the THD if the input is a 1KHz sinusoidal signal of amplitude 200mV 0-p



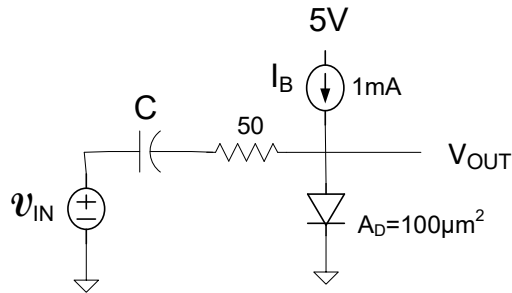
Problem 6 Assume V_{IN} is a low frequency sinusoidal waveform that is below 10mV 0-P and that $W=12\mu\text{m}$, $L=1\mu\text{m}$ for the MOSFET.

- Determine the voltage gain of this circuit as a function of R_F if $V_{XX}=1\text{V}$.
- How does the voltage gain change if V_{XX} is swept between 0.4V and 1.6V?



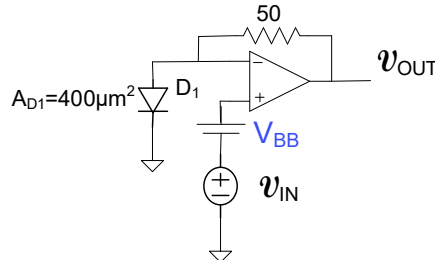
Problem 7 Consider the following circuit operating at $T=300\text{K}$. Assume the capacitor C is very large and the v_{IN} is a small-signal input.

- Determine the quiescent output voltage.
- Draw the small-signal equivalent circuit
- Determine the small-signal voltage gain from the input to the output if the input is a sinusoidal waveform.
- Repeat part c) if the current I_B is increased to 5mA



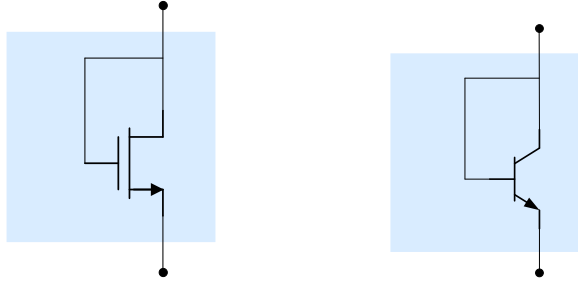
Problem 8 Consider the following circuit operating at $T=300\text{K}$. Assume v_{IN} is a small-signal voltage source.

- Draw the small-signal equivalent circuit
- If the voltage V_{BB} is adjusted so that the quiescent diode current is 1mA, determine the small signal voltage gain $A_v = \frac{v_{OUT}}{v_{IN}}$
- Repeat part b) if V_{BB} is adjusted so that the quiescent diode current is 10mA



Problem 9 Consider the following circuits.

- Obtain the small signal impedance between the two terminals exiting the box in terms of the small-signal model parameters. Assume the MOSFET is operating in the Saturation region and the BJT in the Forward Active region
- Numerically determine the small-signal impedances if the quiescent currents are both 1mA, the width and length of the MOSFET are both $5\mu\text{m}$, and the emitter of the BJT is square and is $5\mu\text{m}$ on a side. Assume $V_{AF}=\infty$ and $\lambda=0$.



Problem 10

- Determine the maximum value of R_1 that will keep M_1 in saturation. M_1 has dimensions $W=18\mu$ and $L=2\mu$.
- If R_1 is $1/3$ of the value determined in Part a), determine the small signal voltage gain of this circuit (do not use small-signal device models which have not yet been introduced in this course to solve this problem)
- With the value of R_1 used in part b), determine the total output voltage if $v_{IN}(t)=.001\sin(5000t+75^\circ)$.

