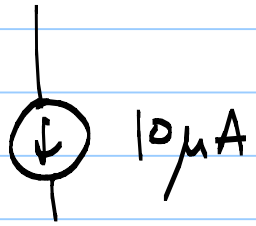
ECE 511 – Lecture 8

Note Title 2/13/2012

BMR ⇒ TC_{Iref} = 1000 ppm/°C = +0.001/°C

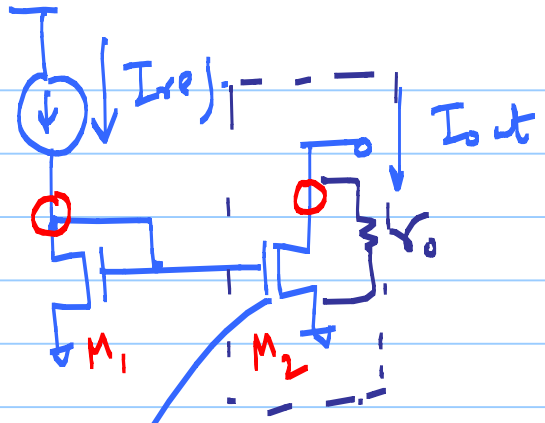
+ve TC tempco

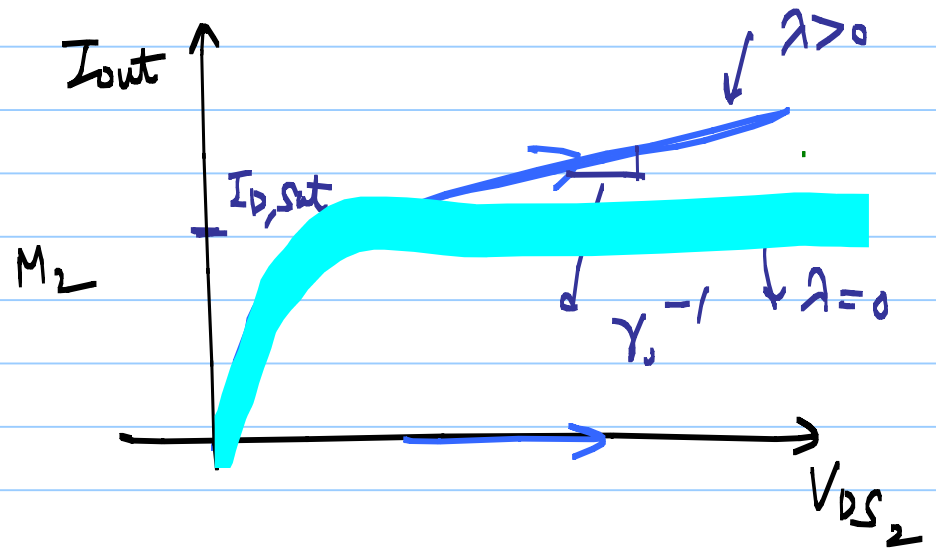


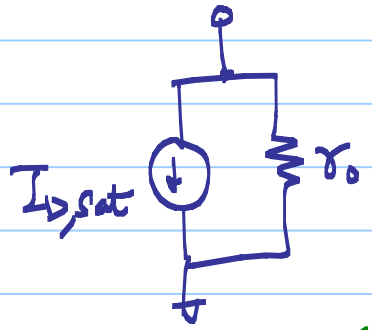
T ↑

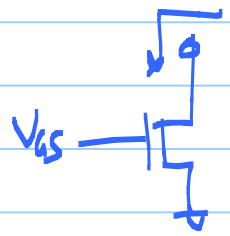
$\frac{I_{ref}}{10\mu A} = 0.001 \times \Delta T$

