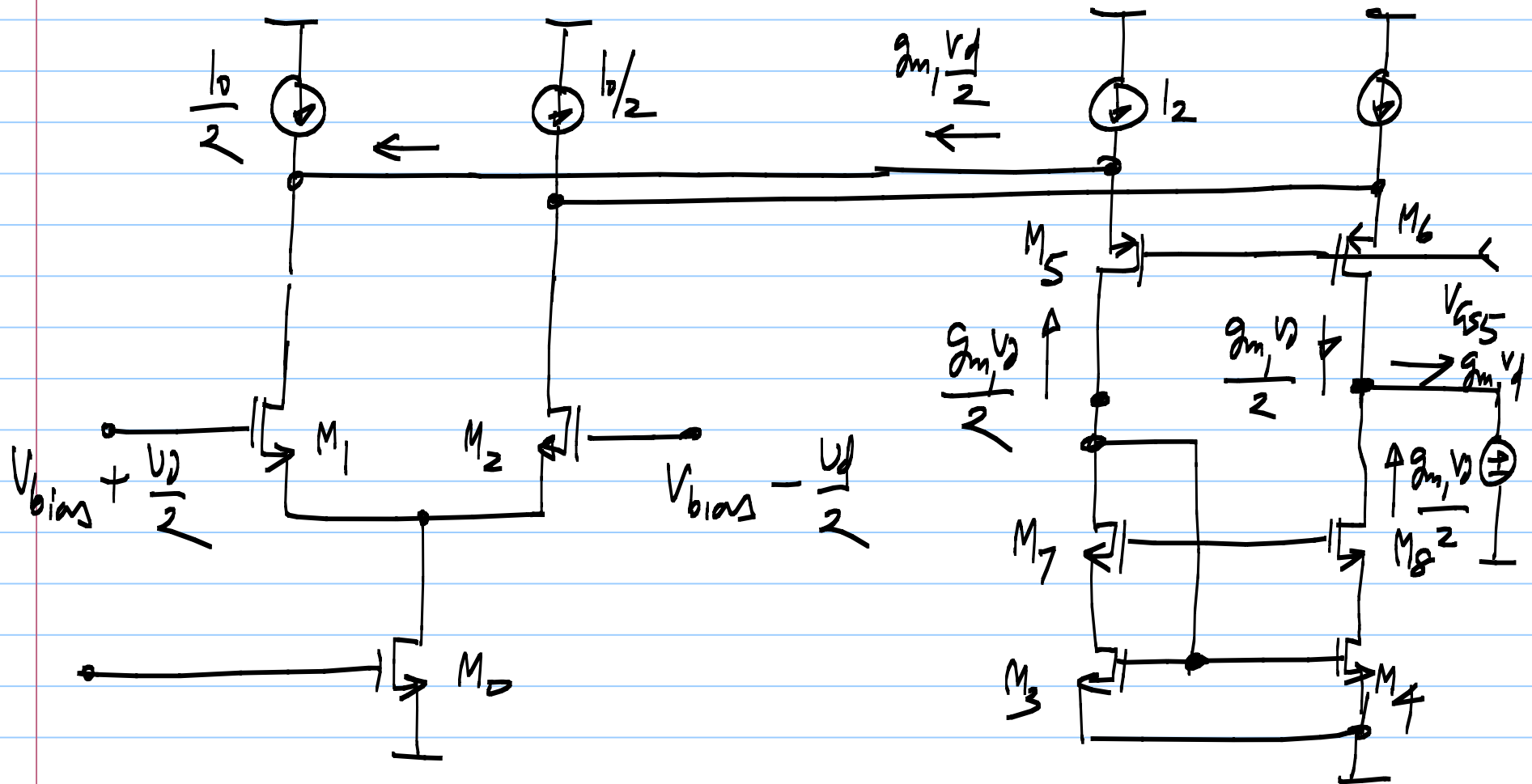
