PROBLEM SET #3

Issued: Thursday, Feb.7, 2013

Due (at 8 a.m.): Friday, Feb. 15, 2013, in the EE 140/240A HW box near 125 Cory.

1. Referring to the multistage amplifier circuit shown in Fig. PS3.1:

(a) Calculate the DC operating points including the 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 the numerical 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.

BJT parameters:

β=100, V_A=50V, $V_{BE(on)}$=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'=165.3μA/V^2, W/L=20μm/1μm, λ=0.05V^{-1}, C_{ox}=30μF/cm^2, C_{ol}=1pF, γ=0.

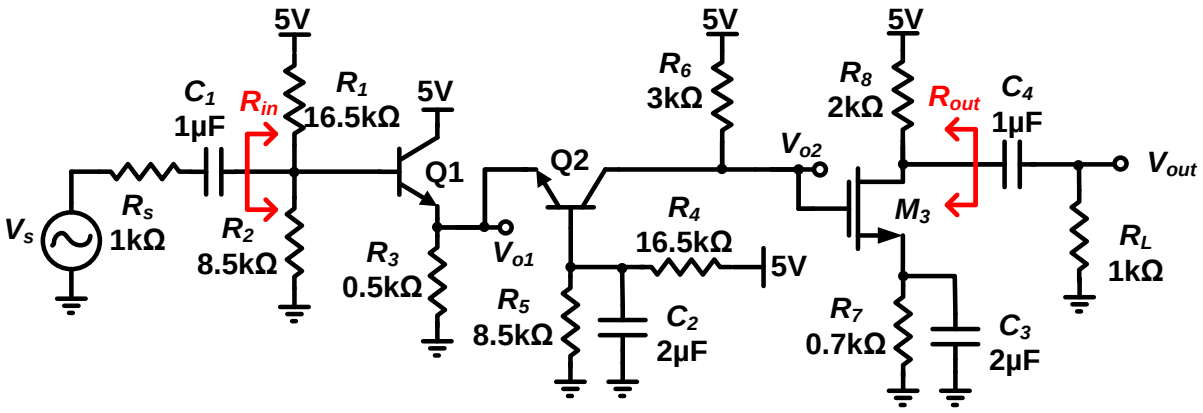

Fig. PS3.1

2. For the small-signal circuits shown in Fig. PS3.2, assume all transistors are identical and have the following parameters:

I_D = 2 mA, W = 50 μm, L_{drwn} = 130 nm, L_d = 15 nm, X_d = 0, k_p' = 200 μA/V^2, γ = 0, λ = 0, C_{ox} = 15 fF/μm^2, C_{sb} = C_{db} = 0.

Given R_S = 500 Ω, R_L = 1 kΩ, and C_L = 50 fF:

(a) Calculate the mid-band, small-signal voltage gain v_o/v_i for each circuit.

(b) Calculate and compare the high 3-dB cutoff frequencies of the two circuits.

