FINAL EXAMINATION

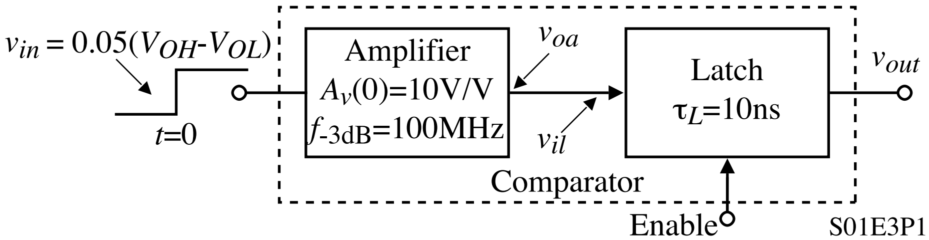
NAME_____________________________________SCORE______________/100

Problem	①	②	3	4	5	6	7	Total Points
Score								

INSTRUCTIONS: The exam is closed book and you are permitted four sheets of notes (three of which are your sheets for the 3 midterms plus a new sheet for the final exam). There should be no xerox reductions on your note sheets. The exam consists of 7, 20-point problems of which you are to work only 5 for a total of 100 points. You must attempt problems 1 and 2. All other problems are optional. **Please circle the number in the table above of the remaining three problems you wish graded.** If you do not indicate the problems to be graded, then problems 1 through 5 will be graded regardless of whether they are worked or not. Be sure to turn in only the 5 problems you wish graded in proper numerical order. Please show your work leading to your answers so that maximum partial credit may be given where appropriate.

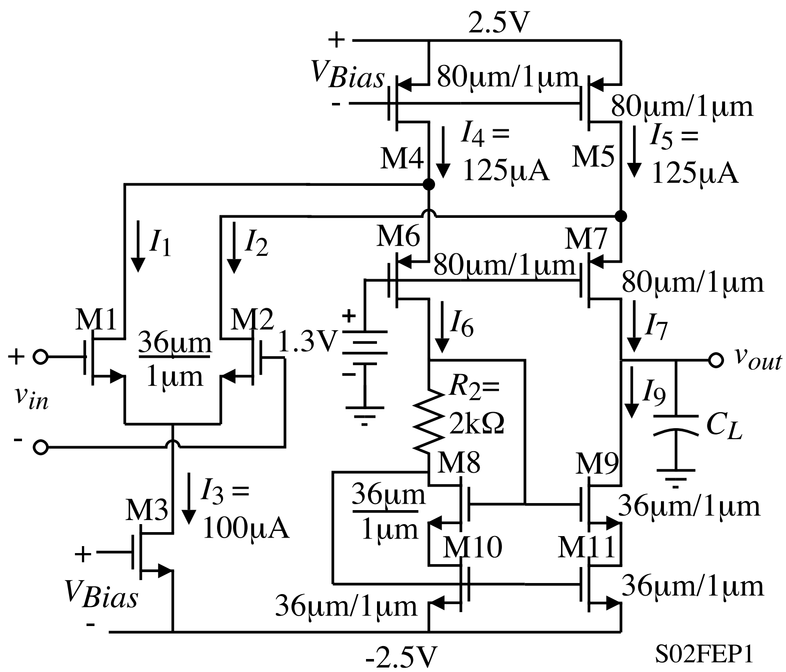
Problem 1 - (20 points - This problem is required)

A comparator consists of an amplifier cascaded with a latch as shown below. The amplifier has a voltage gain of 10V/V and f_{-3dB} = 100MHz and the latch has a time constant of 10ns. The maximum and minimum voltage swings of the amplifier and latch are V_{OH} and V_{OL}. When should the latch be enabled after the application of a step input to the amplifier of $0.05(V_{OH}-V_{OL})$ to get minimum overall propagation time delay? What is the value of the minimum propagation time delay? It may useful to recall that the propagation time delay of the latch is given as $t_p = \tau_L \ ln\left(\frac{V_{OH}-V_{OL}}{2v_{il}}\right)$ where v_{il} is the latch input (ΔV_i of the text).



