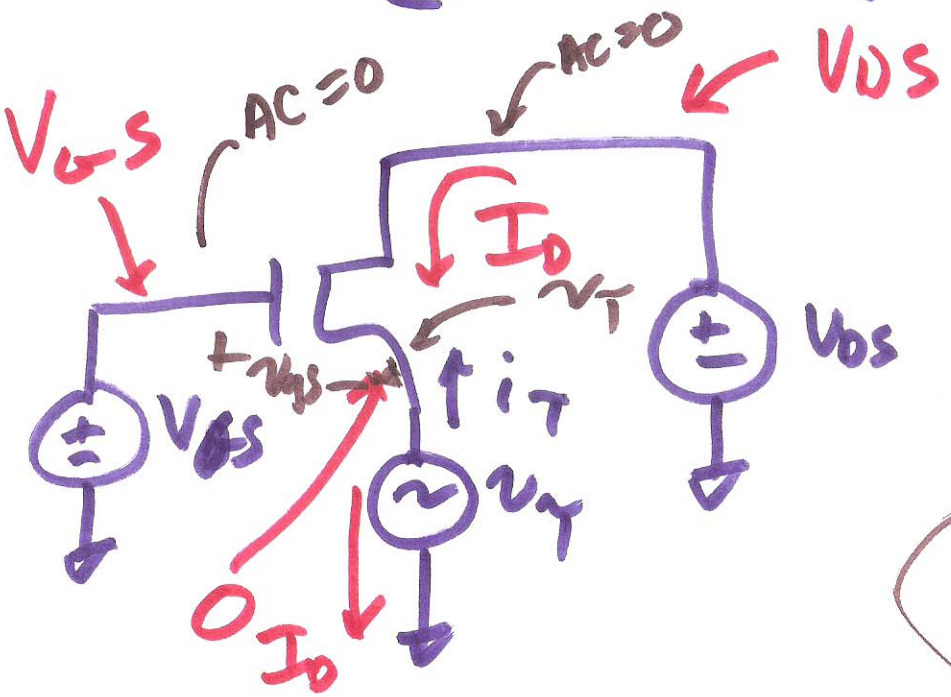
EE 422 ECG 622
Analog IC Design

Lecture 9 2/22/13



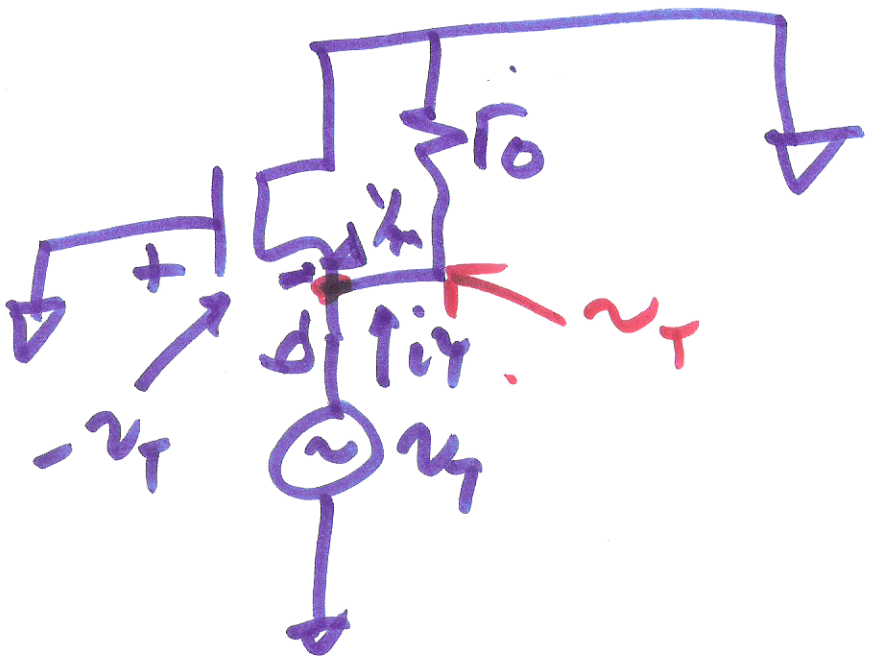
$$v_{gs} = v_g - v_s$$
$$= 0 - v_T$$
$$= -v_T$$