$V_{DS_1} \neq V_{DS_2}$, $\lambda > 0$



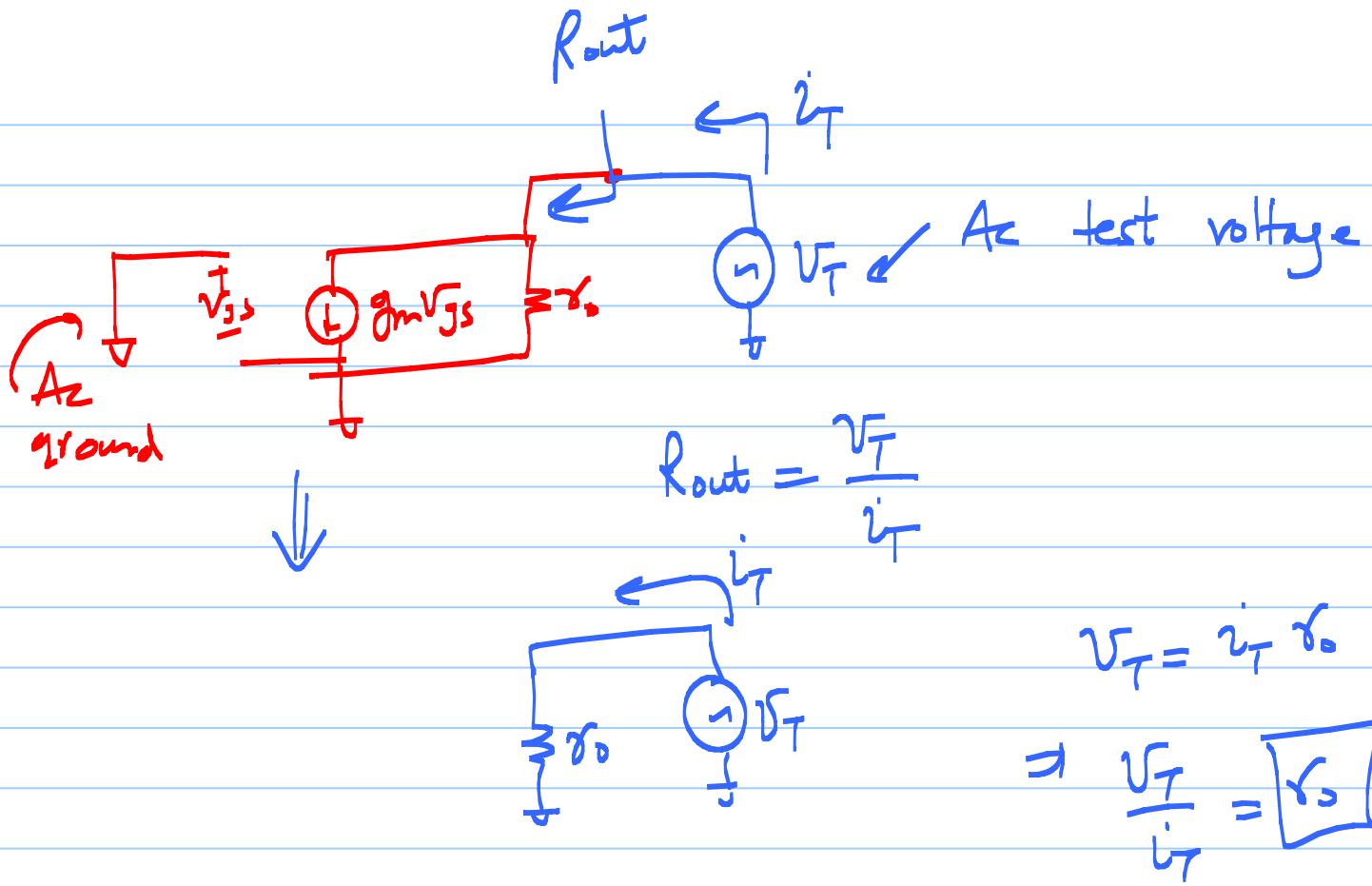






$R_{out} = r_o$

$\Rightarrow$



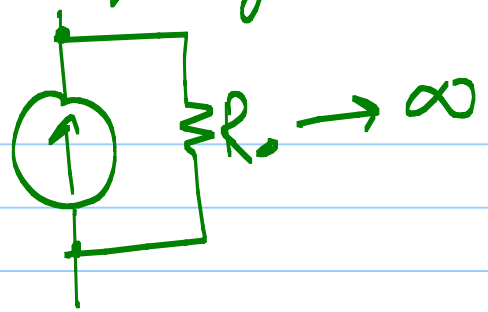