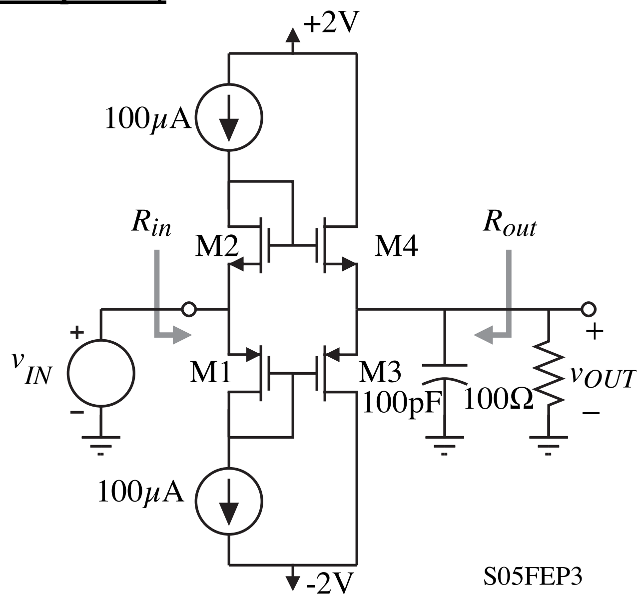
Problem 2 - (20 points - This problem is required)

If the folded-cascode op amp shown having a small-signal voltage gain of 7464V/V is used as a comparator, find the dominant pole if C_L = 5pF. If the input step is 10mV, determine whether the response is linear or slewing and find the propagation delay time. Assume the parameters of the NMOS transistors are K_N'=110V/μA^2, V_{TN} = 0.7V, λ_N=0.04V^{-1} and for the PMOS transistors are K_P'=50V/μA^2, V_{TP} = -0.7V, λ_P=0.05V^{-1}.



Problem 3 – (20 points – This problem is optional)

An source follower, push-pull output stage is shown. Assume the parameters of the NMOS transistors are K_N'=110V/μA^2, V_{TN} = 0.7V, λ_N=0.04V^{-1} and for the PMOS transistors are K_P'=50V/μA^2, V_{TP} = -0.7V, λ_P=0.05V^{-1}.



a.) If $W_1/L_1 = W_2/L_2 = 10$, find the W_3/L_3 and W_4/L_4 so that the drain current in M3 and M4 is 1mA when $v_{IN} = v_{OUT} = 0$.

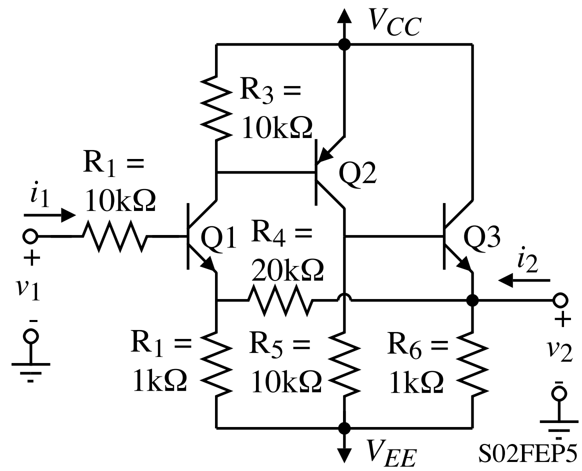
b.) What is the ±peak output voltage of this amplifier? Assume the 100µA sources can have a minimum voltage across them of 0.2V.

c.) What is the ±slew rate of this amplifier in V/µs?

d.) What is the small-signal input and output resistance of this amplifier when $v_{IN} = v_{OUT}$ = 0? (Do not include the load resistance in the output resistance.)

