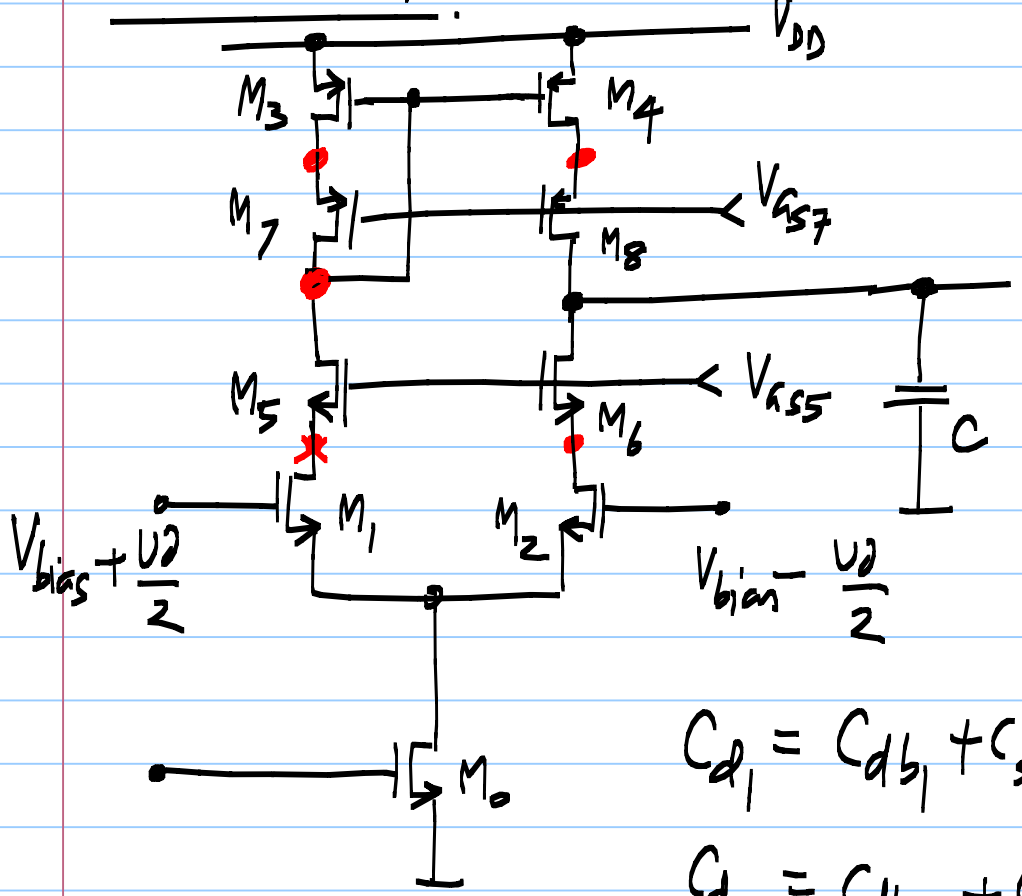
Lecture 34



$$A_0 = \frac{g_{m1}}{\frac{g_{ds1}g_{ds5}}{g_{m5}} + \frac{g_{ds3}g_{ds7}}{g_{m7}}}$$

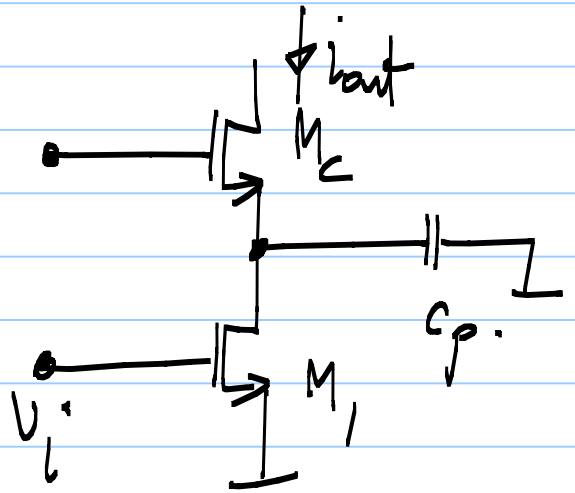
$$G_m = g_{m1}$$

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

$$C_{d1} = C_{db1} + C_{sb5} + C_{gs5} \qquad C_{d5} = C_{db5} + C_{db7} + 2 \cdot C_{gs3}$$

$$C_{d2} = C_{db2} + C_{sb6} + C_{gs6} \qquad C_{d3} = C_{db3} + C_{sb7} + C_{gs7}$$