$$R_{out} = \frac{v_T}{i_T}$$

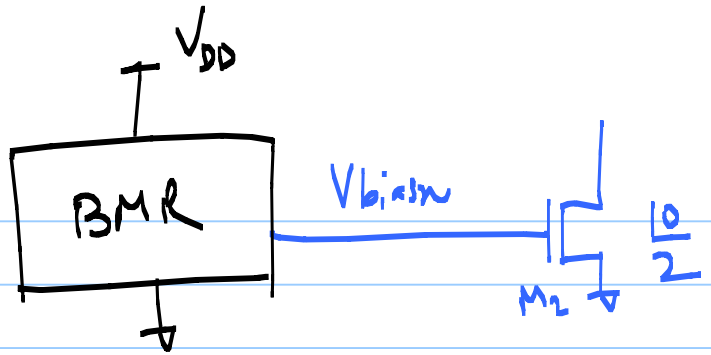
$$v_T = i_T r_o$$

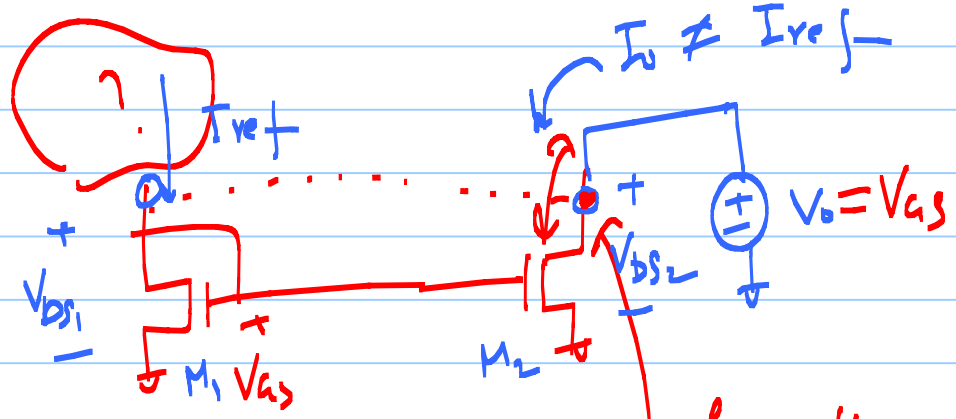
$$\Rightarrow \frac{v_T}{i_T} = \boxed{r_o}$$