$$i_d = g_m v_{gs} = g_m(-v_T)$$

$$i_d = -i_T$$

$$R_{into\ source} = \frac{v_T}{i_T} = \frac{-i_d/g_m}{-i_d} = \frac{1}{g_m}$$

Exact resistance into source



$$= \frac{1}{g_m} \| r_o$$

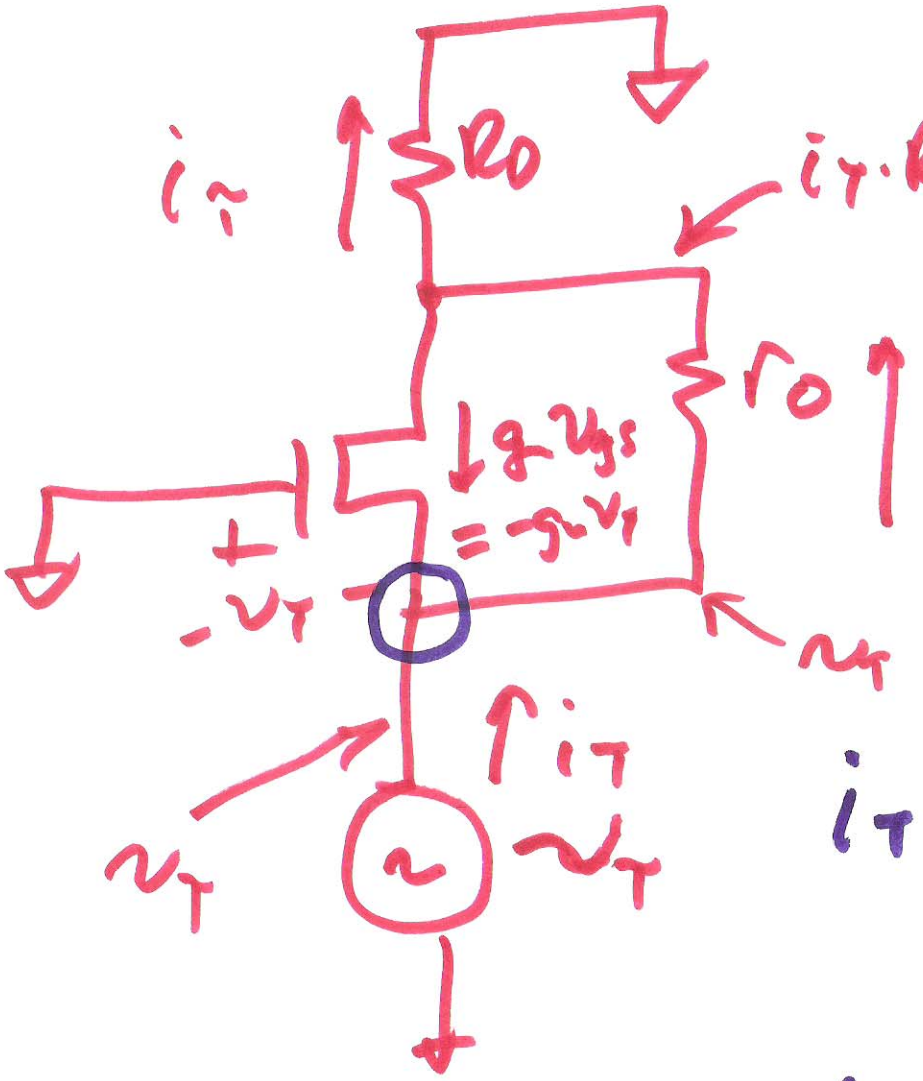
$$i_T = \frac{v_T}{r_o} + (-i_x)$$

$$= \frac{v_T}{r_o} + (-g_m v_{gs})$$

$$= \frac{v_T}{r_o} + \frac{v_T}{1/g_m}$$

$$\frac{v_T}{i_T} = \left(\frac{1}{r_o} + 1/g_m\right)^{-1}$$

$$= \frac{1}{g_m} \| r_o$$



$$i_T + g_m v_{gs} = \frac{v_T - i_T \cdot R_D}{r_O R_D}$$

$-g_m v_T$

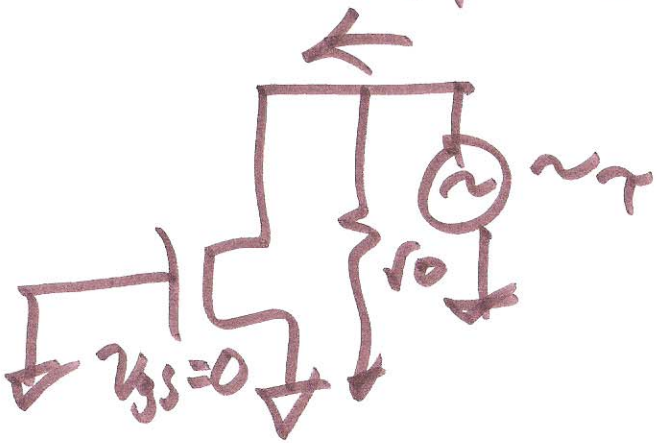
$$i_T\left(1 + \frac{R_D}{r_O}\right) = v_T\left(\frac{1}{r_O} + g_m\right)$$