Due to C_{d5} : $p_2 = -\frac{g_{m3}}{C_{d5}}$; $z_1 = -\frac{2g_{m3}}{C_{d5}}$



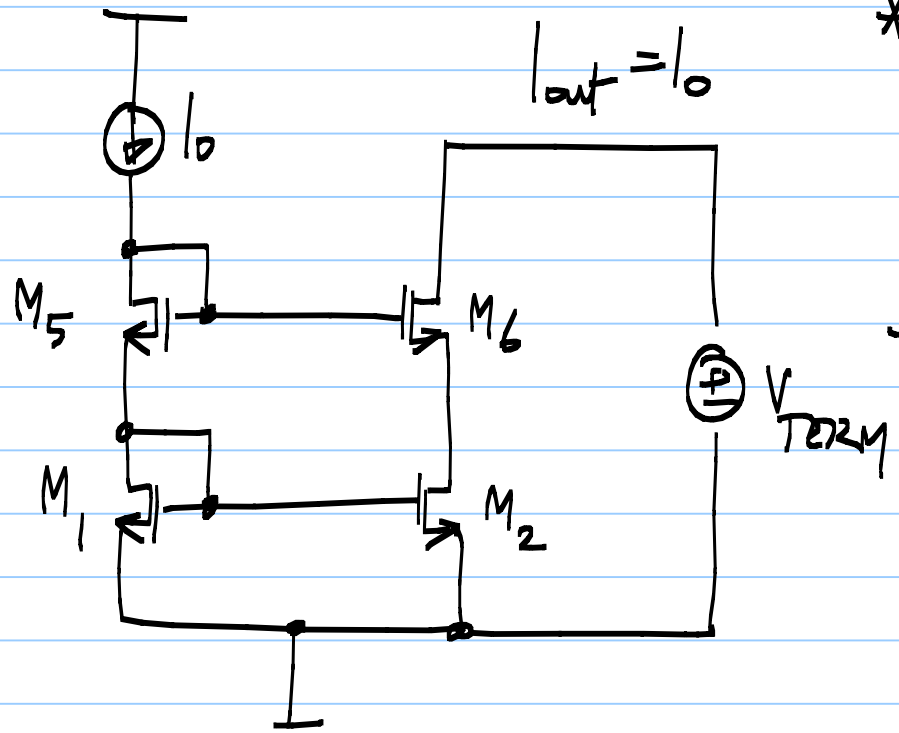
pole @ $-\frac{g_{mc} + g_{mbc}}{C_p}$

C_{d1} : $-\frac{g_{m5}}{C_{d1}}$; C_{d2} : $-\frac{g_{m5}}{C_{d1}}$

C_{d3} : $-\frac{g_{m7}}{C_{d3}}$; C_{d4} : $-\frac{g_{m8}}{C_{d4}}$

acts only on half of I_{out}

Noise & offset:

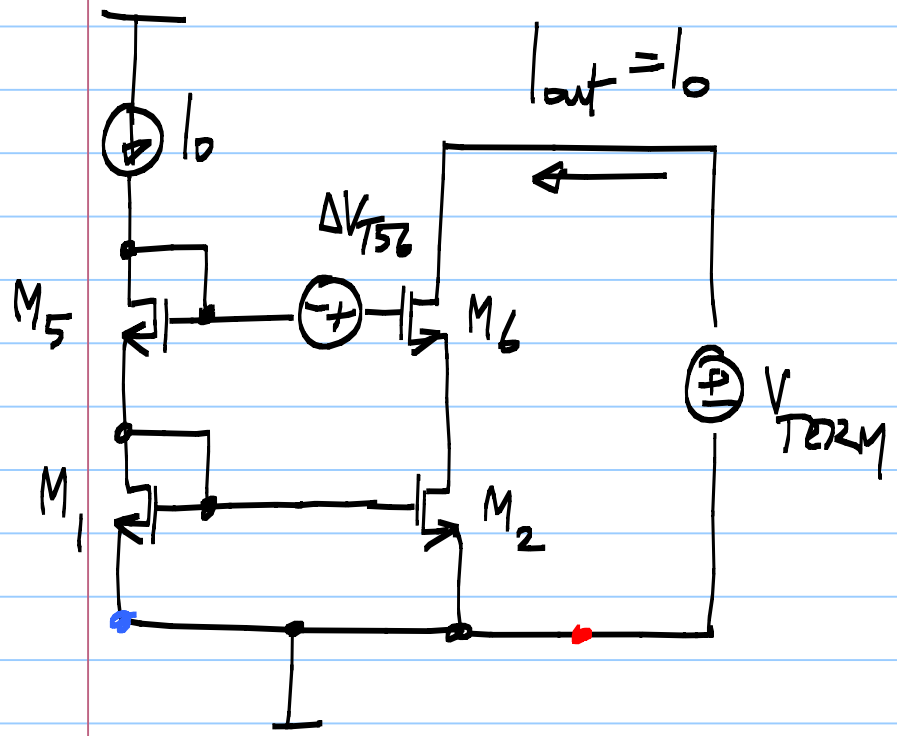


Exercise:

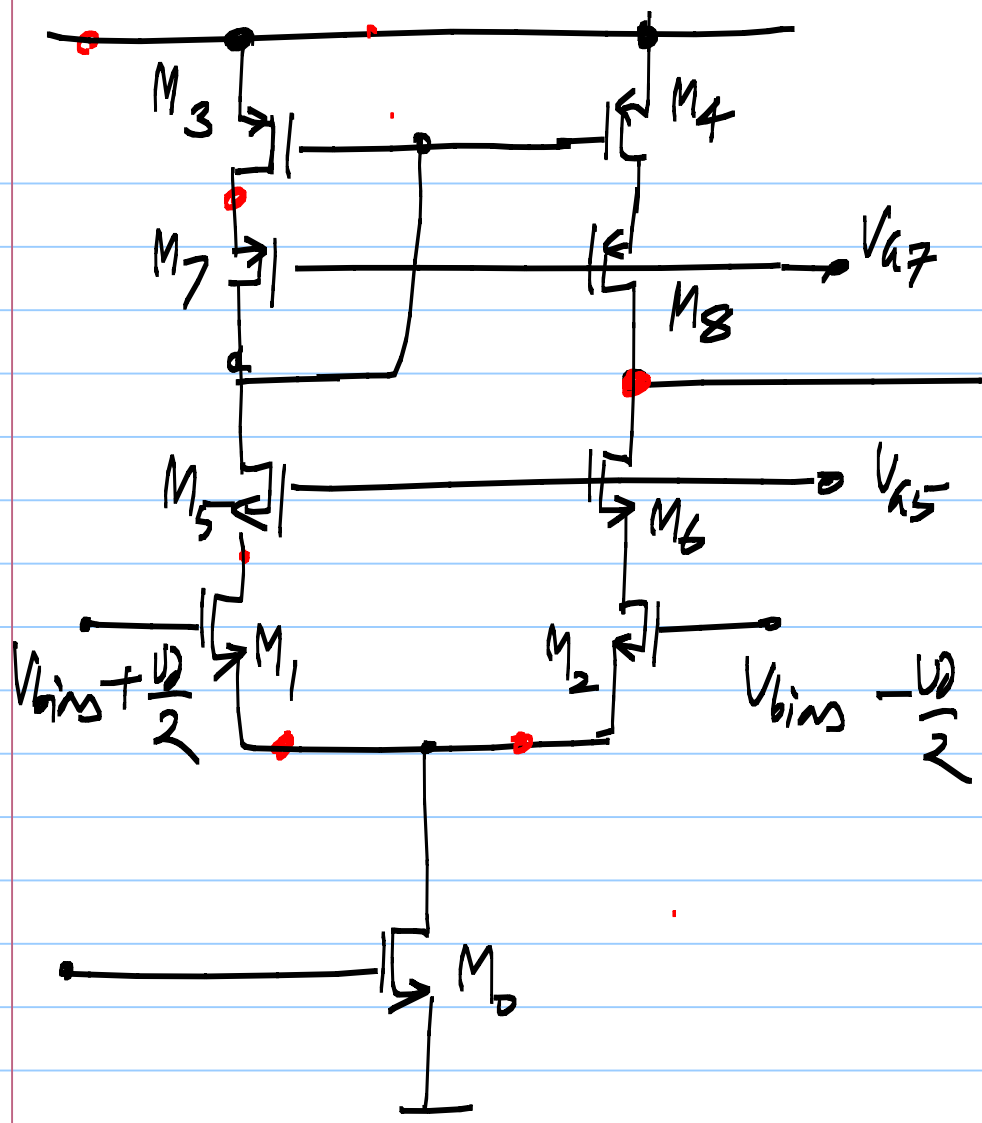
* Calculate the total noise $i_{n,out}$ $\{S_{i_{n,out}}\}$