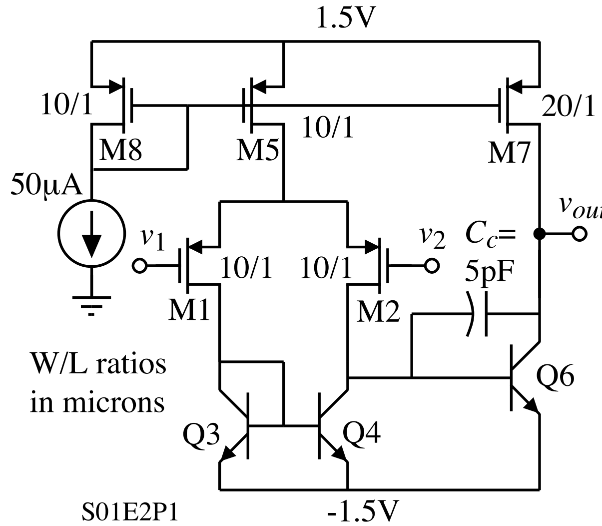
Problem 4 - (20 points - This problem is optional)

The simplified schematic of a feedback amplifier is shown. Use the method of feedback analysis to find v_2/v_1, $R_{in} = v_1/i_1$, and $R_{out} = v_2/i_2$. Assume that all transistors are matched and that $\beta = 100$, $r_\pi = 5k\Omega$ and $r_o = \infty$.



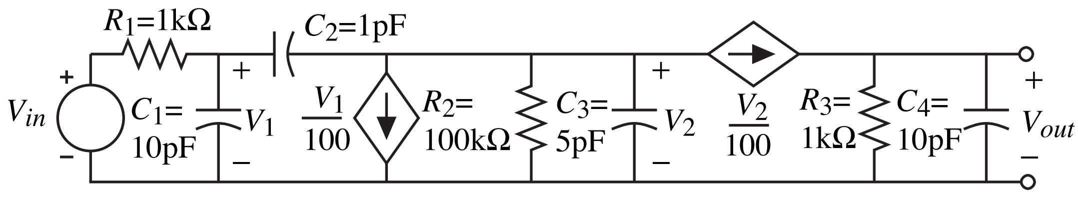
Problem 5 - (20 points - This problem is optional)

A two-stage, BiCMOS op amp is shown. For the PMOS transistors, the model parameters are K_P'=50μA/V^2, V_{TP} = -0.7V and λ_P = 0.05V^{-1}. For the NPN BJTs, the model parameters are β_F = 100, V_{CE}(sat) = 0.2V, V_A = 25V, V_t = 26mV, I_s = 10fA and n=1. (a.) Identify which input is positive and which input is negative. (b.) Find the numerical values of differential voltage gain, $A_v(0)$, GB (in Hertz), the slew rate, SR, and the location of the RHP zero. (c.) Find the numerical value of the maximum and minimum input common mode voltages.



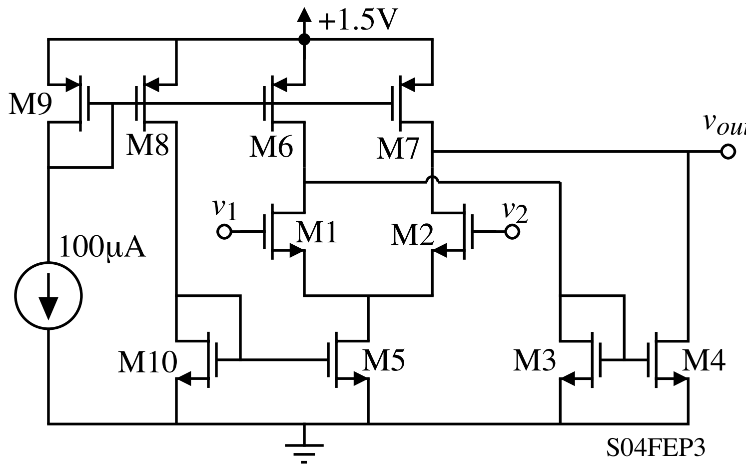
Problem 6 - (20 points - This problem is optional)

Find the midband voltage gain and the –3dB frequency in Hertz for the circuit shown.



Problem 7 – (20 points – This problem is optional)

Find an expression for the equivalent input noise voltage of the circuit in the previous problem, $\overline{e_{eq}^2}$, in terms of the small signal model parameters and the individual equivalent input noise voltages, $\overline{e_{ni}^2}$, of each of the transistors (i = 1 through 7). Assume M1 and M2, M3 and M4, and M6 and M7 are matched.



Extra Page