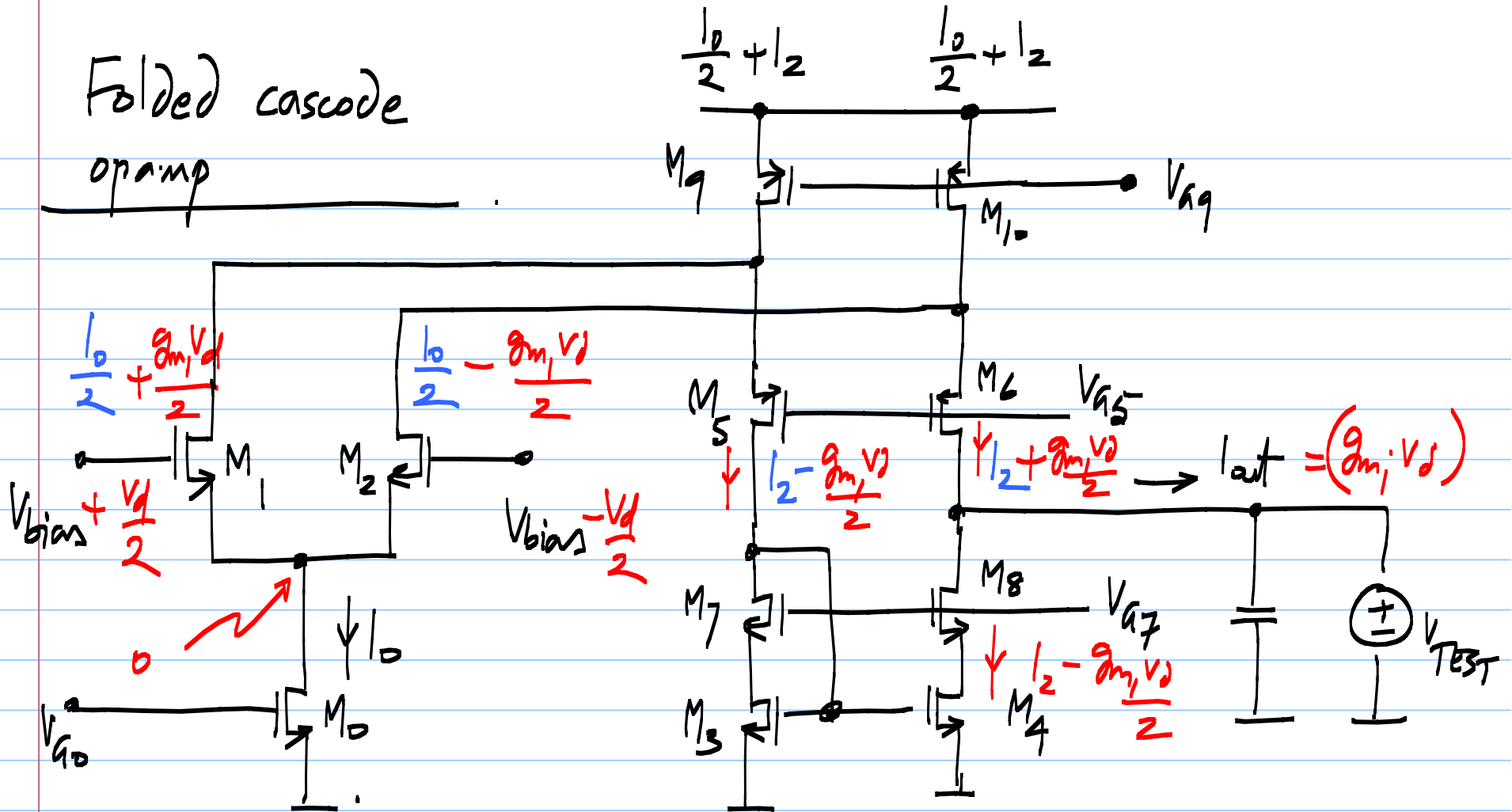


