EE210A: Microelectronics I - Mini-Quiz 6

NAME (in capital)	Roll No

Time: 20 minutes

1) : Consider all transistors are identical. $\mu_n C_{ox} = 200\mu A/V^2$, $W/L = 10$, $\lambda = 0.1V^{-1}$. $I_0 = 1mA$, $V_{tn} = 1V$. Neglect body effect.

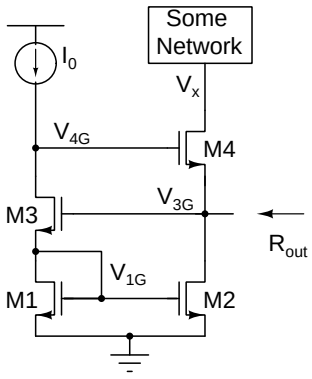


Fig. 1. Problem 1

a) : Neglect channel length modulation for all transistors for this part. Find the quiescent voltages at V_{1G}, V_{3G}. You are allowed to change the aspect ratio of a single transistor to decrease V_{3G} by 500 mV. What will you change in the circuit? **[2+3]**

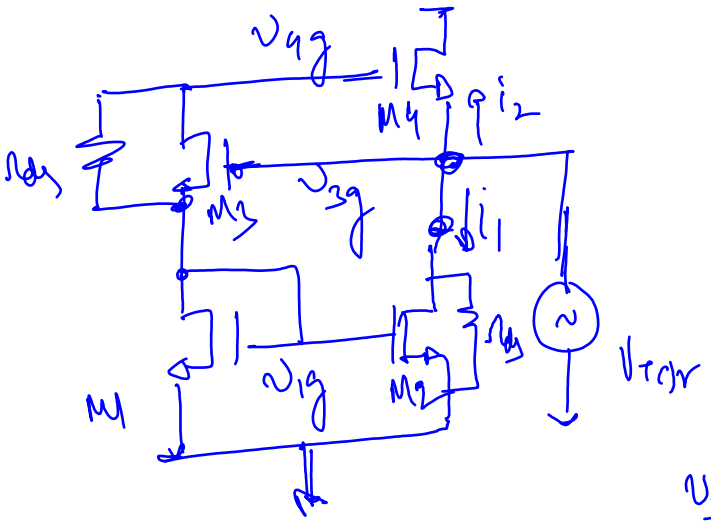
$V_{1G} = V_{tn} + \sqrt{\frac{2I_0}{\mu_n C_{ox} W/L}} = 2V$ $\quad V_{3G} = V_{1G} + V_{tn} + \sqrt{\frac{2I_0}{\mu_n C_{ox}(W/L)_3}}$

$= 4V$

To decrease V_{3G}, either decrease V_{1G} or decrease V_{OV3} (from 1V). But decreasing V_{1G} will effect current mirroring, and will need changing of $(W/L)_2$ to restore the current.

So change V_{OV3} by increasing $(W/L)_3$ by 4X

b) : Find the output resistance R_{out} as indicated in the figure. Neglect channel length modulation for $M1$ and $M4$. **[5]**



$\therefore$ No current can flow into M1 $\therefore$ $v_{1g} = 0$

$\therefore$ $i_1' = \dfrac{V_{Test}}{r_{ds}}$.

To find i_2 we need v_{3g} and v_{4g}.

$v_{3g} = V_{Test}$.

KCL @ v_{1g} $\Rightarrow$ $g_m v_{3g} + \dfrac{v_{4g}}{r_{ds}} = 0$

($\because v_{1g} = 0$)

$\Rightarrow v_{4g} = -g_m r_{ds} v_{3g} = -g_m r_{ds} V_{Test}$

$\therefore$ $i_2' = g_m (V_{Test} - v_{4g})$

$= g_m (1 + g_m r_{ds}) V_{Test}$

$\therefore$ $i_{Test} = \dfrac{V_{Test}}{r_{ds}} + g_m (1 + g_m r_{ds}) V_{Test}$

$\Rightarrow \dfrac{i_{Test}}{V_{Test}} = g_{ds} + g_m + g_m^2 r_{ds}$

$\Rightarrow R_{out} = \dfrac{1}{g_m^2 r_{ds} + g_m + g_{ds}} \approx \dfrac{1}{g_m^2 r_{ds}}$