# <u>PROBLEM SET #3</u>

*Issued: Tuesday, Feb. 7, 2012*

*Due: Tuesday, Feb.14, 2012*, 6:00 p.m. in the EE 140 homework box in 240 Cory

1. Estimate the $f_L$ and $f_H$ of a multistage amplifier shown in Fig. PS3.3.
   The transistor parameters are listed in the following table:

| | $g_m$ | $r_O$ | $\beta_O$ | $C_{GS}$, $C_\pi$ | $C_{GD}$, $C_\mu$ | $r_g$, $r_b$ |
|---|---|---|---|---|---|---|
| $M_1$ | 10 mS | 12 kΩ | ∞ | 5 pF | 1 pF | 0 Ω |
| $Q_2$ | 68 mS | 55 kΩ | 150 | 50 pF | 1 pF | 100 Ω |
| $Q_3$ | 80 mS | 35 kΩ | 80 | 50 pF | 1 pF | 100 Ω |

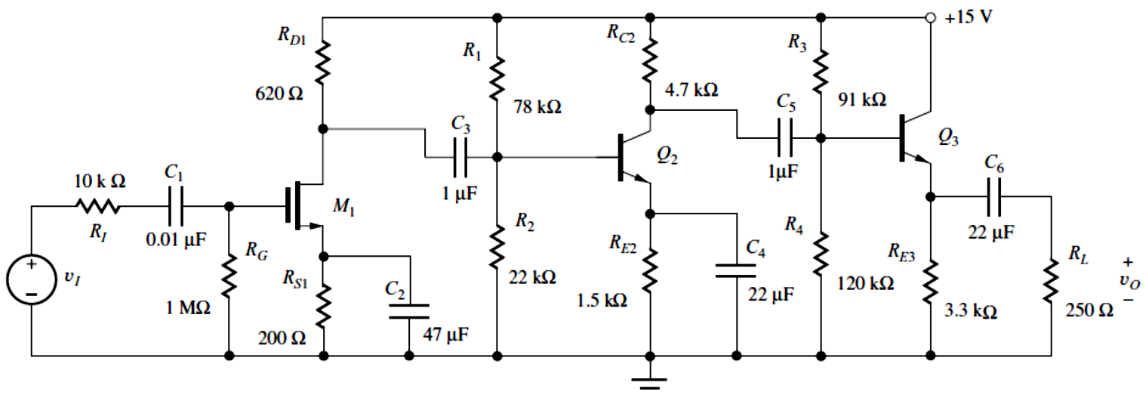


Fig. PS3.1

2. For the small-signal circuits shown schematically in Fig. PS3.2, assume $R_S$ = 5kΩ, $R_L$ = 3kΩ, $C_L$ = 4pF. For the transistors, assume $I_C$ = 1mA, $\beta_F$ = 100, $f_T$ = 500MHz (at $I_C$ = 1mA), $C_\mu$ = 0.4pF, $C_{cs}$ = 1pF, $r_b$ = 0Ω, and $r_o$ = ∞.
   a. Calculate the low-frequency, small signal voltage gain $v_o/v_i$ for each circuit.
   b. Calculate and compare the 3-dB frequencies of the two circuits.