Lecture 35 :



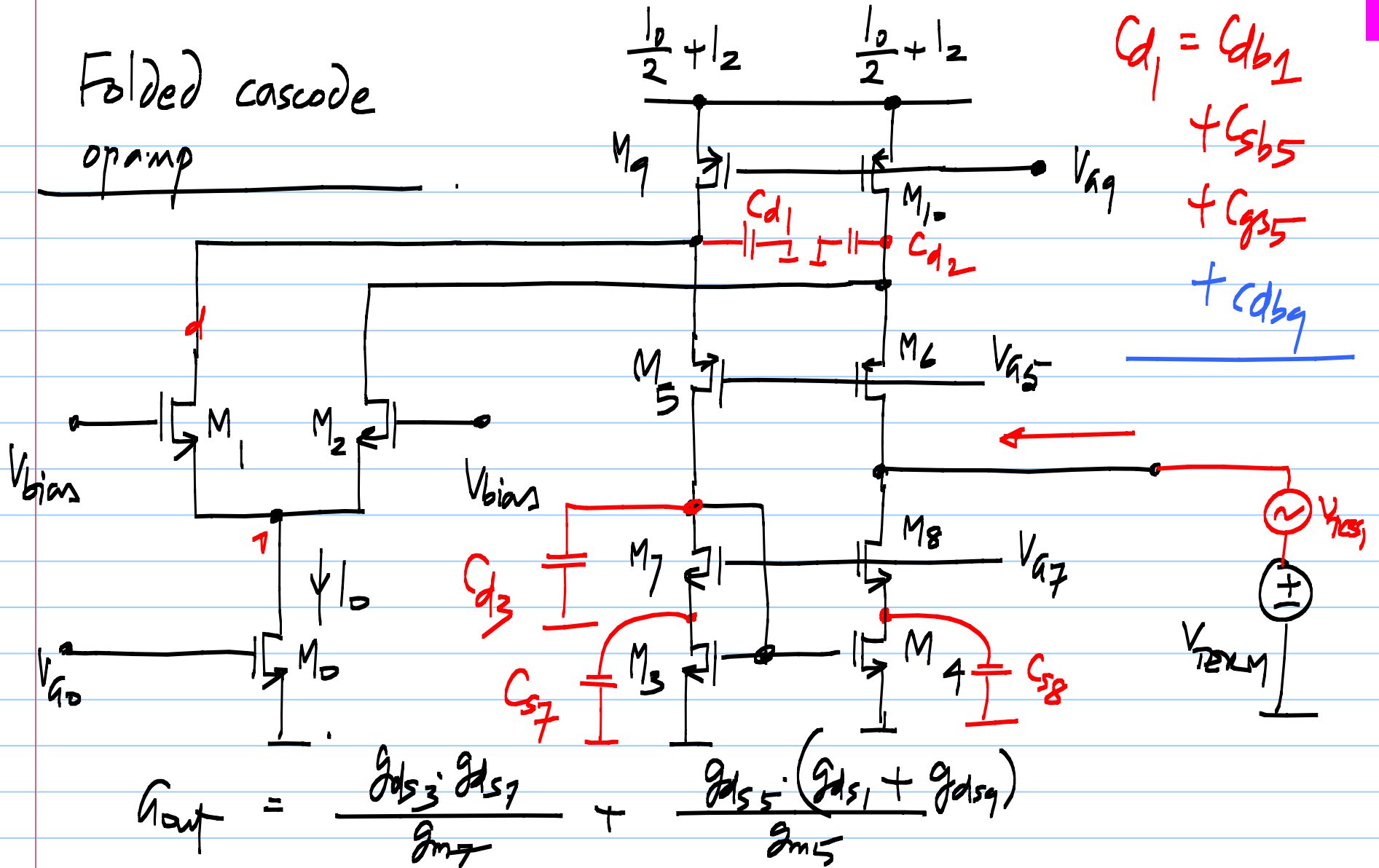
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opamp



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opamp



$$C_{d1} = C_{db1} + C_{sb5} + C_{gs5} + C_{db9}$$

$$A_{out} = \frac{g_{ds3} \cdot g_{ds7}}{g_{m7}} + \frac{g_{ds5} \cdot (g_{ds1} + g_{ds9})}{g_{m5}}$$