$$R_{out\,source} = \frac{v_T}{i_T} = \frac{1 + \frac{R_D}{r_O}}{\frac{1}{r_O} + g_m}$$

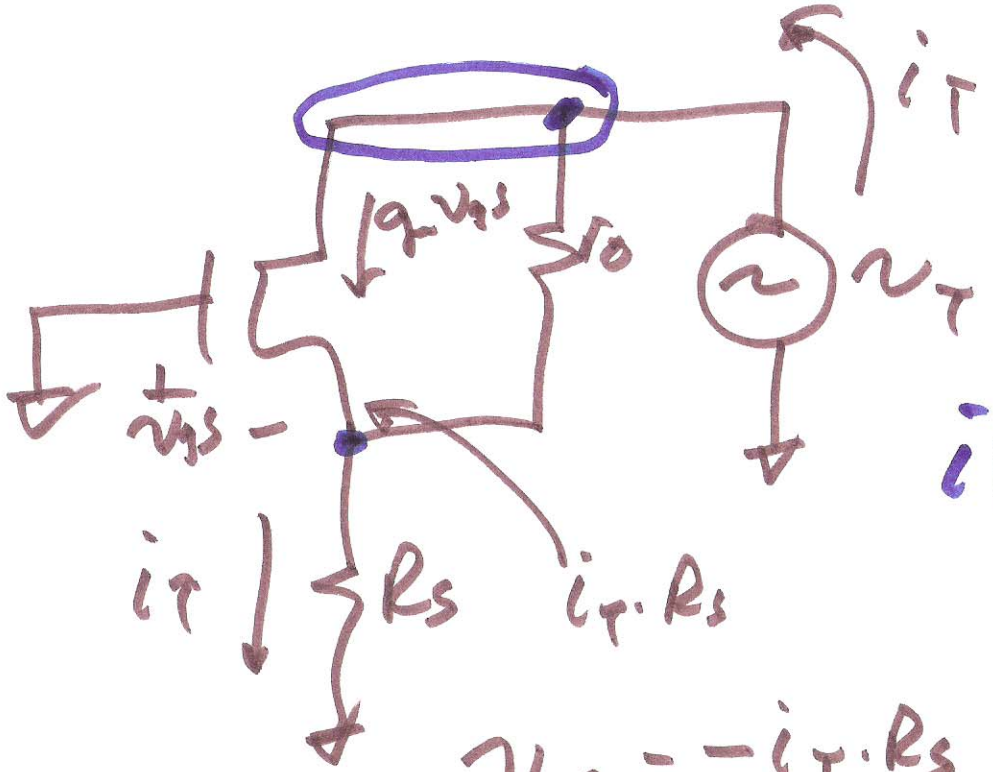
$$R_{into\,source} = \frac{v_T}{i_T} = 1 + \frac{R_D}{r_O} \Big/ \left(\frac{1}{r_O} + \frac{1}{1/g_m}\right)$$

$$= \left(1 + \frac{R_D}{r_O}\right)\left(r_O \parallel 1/g_m\right)$$

i_T R into drain



$$\frac{v_T}{i_T} = r_O$$



$$i_T = g_m v_{gs} + \frac{v_T - i_T R_s}{r_o}$$

$$i_T = g_m(-i_T R_s) + \frac{v_T}{r_o} - \frac{R_s}{r_o} \cdot i_T$$

$$v_{gs} = -i_T \cdot R_s$$

$$i_T\left(1 + g_m R_s + \frac{R_s}{r_o}\right) = \frac{v_T}{r_o}$$

$$R_{\text{into drain}} = \frac{v_T}{i_T} = \left(r_o + g_m R_s r_o + R_s\right)$$

