# EE210: Analog Electronics

## Question Set 8

Instructor: Imon Mondal, imon@iitk.ac.in

*1)* Consider the current mirror in Fig. 1. $I_0 = 100\mu A$, $(W/L)_1 = (W/L)_2 = (W/L)_3 = (W/L)_4$=10 and $V_{tn}$=1V. Neglect body effect. Also, consider $\mu_n C_{ox} = 0.2mA/V^2$ and $\lambda = 0.1V^{-1}$.

*a) :* Find $V_{S3}$,$V_{S4}$,$V_{G3}$. Who sets the voltages $V_{S3}$ and $V_{S4}$? (Neglect CLM for calculating Q-point)

*b) :* Find the incremental $R_{out}$.

*c) :* Find the minimum $V_X$ while keeping all transistors in saturation.

*d):* If $V_X$ changes by 100 mV (while keeping $M4$ is saturation) how much change in current will you observe through $M2$?

*e):* If $V_X$ changes by 100 mV, how much change in $V_{S4}$ will you observe?

*f):* What will you do if you want to reduce $V_{S3}$ and $V_{S4}$ by 100 mV without affecting anything else?

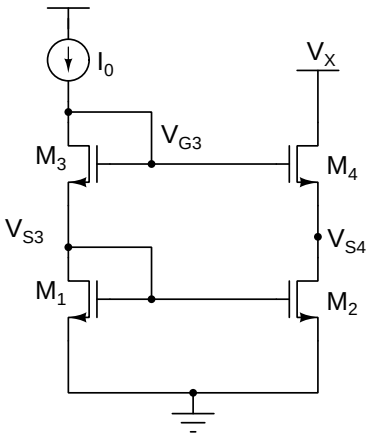


**Figure 1:** Problem 1.

*2)* Consider the circuit in Fig. 2. The currents $I_0$, and the transistors $M1 - M4$ are identical to that of Q3.

*a) :* Is it possible to have $V_{Xmin} = 2V_{ov|M2,M4}$?

*b) :* What must $V_{G5}$ be to realize the condition in a)?

*c) :* How will you size $M5$ to set this $V_{G5}$?

*3)* Consider Fig. 3. $(W/L) = 10$ for all transistors, $V_{tn}$=1V, $\mu_n C_{ox}$=200 $\mu A/V^2$. Assume the amplifier to be a VCVS of gain 100.

*a) :* Find $V_B$ such that $M2$ is biased just at the edge of saturation region.

*b) :* Assume $I_{DS2} \approx 1mA$. Find the incremental $R_{out}$.

*c) :* How does this architecture fare with respect to the previous ones?

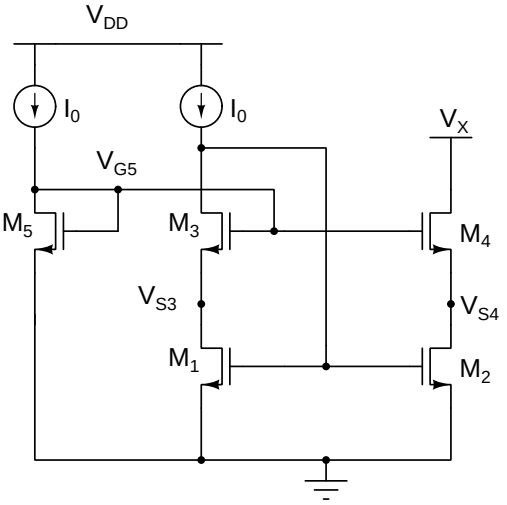


**Figure 2:** Problem 2.

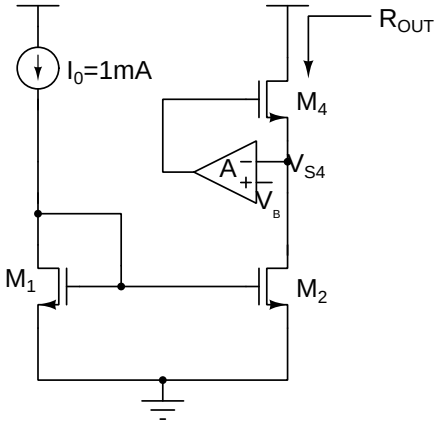


**Figure 3:** Problem 3.

*4)* Consider the Fig. 4. The amplifier in $Q3$. has been replaced by a common source stage. (Neglect channel length modulation for $M5$)

*a) :* Size $M5$ such that $V_{DS_{M2}} = V_{DS_{M1}}$.

*b) :* What is the gain of the common source stage?

*c) :* If you want to move the $V_{DS_{M2}}$ up or down, what will you change in the circuit?
*d) :* If $I_0$ changes to $I_0 + \Delta I$, what will be the total voltage at the drain of $M2$? (Nelgect channel length modulation for this part).

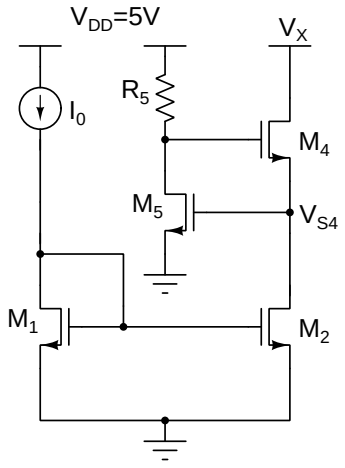


**Figure 4:** Problem 4.