* Calculate the mismatch induced error in I_{out}

Identify the contribution of individual transistors

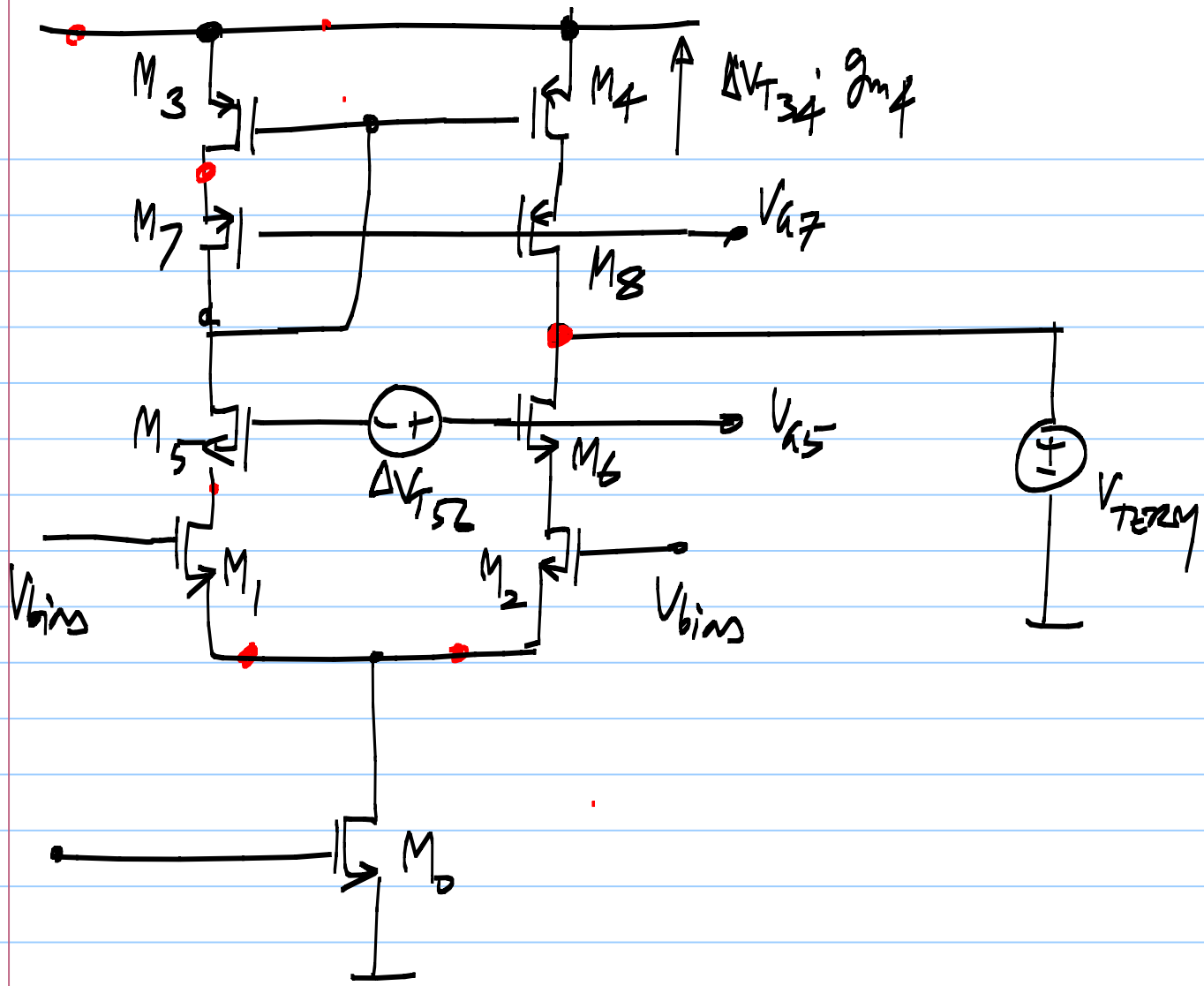


	$i_{n,out}$	Mismatch
M_1	i_{n_1}	$\Delta V_{T12} \cdot g_{m_2}$
M_2	i_{n_2}	
M_5	0	0
M_6	0	



Noise. $i_{n,out}$

M_0	0
M_1	i_{n_1}
M_2	$-i_{n_2}$
M_3	i_{n_3}
M_4	$-i_{n_4}$
M_5	0
M_6	0
M_7	0
M_8	0



	i_{out}
ΔV_{T12}	$g_{m1} \cdot \Delta V_{T12}$
ΔV_{T34}	$-g_{m3} \cdot \Delta V_{T34}$
ΔV_{T52}	0
ΔV_{T78}	0