Not a "good quality" current source $\Rightarrow R_o \Leftarrow$ low

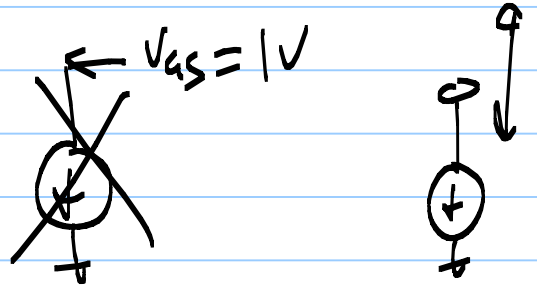
for a "good quality" Current source



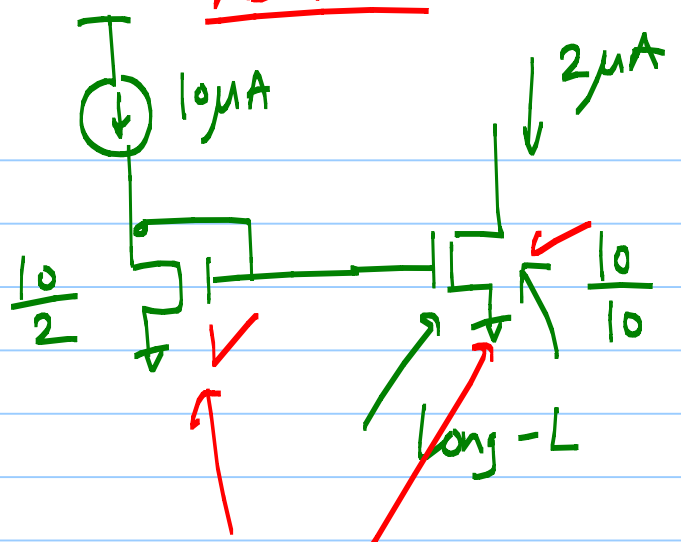




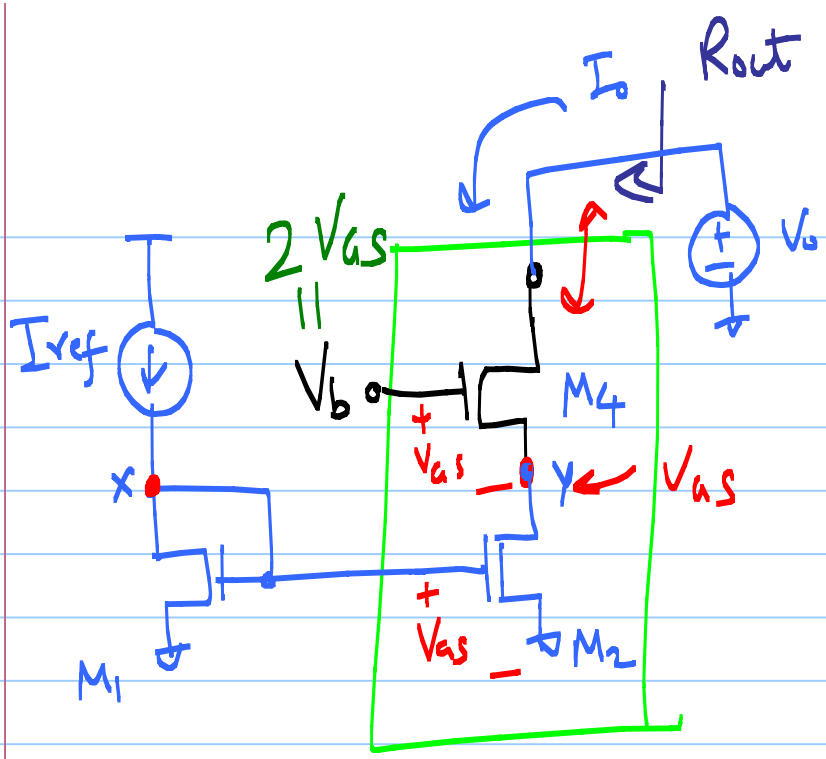
fix this drain voltage



ASIDE



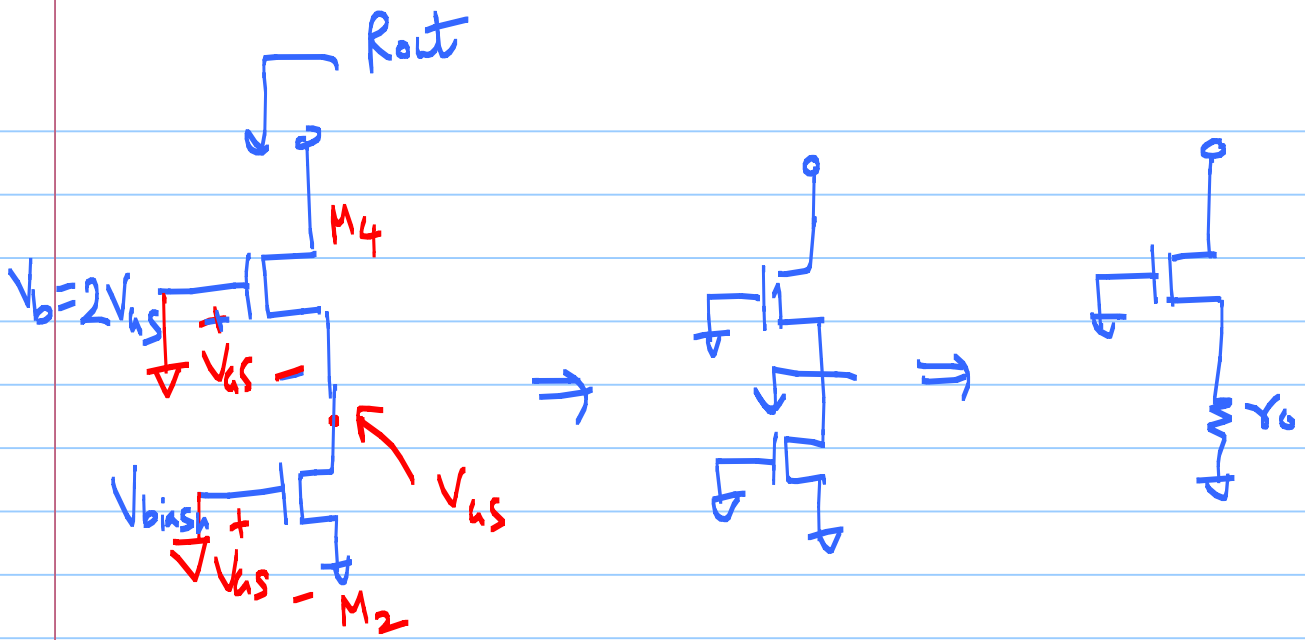
matching is very critical



