Homework 3

Due: Friday, 14 February 2014 at 1pm

This is an individual assignment!

PROBLEM 1 (10pts):
For both circuits depicted in Fig. 1, calculate the input impedance, output impedance, and voltage gain, v_{out}/v_{in}. Assume $\beta = 100$ and $V_A = \infty$. Repeat assuming $V_A = 100$V.

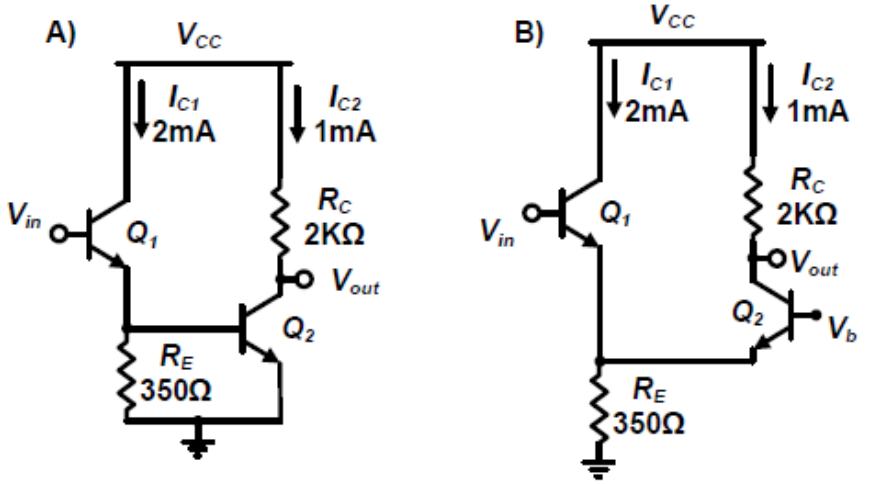
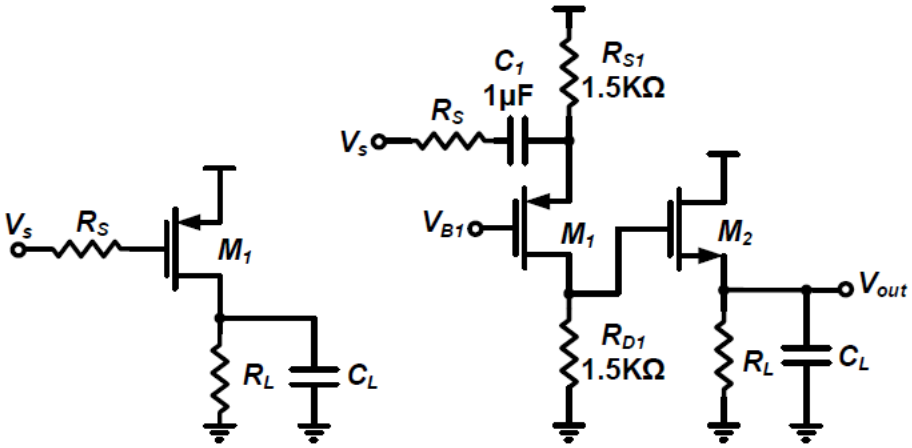


Figure 1

PROBLEM 2 (10pts):
For the small-signal circuits shown in Fig. 2, assume all transistors are identical and have the following parameters: $I_D = 2$ mA, $W = 10$ µm, $L_{drwn} = 130$ nm, $L_d = 15$ nm, $X_d = 0$, $k_p' = 200$ µA/V^2, $\gamma = 0$, $\lambda = 0$, $C_{ox} = 15$ fF/µm^2, $C_{sb} = C_{db} = 0$.
Given $R_S = 500$ Ω, $R_L = 1$ kΩ, and $C_L = 100$ fF:
(a) Calculate the DC small-signal voltage gain v_o/v_i for circuit in Fig. 2A.
(b) Calculate the low -3dB cutoff frequency and mid-band voltage gain v_o/v_i for circuit in Fig. 2B.
(c) Calculate and compare the high 3-dB cutoff frequencies of the two circuits.