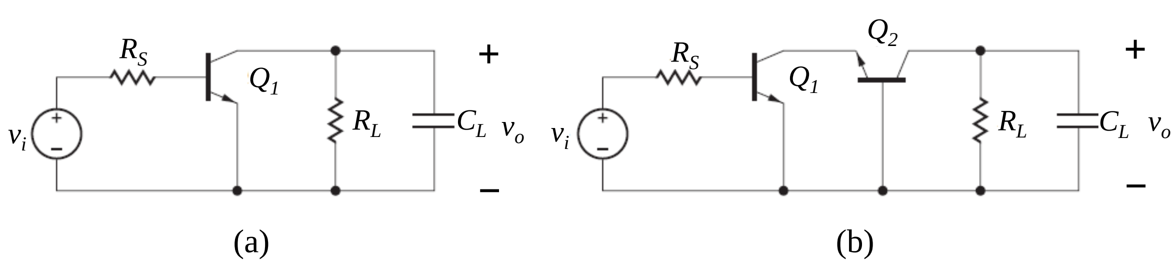


Fig. PS3.2

3. The ac schematic of a wideband MOS current amplifier is shown in Fig. PS3.3. The transistors have parameters $L_{drawn}$ = 3μm, $L_d$ = 0.1μm, $X_d$ = 0μm, the length of the drain and source diffusion is $2L_{drawn}$ ($L_{DE}$ and $L_{SE}$ in the lecture module), $C_{j0}$ = 0.08fF/μm$^2$, $C_{jsw0}$ = 0.5fF/μm, $n$ = 0.5, $\psi_0$ = 0.65V, $\mu_n$ = 700cm$^2$/V-s, $t_{ox}$ = 400Å , $\lambda$ = 0, and $V_t$ = 0.7V. Size of transistors: $W_1$ = 9μm, $W_2$ = 36μm. Both transistors use the minimum channel length. Assume the bias point at the gate of $M_1$ is $V_{G1}$ = 1V.
   a. Calculate the low-frequency small-signal current gain $i_o/i_i$.
   b. Estimate the -3-dB frequency.

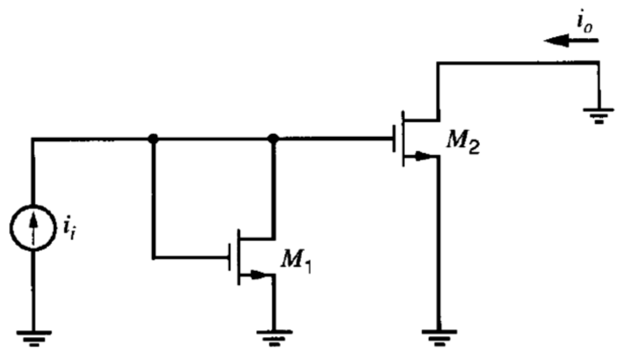


Fig. PS3.3

4. A BJT differential amplifier shown in Fig. PS3.4 operating with a 1-mA current source $I_{EE}$ uses transistor for which $\beta_F$ = 100, $f_T$ = 600MHz, $C_\mu$ = 0.5pF, $r_b$ = 100Ω and $r_o = \infty$. Both the input resistance $R_S$ and load resistances $R_L$ are 10kΩ.
   a. Determine the low-frequency value of the overall differential gain. Estimate the -3-dB frequency $f_H$ and the gain-bandwidth product.
   b. Suppose the circuit is modified by including 100-Ω resistor $R_E$ in each of the emitters. Determine the low-frequency value of the overall differential gain. And estimate the $f_H$ and gain-bandwidth product.
   c. From part (b), suppose you are requested to increase the 3-dB frequency of the differential amplifier to 1MHz by changing the value of the emitter resistance $R_E$ (as the 100-Ω resistors in part (b)). Find the value of $R_E$ to achieve this goal. What does the dc gain become? Also determine the resulting gain-bandwidth product.
   d. Now, suppose the circuit in part (a) (with no $R_E$) is modified by eliminating the load resistor $R_L$ of the left-hand-side transistor and the input signal (still series with the $R_S$) is fed to the base of the left-hand-side transistor while the base of the other transistor in the pair is grounded. Find the dc gain and $f_H$.

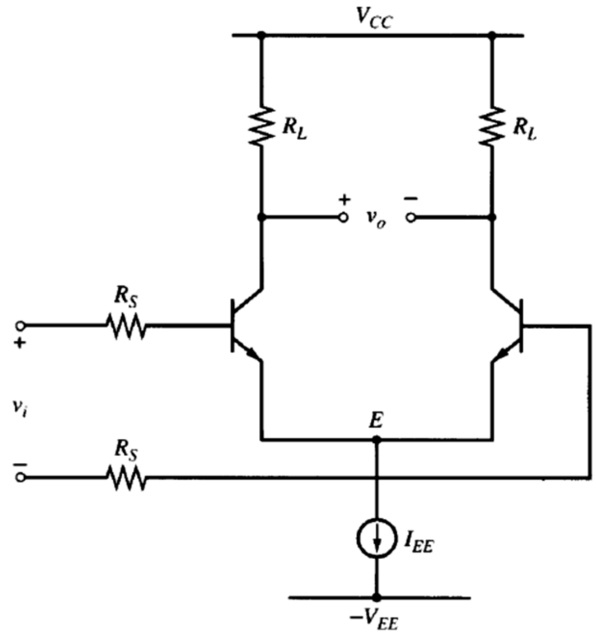


Fig. PS3.4