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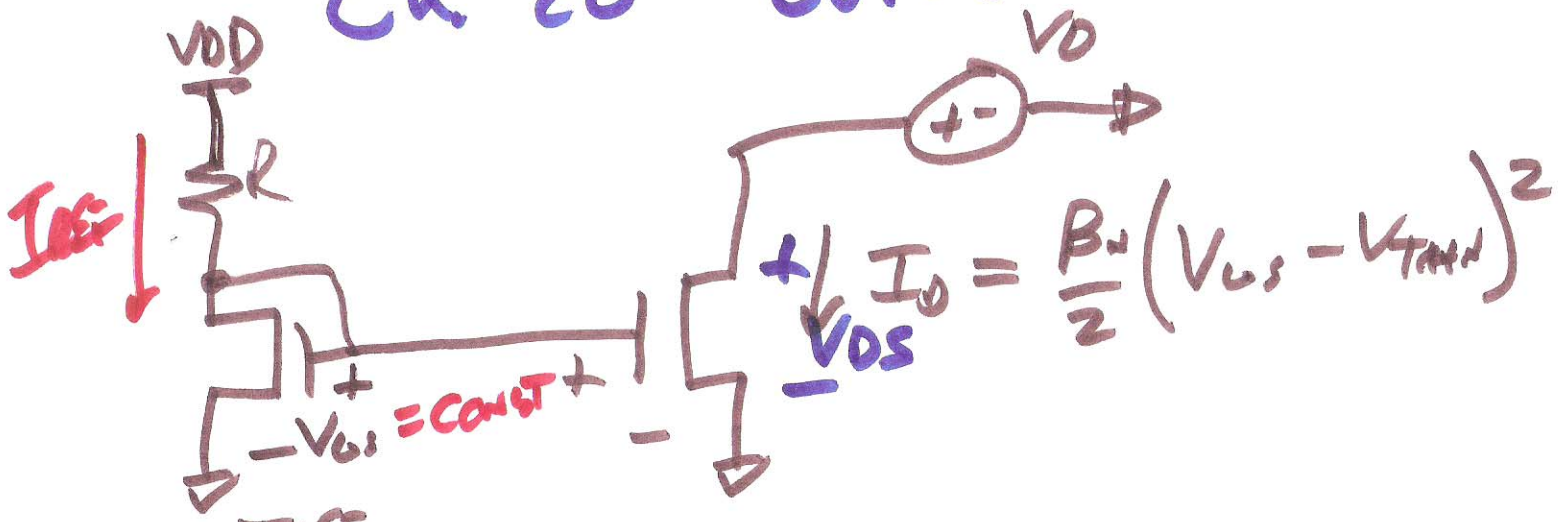