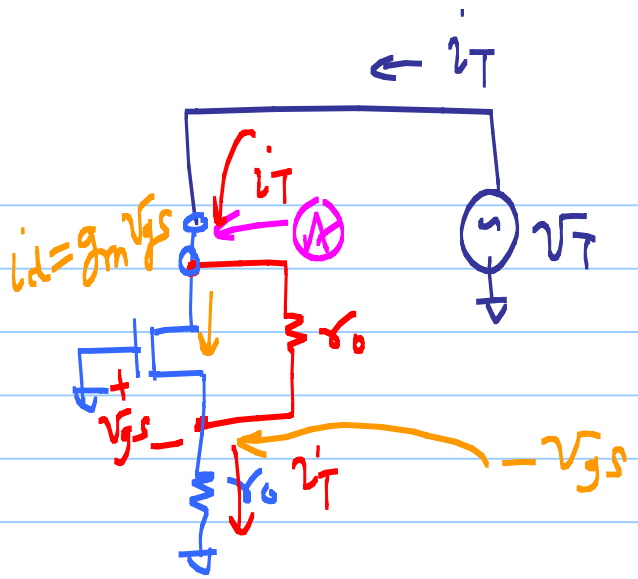
$$V_y = V_x = V_{GS}$$

$\Rightarrow$ I_o closely tracks I_{ref}

$$I_o \overset{D}{=} I_{ref}$$


Rout
M4
$V_b = 2V_{GS}$
+
V_{GS}
−
V_{biasn}
+
V_{GS}
−
V_{GS}
M2

r_o



$i_T = ??$

KVL: $v_{gs} = -i_T r_o$ ⟶ (1)

KCL @ (A) $\Rightarrow$ $i_T - g_m v_{gs} - \dfrac{(v_T - (-v_{gs}))}{r_o} = 0$ ⟶ (2)