Folded cascode transconductor / opamp

$$G_m : g_{m1}$$

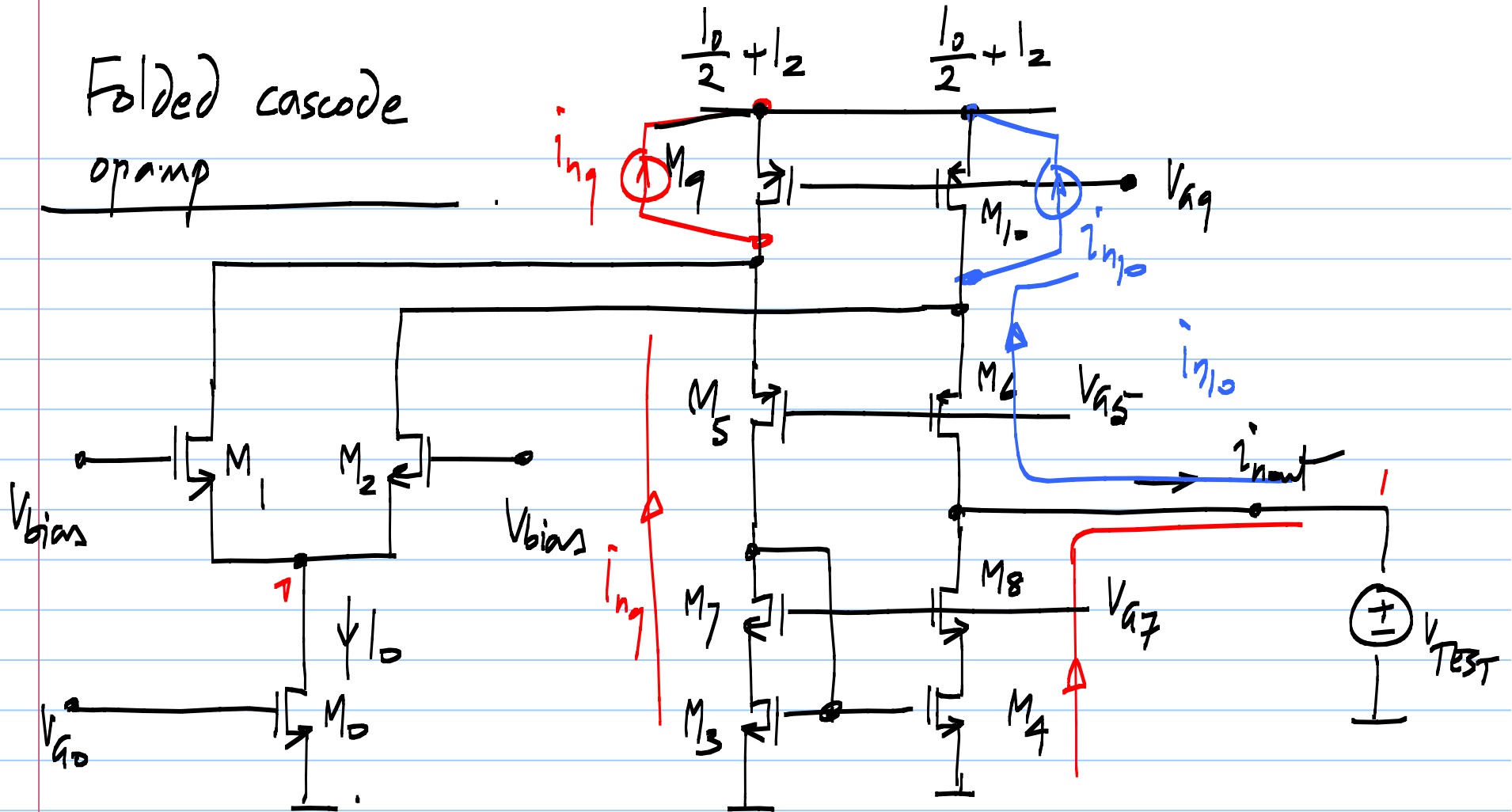
$$G_{out} = \frac{g_{ds7} g_{ds3}}{g_{m7}} + \frac{g_{ds5} (g_{ds1} + g_{ds10})}{g_{m5}}$$

$$\text{Parasitic poles/zeros: } p_2 = -\frac{g_{m3}}{C_{d3}}; \quad z_1 = -\frac{2g_{m3}}{C_{d3}}; \quad -\frac{g_{m5}}{C_{d1}} \dots$$