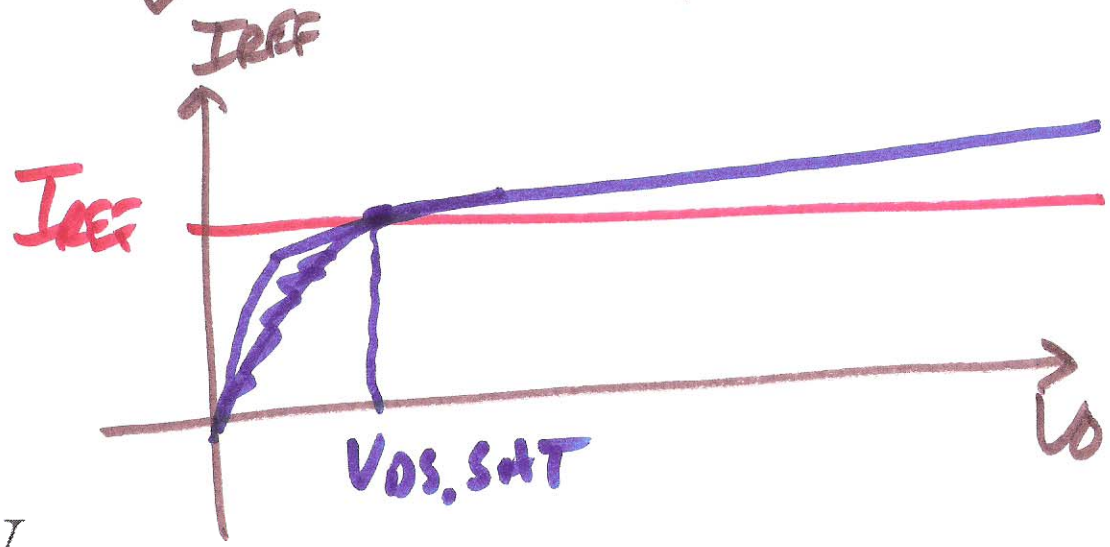
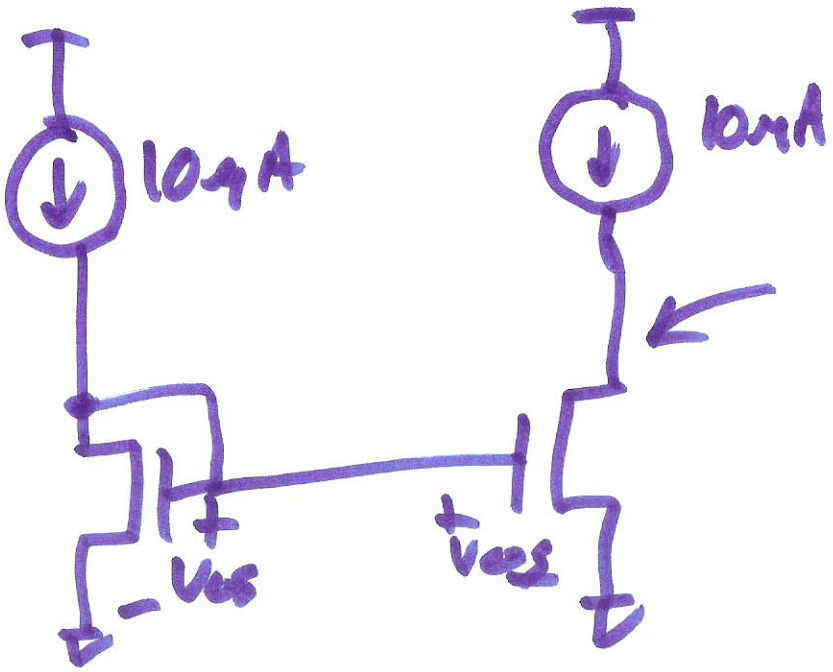
$$R_{out,drain} = r_o(1 + g_m R_s) + R_s$$