Eliminate V_{gs}

$$\Rightarrow i_T + g_m r_o i_T - \frac{V_T}{r_o} + i_T = 0$$

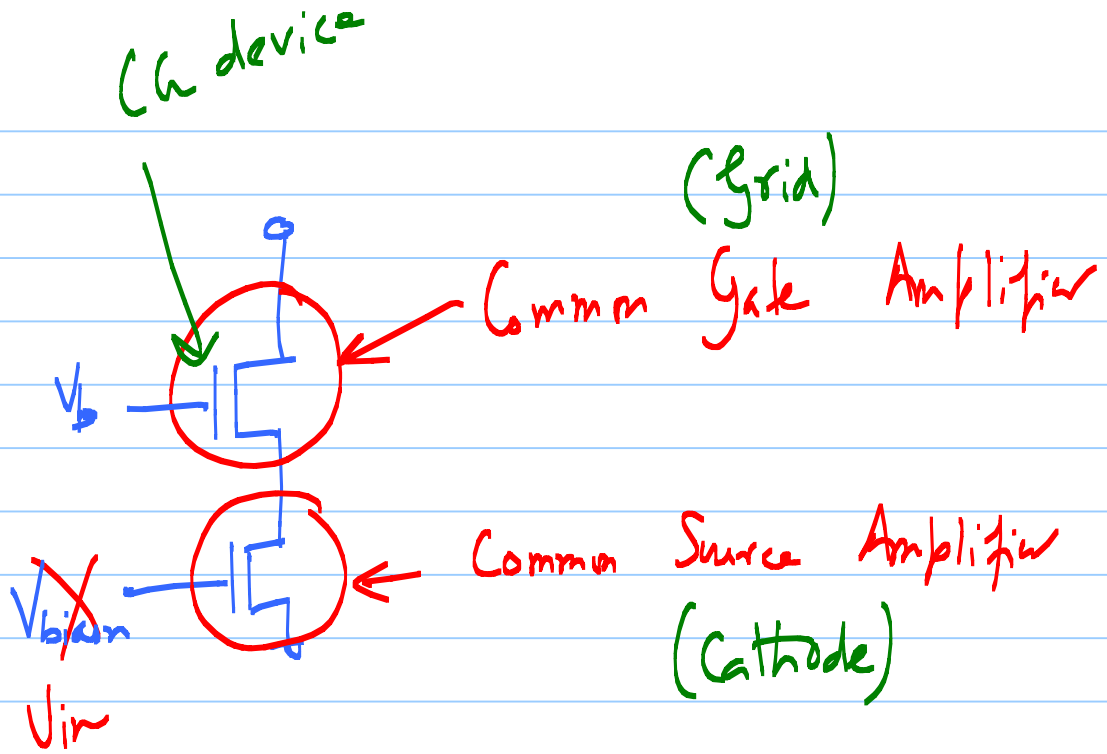
$$\Rightarrow \frac{V_T}{r_o} = i_T \left(2 + g_m r_o\right)$$

$$\Rightarrow R_o = \frac{V_T}{i_T} = \left(2 + g_m r_o\right) r_o = 2r_o + g_m r_o^2$$

$\downarrow (g_m r_o)\, r_o$

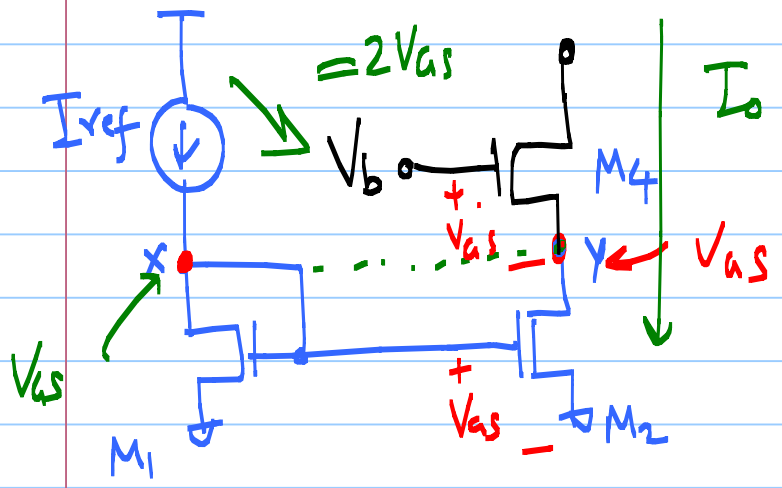
if $g_m r_o \gg 1$

$$\Rightarrow R_o \approx g_m r_o^2 = (g_m r_o)\, r_o \gg r_o$$



(Cascode Current Mirror)

