In the op-amp shown on the following page the transistors have the following properties:

V_{tn}=0.7V, V_{tp}=-0.8V, $\mu_n C_{ox}$160μA/V^2, $\mu_p C_{ox}$=40μA/V^2, $|V_A|$=10V (both NMOS and PMOS), $V_{DD}=V_{SS}$=2.5V. The Current source I_{REF} is 90 μA.

The Transistor widths and lengths are as follows (all dimensions in μm):

Transistor:	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
W/L	20/0.8	20/0.8	5/0.8	40/0.8	10/0.8	10/0.8	40/0.8	40/0.8

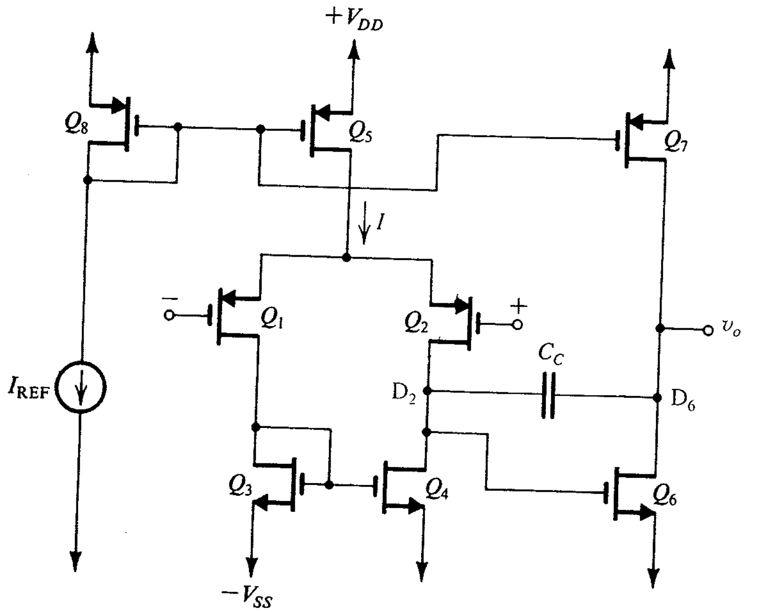
1) Calculate the overall gain of this amplifier. (Hint: all of the transistors are operated at the same V_{ov}, which is 0.3 V. Some useful formulas for transistors are $g_m=2I_D/V_{OV}$ and $r_o=|V_A|/|I_D$.

2) If the op-amp is connected as a unity gain follower, what is the maximum useful range of the input (i.e. what is the headroom?)

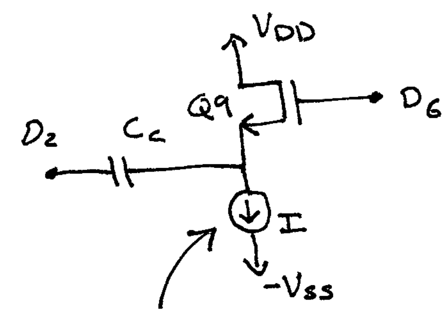
3) If this amplifier is Miller compensated as shown with C_C=5pF, what is the approximate location of the dominant pole in the amplifier transfer function? Ignore any parasitic device capacitances.

4) What is the resulting slew rate of the amplifier?

5) It is well known that amplifiers of this type are not compensated well by a simple Miller capacitor due to the presence of a right half plane zero in the transfer function (the "feed forward zero"). One way to correct this is to eliminate the feed forward current by connecting the output node to C_C through a source follower (see the inset in the figure). If this is done, and the source follower is also operated at a V_{ov} of 0.3 Volts, what is the resulting useful operating range of the amplifier when operated as a unity gain follower?



Feedback Modification



Assume simple single MOSFET Current Source