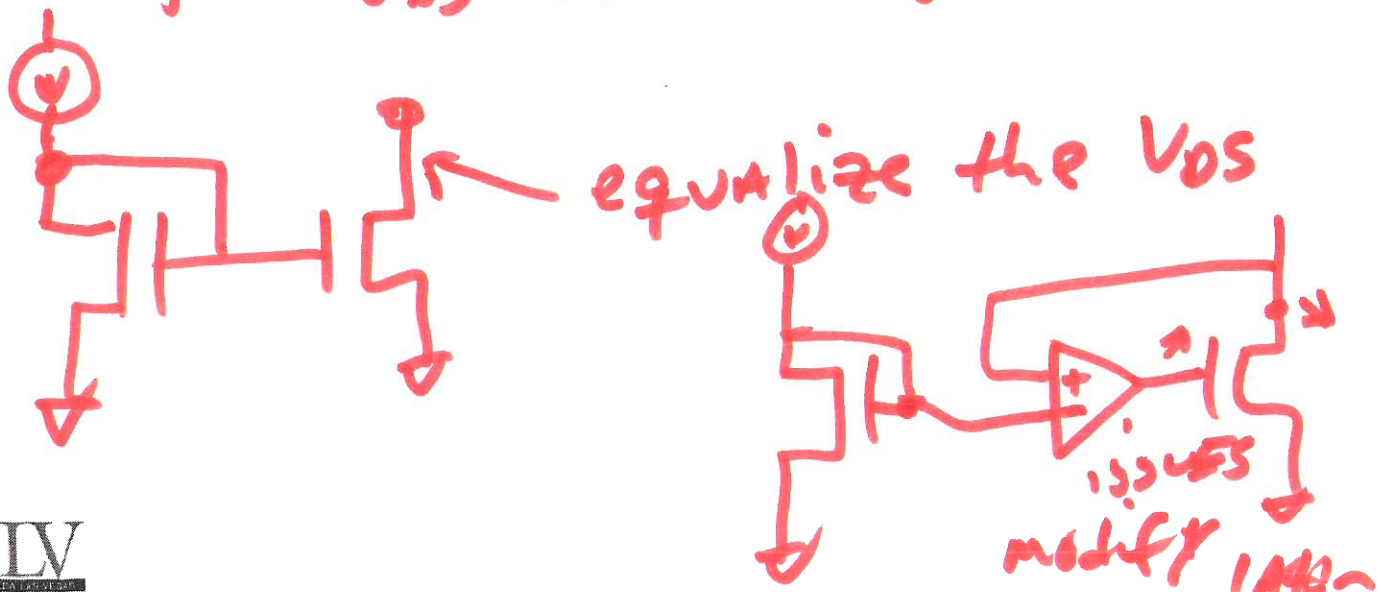
Ch. 20 current mirrors







Matching VDS MAtching



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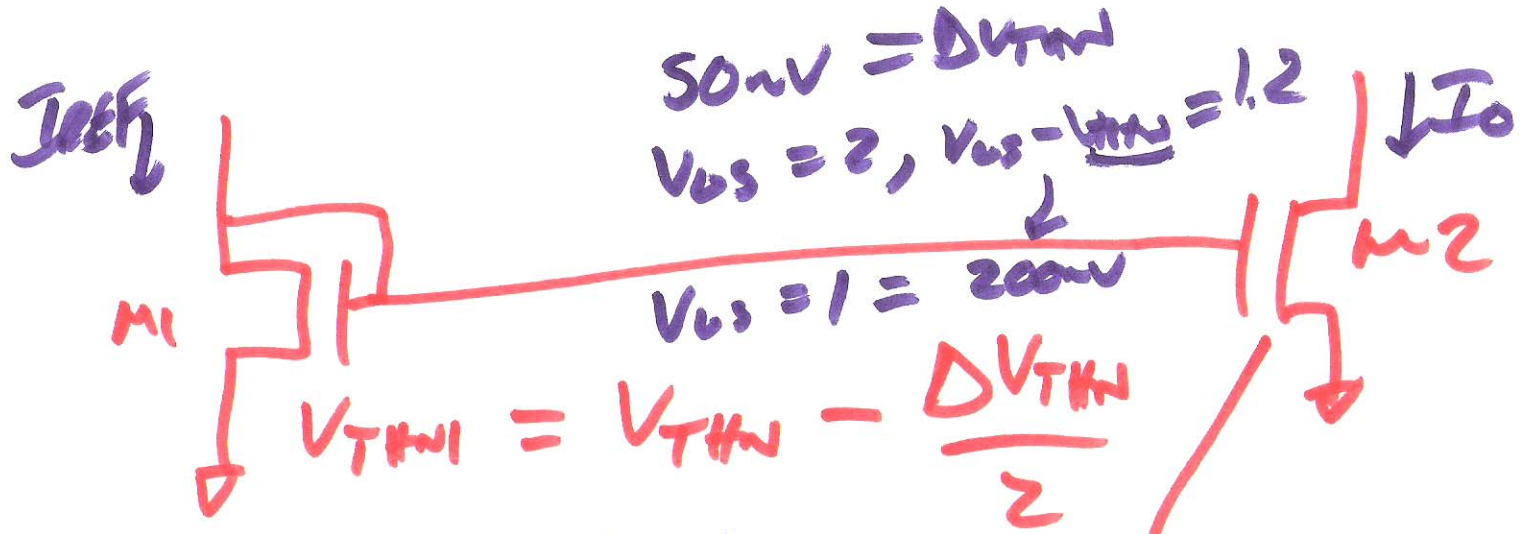