$$i_{out} = i_{n_1} - i_{n_2} + i_{n_3} - i_{n_4}$$

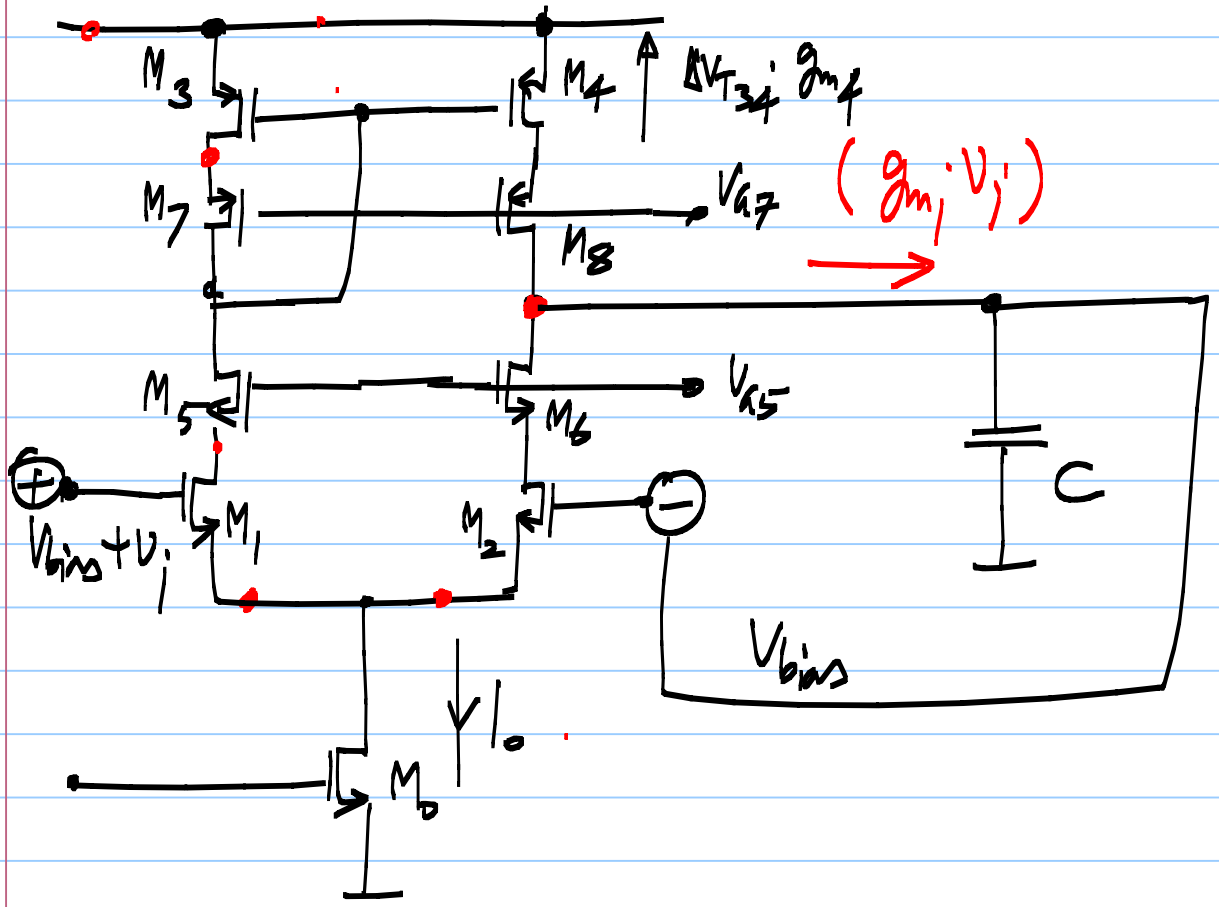
$$S_{i_{out}} = S_{i_{n_1}} + S_{i_{n_2}} + S_{i_{n_3}} + S_{i_{n_4}}$$

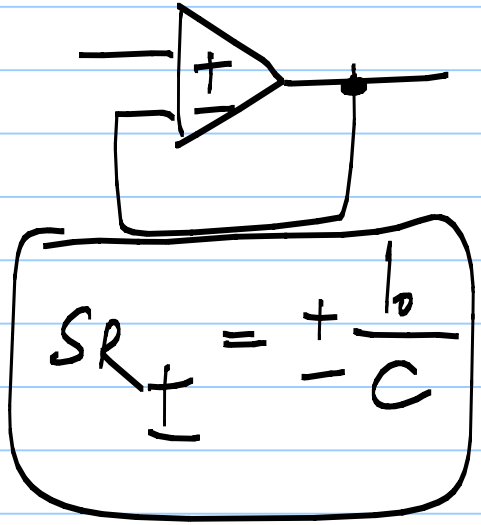
$$= \frac{16}{3} kT \cdot (g_{m_1} + g_{m_3})$$