A) B)

Figure 2

PROBLEM 3 (10pts):
The ac schematic of a wideband MOS current amplifier is shown in Fig. 3. The W/L of M_2 is four times that of M_1 and corresponding bias currents are I_{D1} = 1mA and I_{D2}=4mA. Calculate the low-frequency, small-signal current gain io/ii and use the open-circuit time constant method to estimate the -3dB cutoff frequency. M1: C_{gd} = 5 fF, C_{gs} = 20 fF, C_{sb} = C_{db} = 9 fF, V_{ov}=0.3V, and r_o = ∞. M2: C_{gd} = 20 fF, C_{gs} = 80 fF, C_{sb} = C_{db} = 36 fF, Vov = 0.3V, and r_o = ∞.

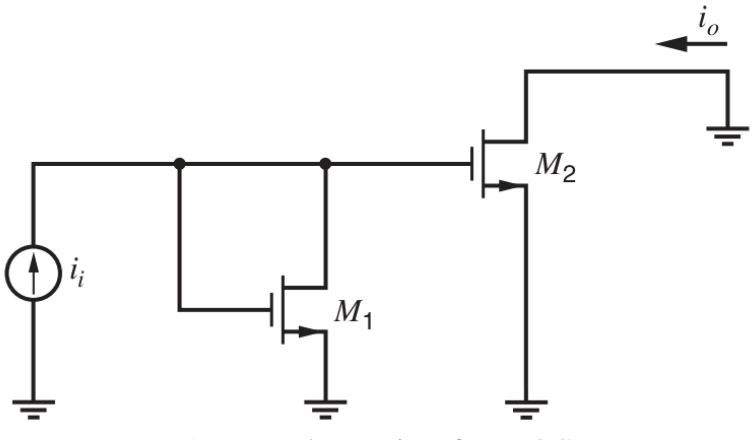


Figure 3

EXTRA PROBLEM FOR EE 240A STUDENTS:
PROBLEM 4 (20pts):
A multistage BiCMOS amplifier circuit is shown in Fig. 1:

(a) Calculate the DC current flowing through each branch and DC voltage at each node.

(b) Calculate transistor small-signal parameters (i.e. g_m, r_π, r_o, C_π, C_μ, C_{gs}, C_{gd})

(c) Provide expressions and calculate numeric values for the input resistance, R_{in}; output resistance, R_{out}; first stage gain, v_{o1}/v_s; second stage gain, v_{o2}/v_{o1}; third stage gain, v_{out}/v_{o2} and total gain, v_{out}/v_s.

(d) Estimate the low frequency cut-off f_L and high frequency cut-off f_H of the amplifier using open and short-circuit time-constant methods.
BJT parameters: β=100, V_A=100V, $V_{BE(on)}$=0.7V, $V_{CE(SAT)}$=0.2V, τ_F=150ps, C_{je}=50fF, C_μ=1pF, V_T=25mV.
MOS parameters: V_{th0}=0.5V, k'=160μA/V^2, W/L=10μm/1μm, λ=0.05V^{-1}, C_{ox}=30μF/cm^2, C_{ol}=1pF, γ=0.

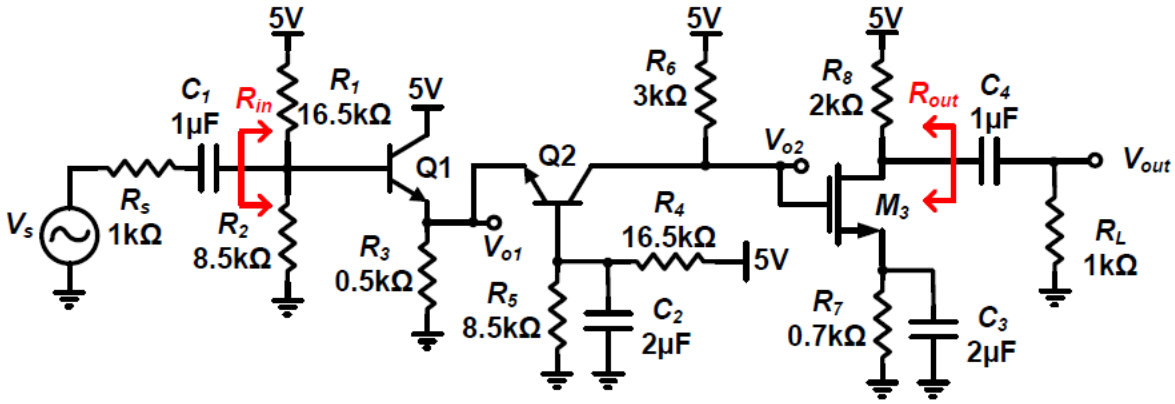


Figure 4