{ larger parasitic capacitances due to $M_{9,10}$ }

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opamp



$$i_{n_{out}} = i_{n1} - i_{n2} + i_{n3} - i_{n4} + i_{n7} - i_{n10}$$

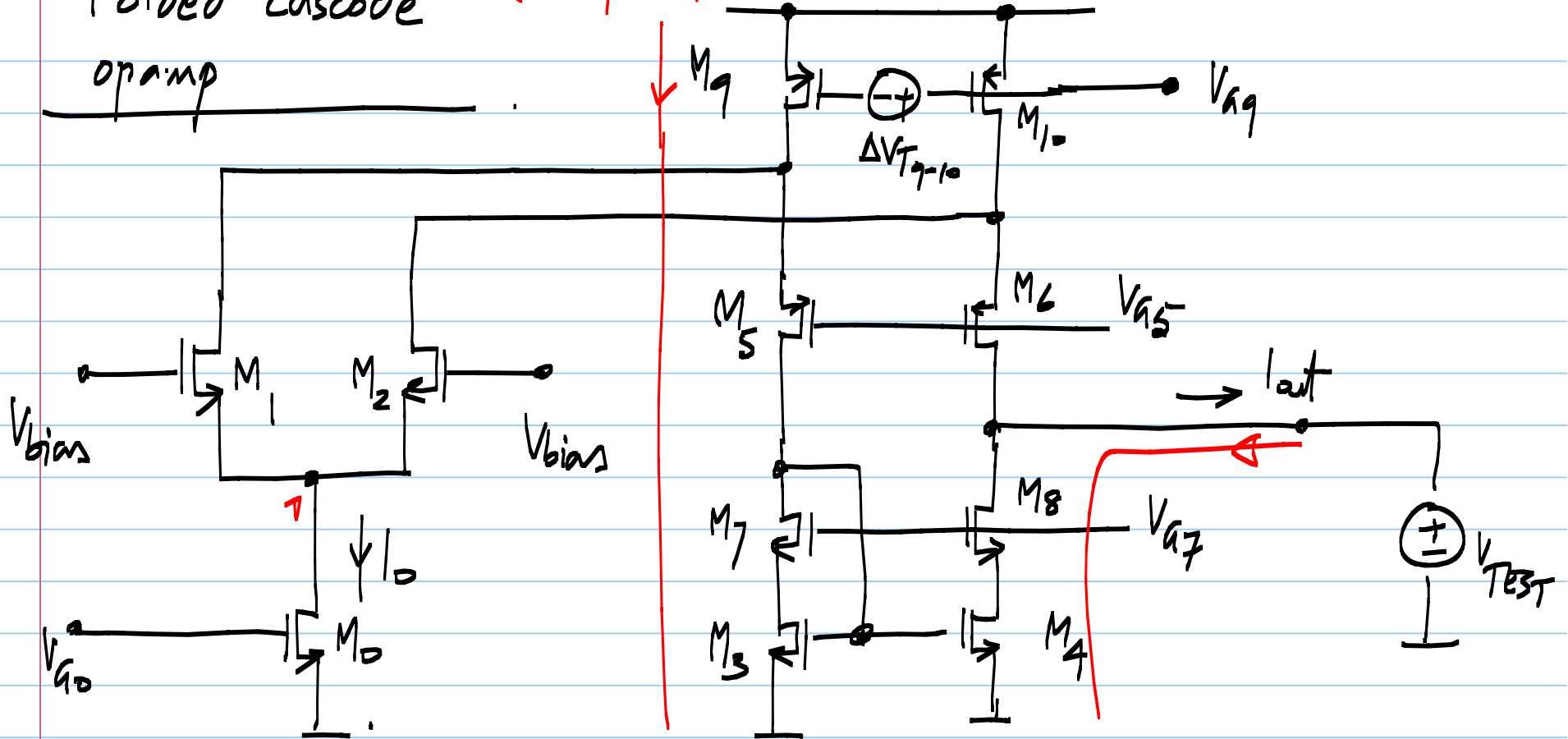
$$i_{n,out} = i_{n_1} - i_{n_2} + i_{n_3} - i_{n_4} + i_{n_9} - i_{n_{10}}$$

$$S_{i_{n,out}} = \frac{16}{3} kT (g_{m_1} + g_{m_3} + g_{m_9})$$

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$$(g_{m9} \Delta V_{T9,10}) \frac{I_0}{2} + I_2 \quad \frac{I_0}{2} + I_2$$



