

Fig. 1 shows three MOS current mirrors. The dc supply voltage is $V_{DD} = 12V$. All devices have identical characteristics, $K = (\mu_n C_{ox}/2)(W/L) = 0.1mA/V^2$, $V_{tn} = 2V$, and $\lambda = 0.0125 1/V$. You can neglect body-bias effects, i.e., you may assume that $\gamma \approx 0$.

- a) Select R in the current mirror 1.1 so that the output current is $I_o = 0.1mA$. State the assumptions you made.
- b) Find the output resistance R_{out} of the current mirror 1.1.
- c) Find the minimum voltage $(V_o)_{min}$ such that the circuit operates as a current source, with the output resistance computed in b).
- d) To increase the output resistance, the current mirror is modified as shown in 1.2. Repeat parts a), b) and c) for the current mirror 1.2. Then, do a .dc PSpice simulation and plot $I(V_o)$ for $0 \leq V_o \leq V_{DD}$ to verify your results for $(V_o)_{min}$ and for the output resistance. Turn in only the plots used to verify $(V_o)_{min}$ and R_{out} .
- e) In part d) you will find that the current source 1.2 has a much higher output resistance than the current source 1.1, but that it also has a considerably higher $(V_o)_{min}$. To reduce $(V_o)_{min}$, the mirror 1.2 is modified further, as shown in 1.3. In 1.3, all devices are identical except that M_7 has a different K (different W/L ratio). Select K_7 of M_7 to obtain the minimum possible $(V_o)_{min}$. Then, repeat parts a), b), c) for the current mirror 1.3.

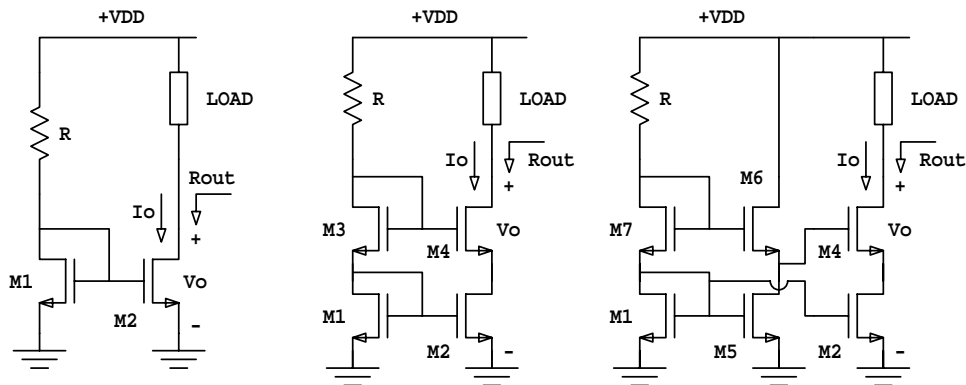


Figure 1: Left to right: NMOS current mirrors 1, 2, 3.