Average threshold voltage =

$$V_{THN2} = V_{THN} + \frac{V_{THN}}{2}$$

$$\frac{I_O}{I_{REF}} = \frac{\frac{KP}{2}\frac{W}{L}\left(V_{GS} - \left(V_{THN} - \frac{\Delta V_{THN}}{2}\right)\right)^2}{\frac{KP}{2}\frac{W}{L}\left(V_{GS} - \left(V_{THN} + \frac{\Delta V_{THN}}{2}\right)\right)^2}$$

$$\simeq 1 - \frac{2\Delta V_{THN}}{V_{OS,SAT}}$$

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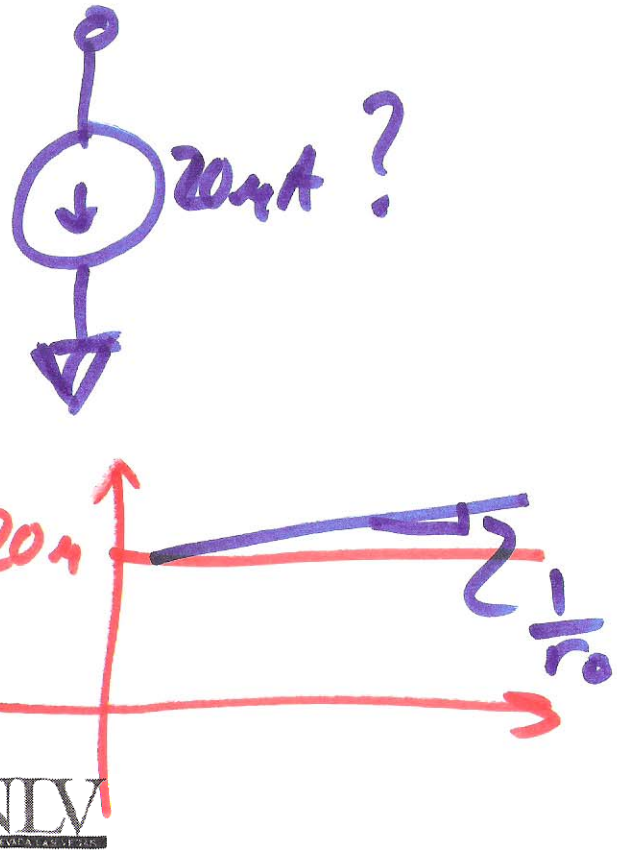
