EE 105, Spring 1994
Midterm #2
professor Howe

Default bipolar transistor parameters:
npn: $ß_n = 100$, $V_{A_n} = 50V$, $I_{S_b} = 10^{-16}$, $V_{Th} = 25$ mV

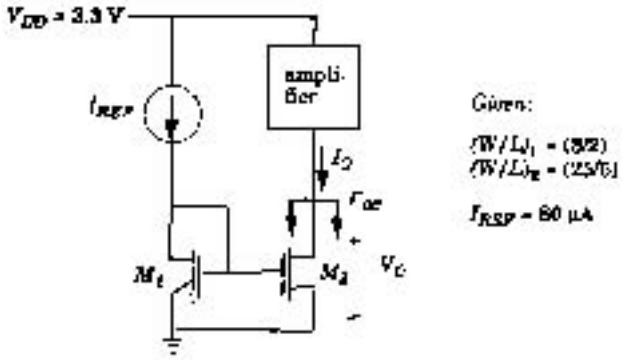
pnp: $ß_n = 50$, $V_{A_n} = 25V$, $I_{S_b} = 10^{-16}$, $V_{Th} = 25$ mV

Default MOS transistor parameters:
NMOS: $\mu_n C'_{ox} = 50\ \mu AV^{-2}$, $[LAMBDA]_n = 0.02\ V^{-1}$, $V_{T_n} = 1V$.

PMOS: $\mu_p C'_{ox} = 25\ \mu AV^{-2}$, $[LAMBDA]_p = 0.02\ V^{-1}$, $V_{T_p} = -1V$.

Problem #1a

Assuming that transistor M2 is saturated, what is the numerical value of Io, the output current of this simple current source.

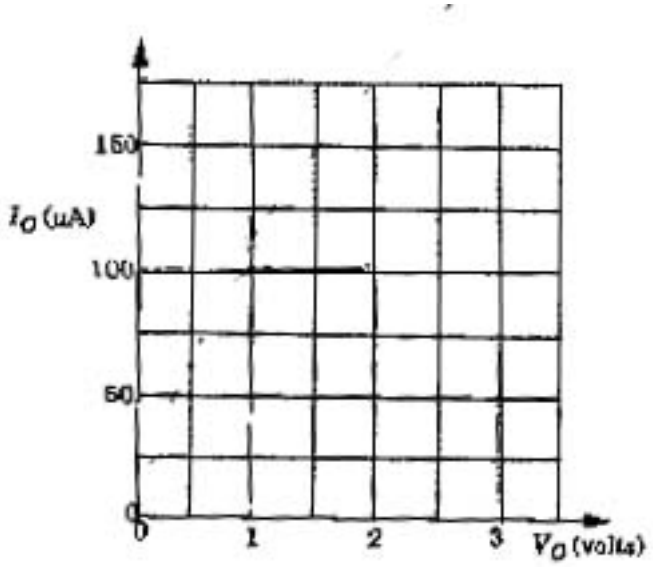


Problem #1b[4 pts]

Assuming that Vo = 2 V, find the numerical value of Roc, the output resistance of this simple current source. If you couldn't solve part(a), you may assume that the saturation current Io = 50 uA, which is not the correct answer to (a).

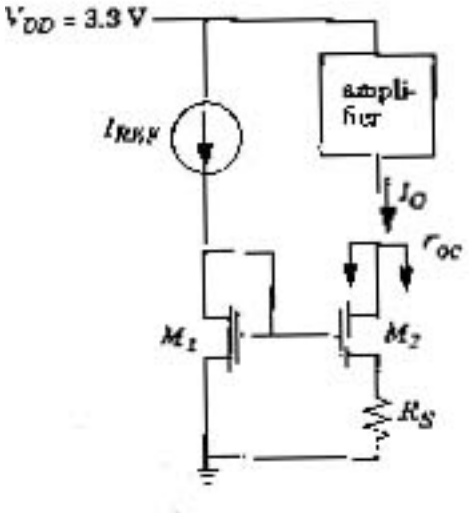
Problem #1c[7 pts]

Plot the output current Io versus the output voltage Vo(which should vary from 0 to 3.5 V). There is no need for accuracy in the triode region; however, the numerical value for the saturation current and the boundary between the triode and the saturation region should be correct.



Problem #1d[3 pts]

For the new current source below, we would like to keep the same value for Io in saturation as you found in part(a). In order to do this, we must change the width-to-length ratio of M1. Note that the reference current Iref is unchanged. Find the numerical value of the width of M1, given that its length is L1=2um. Again, you an assume for this part that Io=50uA, in case you were not able to solve part (a).