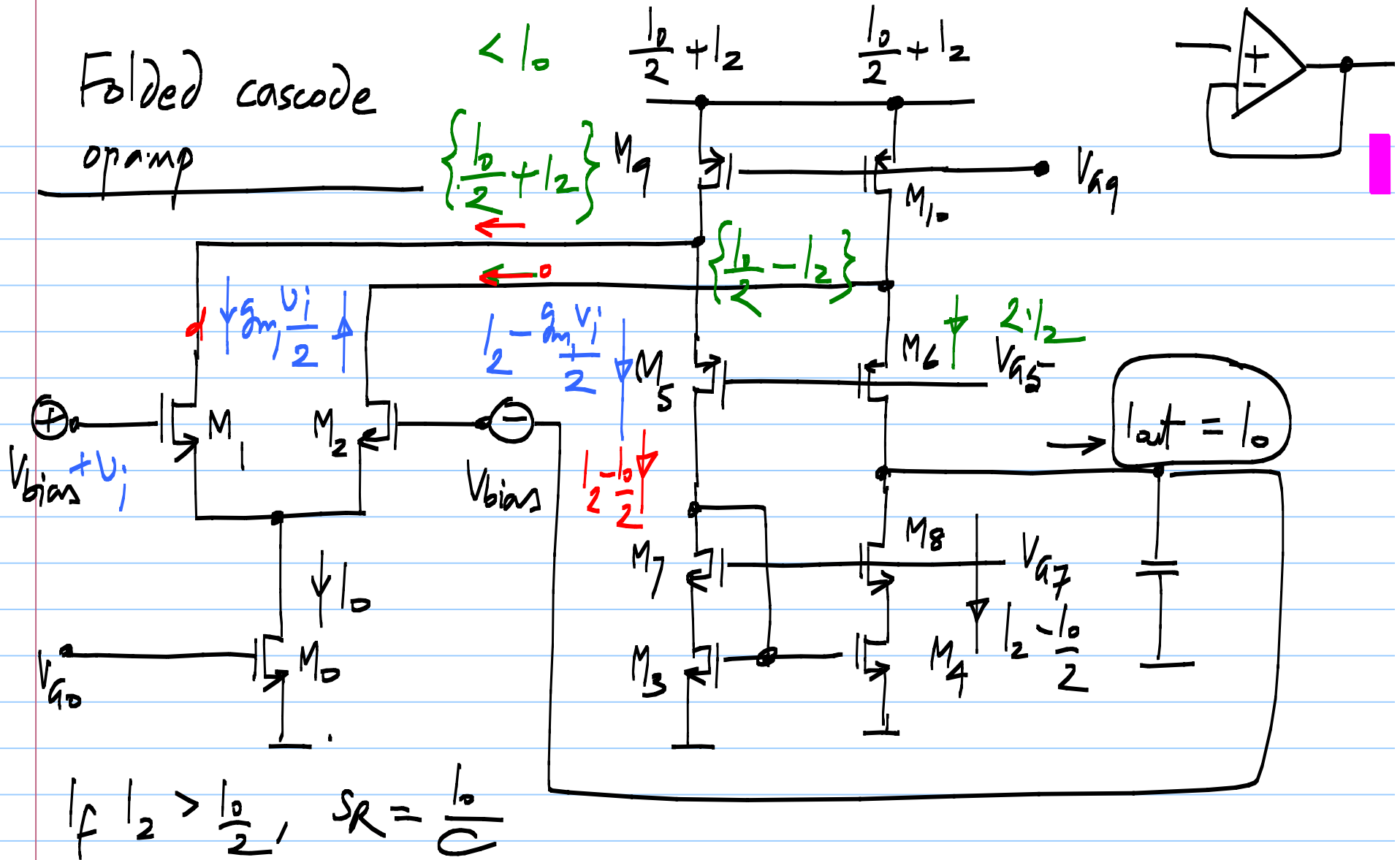
$$I_{out, mismatch} = \Delta V_{T12} \cdot g_{m1} + \Delta V_{T34} \cdot g_{m3} - \Delta V_{T9,10} \cdot g_{m10}$$

Input referred offset : $\sigma^2 \left(\frac{i_{out, mismatch}}{g_{m1}} \right)$

$$\sigma_{v_{OS}}^2 = \sigma_{v_{T12}}^2 + \sigma_{v_{T34}}^2 \left(\frac{g_{m3}}{g_{m1}} \right)^2 + \sigma_{v_{T9,10}}^2 \left(\frac{g_{m10}}{g_{m1}} \right)^2$$