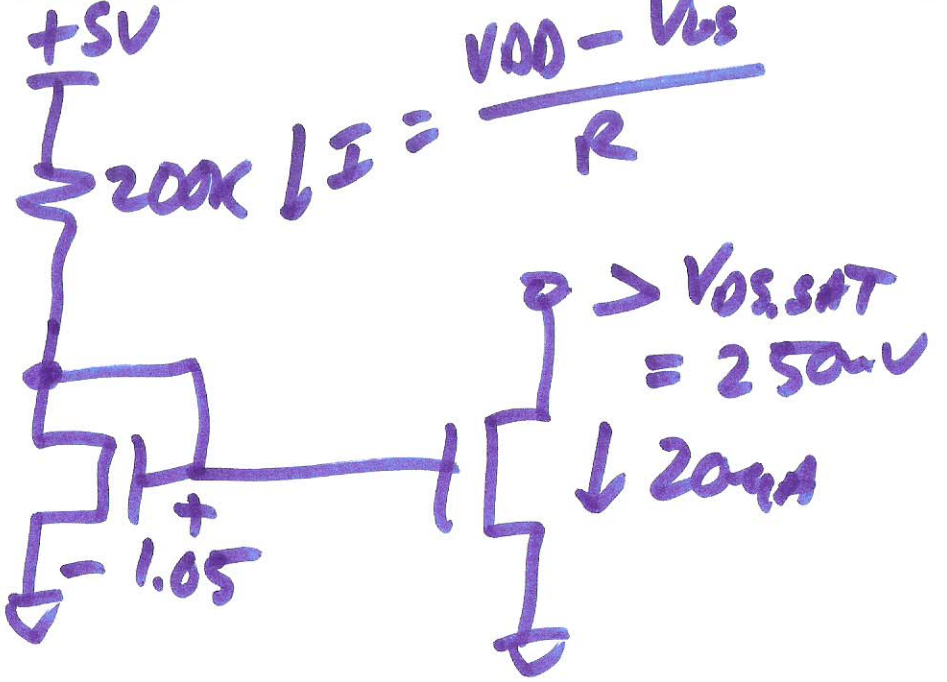
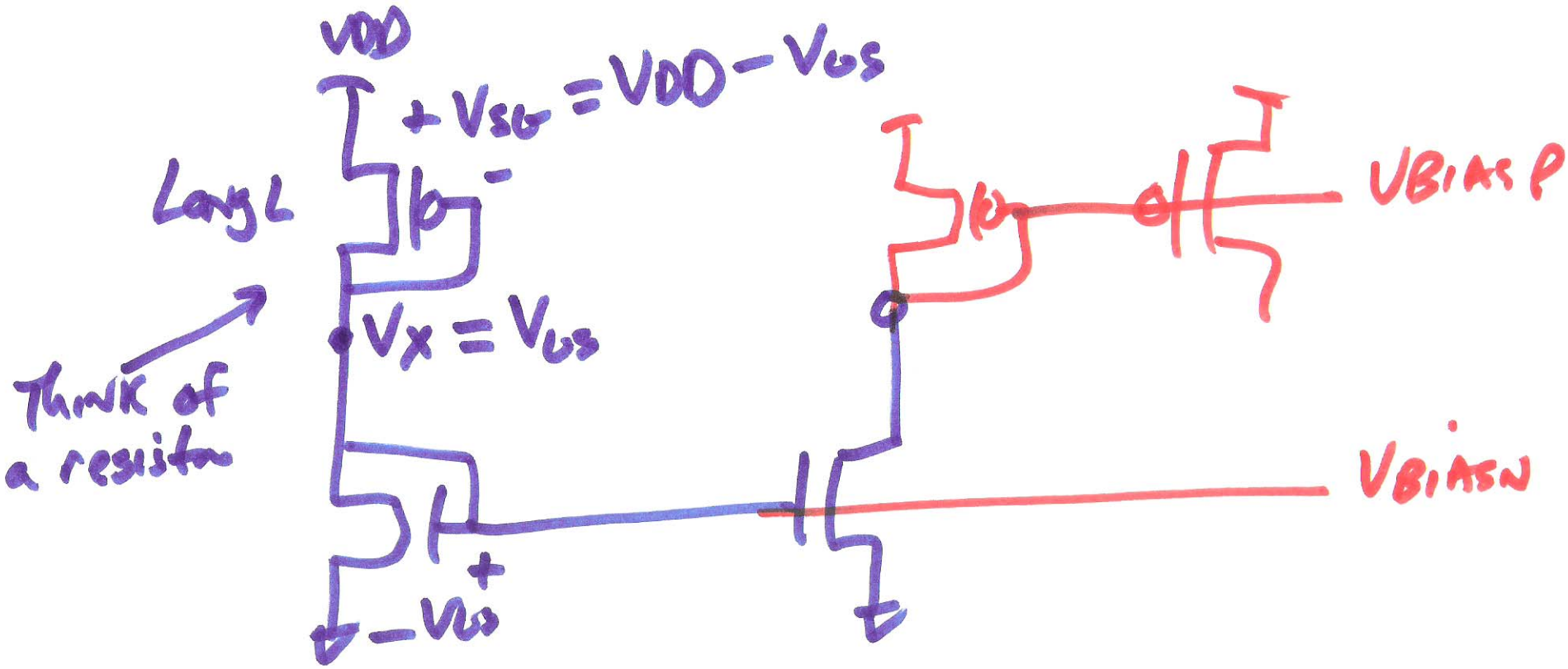
Matching parameter is $KP = \mu_n C_{ox}$

$$\simeq 1 + \frac{\Delta KP}{KP}$$





$$V_{GS} - V_{THN} = 1.05 - 0.8 = 0.25$$



$$\frac{KP_P}{2} \cdot \frac{W_P}{L_P} \left(\underbrace{VDD - V_{GS}}_{V_{SG}} - V_{THP} \right)^2 =$$

$$\frac{KP_N}{2} \frac{W_N}{L_N} \left(V_{GS} - V_{THN} \right)^2$$

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