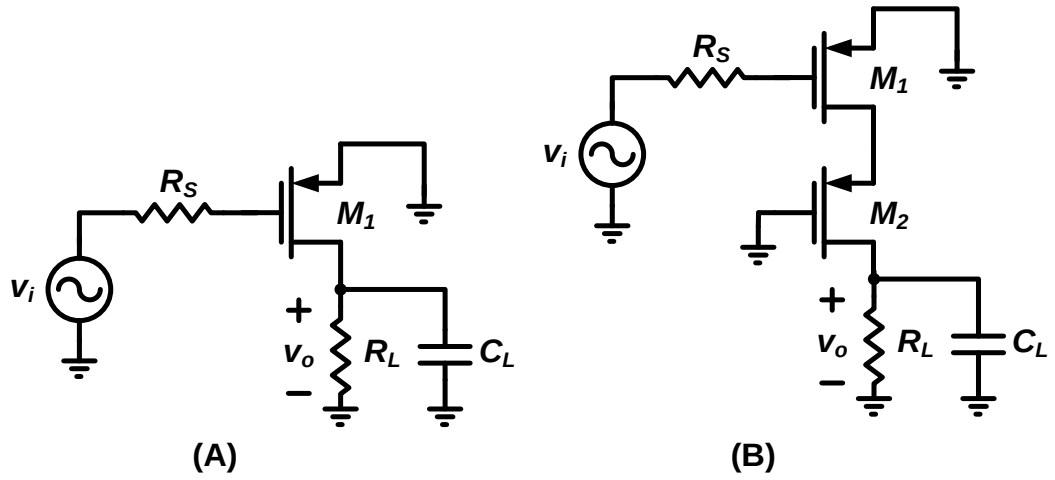

Fig. PS3.2

3. For the both circuits depicted in PS3.3, calculate the input impedance, output impedance, and voltage gain, v_{out}/v_{in}. Assume β = 100 and V_A = 50V. Repeat assuming $V_A = \infty$.

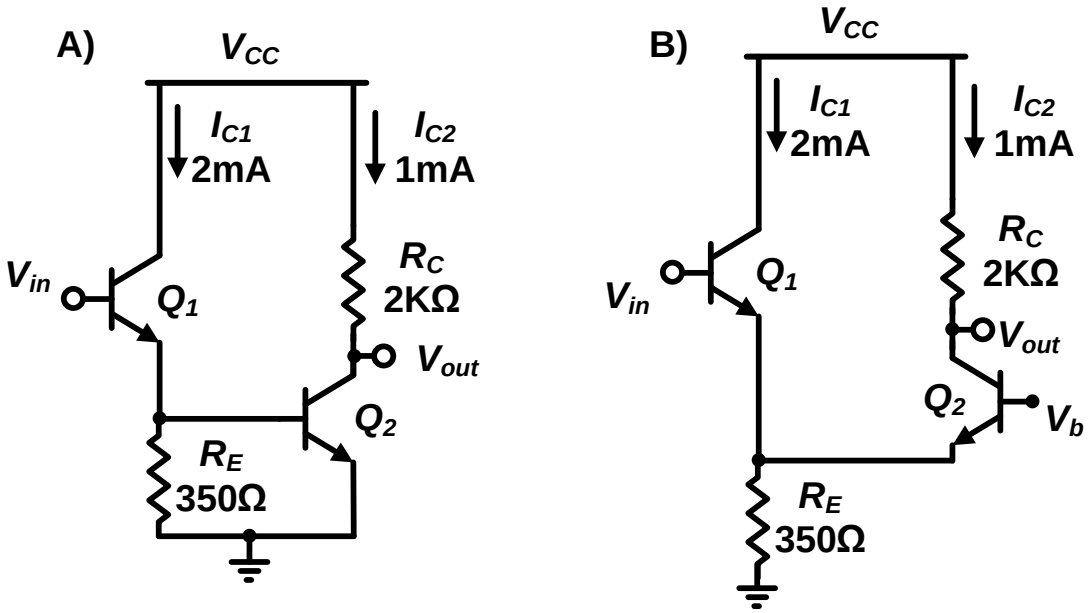

Fig. PS3.3

4. Design the common-base stage shown in Fig. PS3.4 for a voltage gain of 20 and an input impedance of 50Ω using a transistor with β = 100 and V_A = 20V. Assume a voltage drop of $10V_T$ = 260mV across R_E so that this resistor does not affect the input impedance significantly. Also, assume the current flowing through R_1 is approximately 10 times the base current, and the lowest frequency of interest is 200Hz.

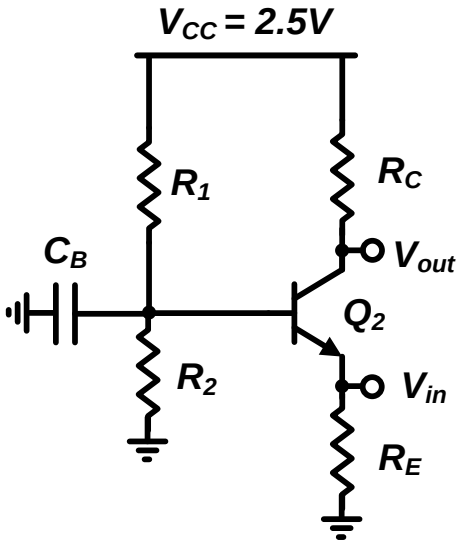

Fig. PS3.4