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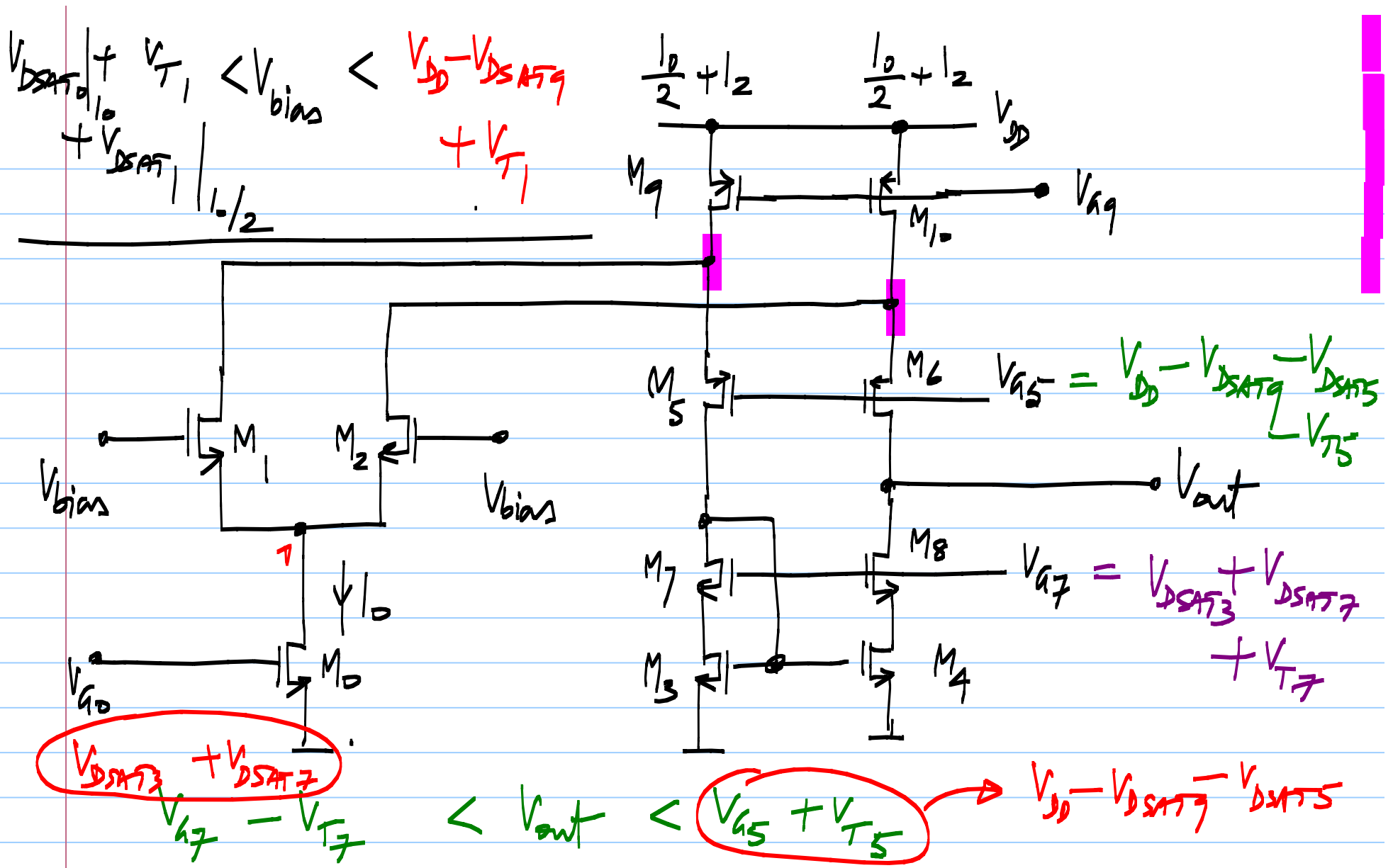


$$f_{1/2} > \frac{I_0}{2}, \quad SR = \frac{I_0}{C_{1/2}}$$

$$\left. \begin{array}{l} \text{If } l_2 > \frac{l_0}{2} : \quad SR = \frac{l_0}{C} ; \\ \text{If } l_2 < \frac{l_0}{2} : \quad SR = \frac{2l_2}{C} ; \end{array} \right\} \frac{\min(l_0, 2l_2)}{C}$$

$l_2 = \frac{l_0}{2}$. The two limits are equal

Common choice



Folded cascode opamp swing limits:

$$V_{DSAT0} + V_{DSAT1} + V_{T1} < V_{bins} < V_{G5} + V_{S45} + V_{T1}$$
$$\left\{ V_{DD} - V_{DSAT4} + V_{T1} \right\}$$

$$V_{G7} - V_{T7} < V_{out} < V_{G5} + V_{T5}$$
$$\left\{ V_{DSAT3} + V_{DSAT7} \right\} \quad \left\{ V_{DD} - V_{DSAT9} - V_{DSAT6} \right\}$$