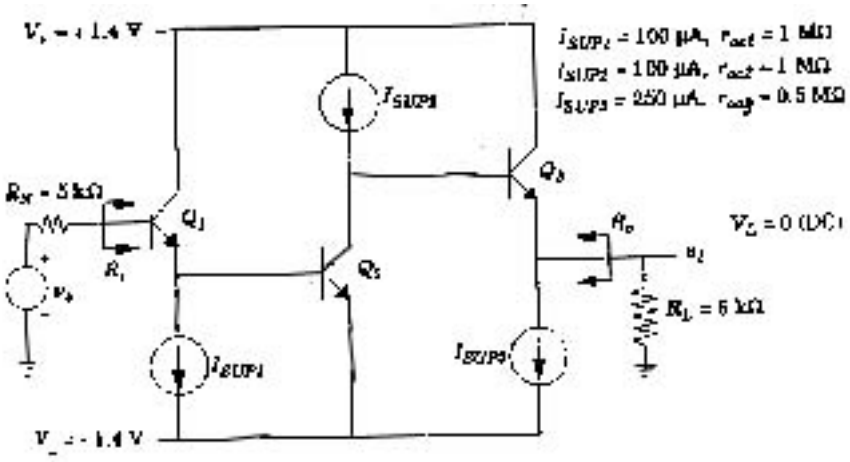


Problem #1e[3 pts]

What is the numerical value of the output resistance of the new current souce? Again, you can assume for this part that Io=50uA, in case you were not able to solve part (a).

Problem #2a[3 pts]

Find the numerical value of VCE for each transistor. Note that the DC output voltage VL = 0V. You can assume that the transistors are forward-active and that VBE = 0.7 V.



Problem #2b[5 pts]

Find the numerical value of the input resistance, Ri.

Problem #2c[6 pts]

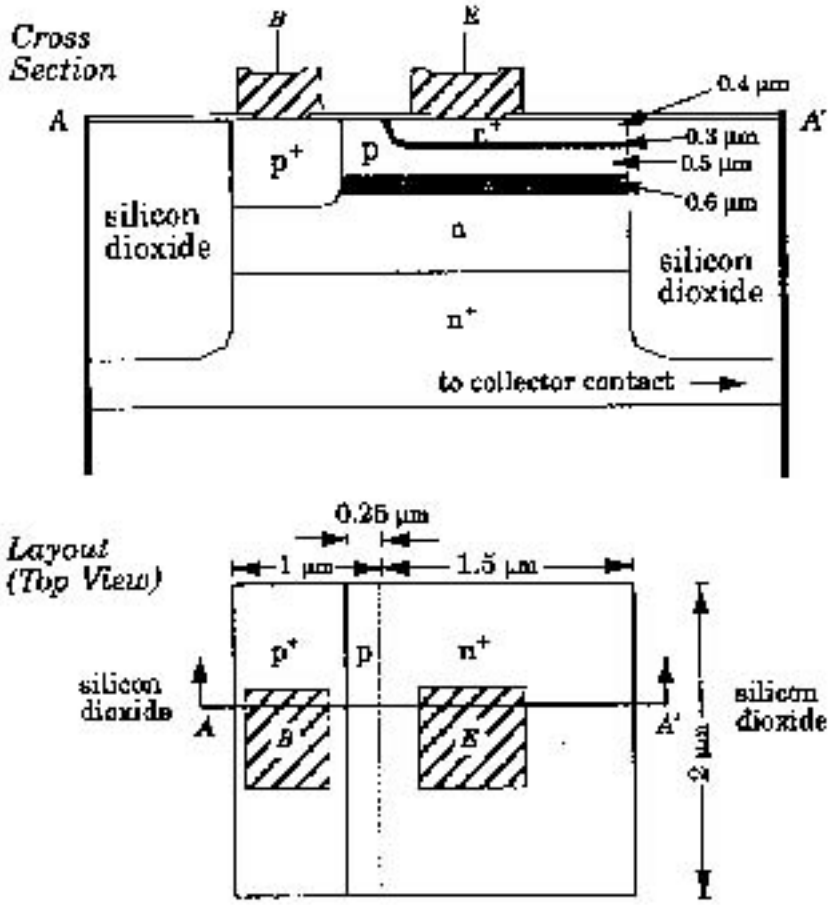
Find the numerical value of the output resistance, Ro.

Problem #2d[6 pts]

Find the numerical value of the overall small-signal voltage gain, Av, including the loading effects of the source and load resistors: Av = v1/vs.

Problem #3a[5pts]

Note that the thicknesses of the emitter and the base regions We and Wb are given in the cross section, along with the thicknesses of the depletion regions between emitter and base, xBE and between the base and collector xBC. The base doping is NaB = 10e16 per cubic cm. Given epsilon of silicon is 1.03*10e-12 F/cm. What is the numerical value of the small-signal capacitor Cu between the base and collector?



Problem #3b[5 pts]

Given that the transistor is under forward-active bias with VBE=650mV and VCE=1.0V. Sketch the electron concentration in the base, npB(x) on the graph below. The numerical values for the electron concentration should be accurate at x=0 (edge of the emitter-base junction) and at x=0.5um (edge of the base-collector junction).