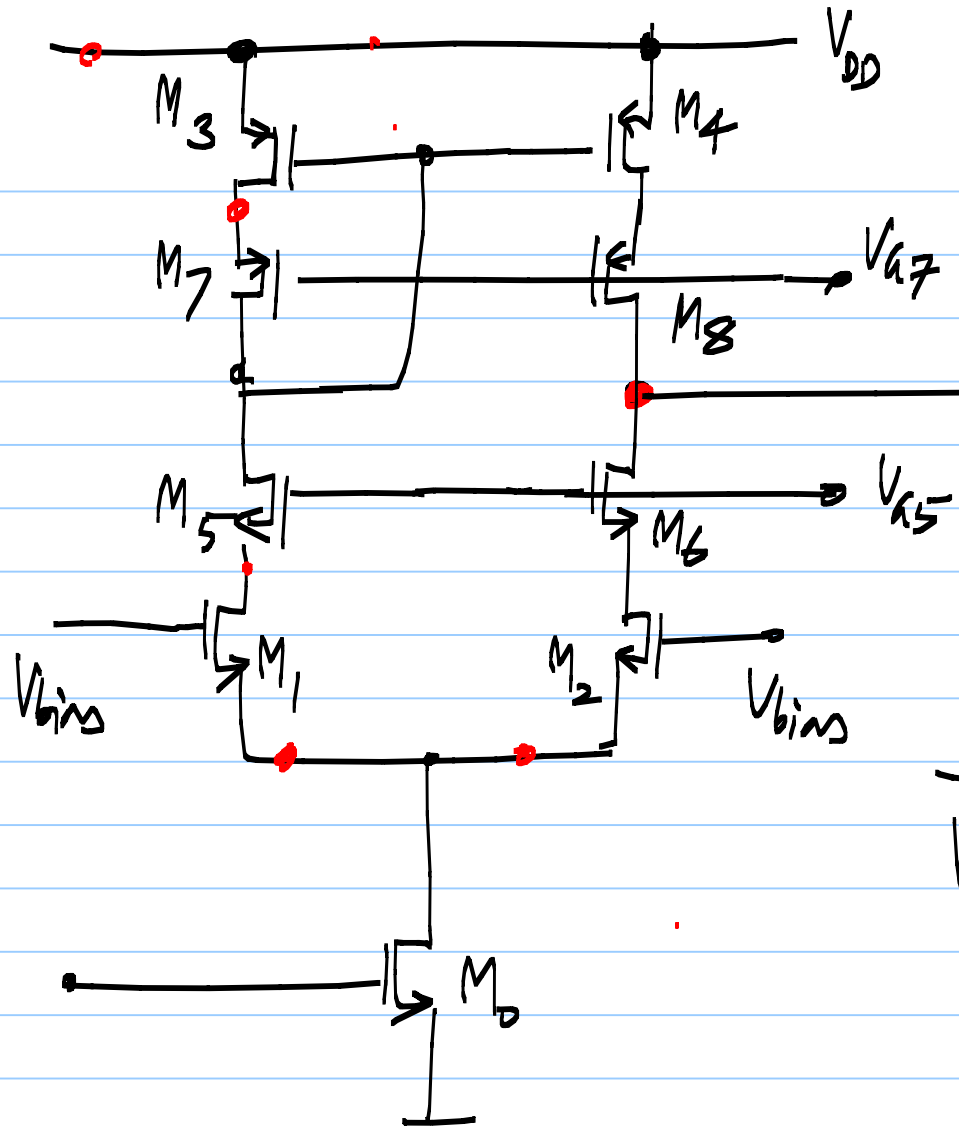
$$S_{V_{in}} = \frac{S_{i_{out}}}{g_{m_1}^2} = \frac{16}{3} \frac{kT}{g_{m_1}} \left(1 + \frac{g_{m_3}}{g_{m_1}}\right)$$

$$\sigma_{V_{os}}^2 = \sigma_{V_{T12}}^2 + \sigma_{V_{T34}}^2 \cdot \left(\frac{g_{m_3}}{g_{m_1}}\right)^2$$

Slew rate of the telescopic cascode opamp.







$$V_{G5} - V_{T5} < V_{out} < V_{G7} + V_{T7}$$

V_{out}

$$V_{G7,max} = V_{DD} - V_{DSAT3} - V_{SG7} \Big|_{I_D/2}$$

$$V_{G5,min} = V_{bias} - V_{T1} + V_{GS5} \Big|_{I_D/2}$$

$$V_{DSAT_0}\Big|_{I_0} + V_{T_1} + V_{DSAT_1}\Big|_{I_0/2} < V_{bias} < V_{G5} - V_{T_5} - V_{DSAT_5}\Big|_{\frac{I_0}{2}} + V_{T_1}$$

Telescopic cascode vs. the Differential pair

* gain is higher
* Swing limit : smaller
* Noise, offset, ω_u, SR similar
* Many more parasitic poles