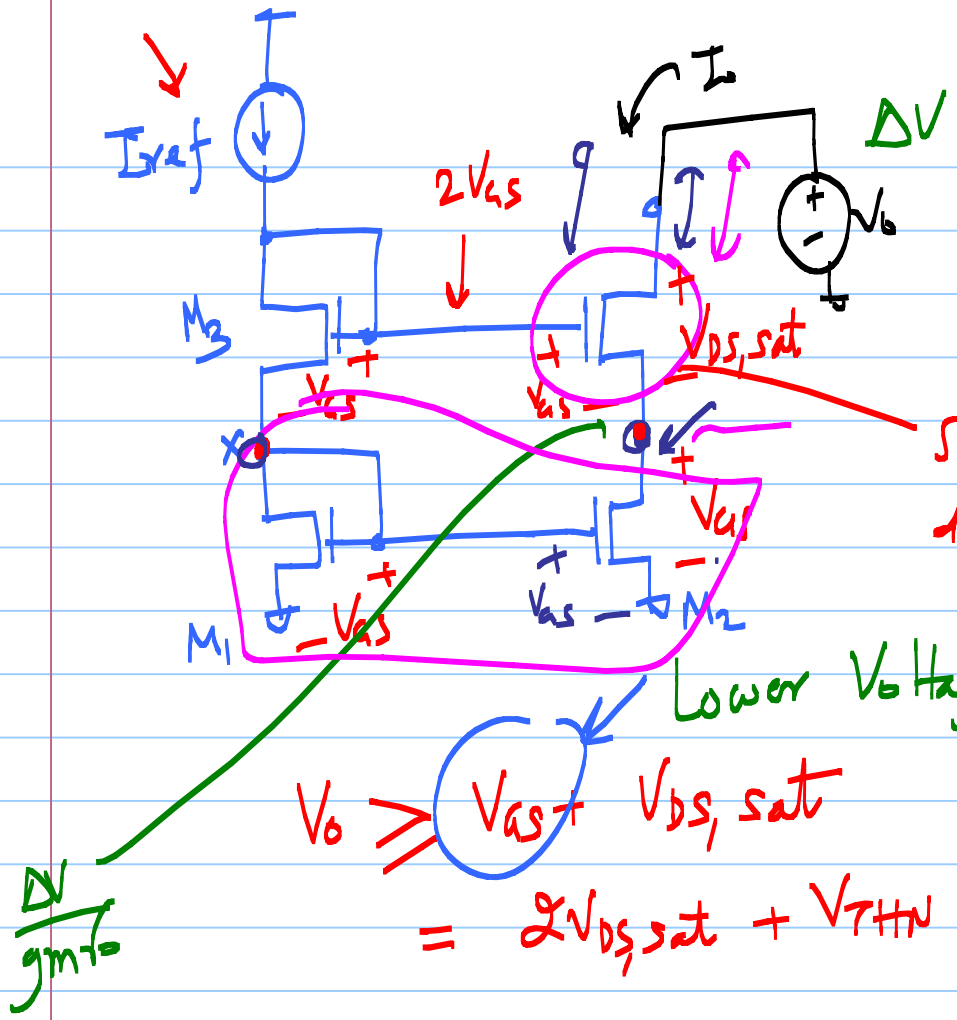
CASCODE ⇒ Cascade of Common cathode and Common grid amplifier.

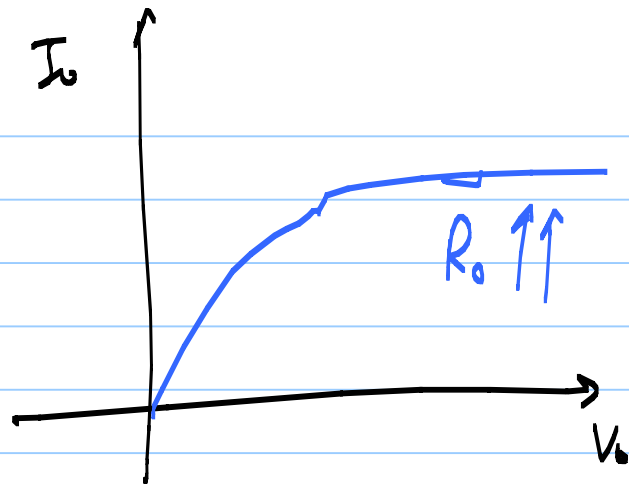


$M_4 \leftrightarrow M_1 \leftrightarrow M_2$ identical

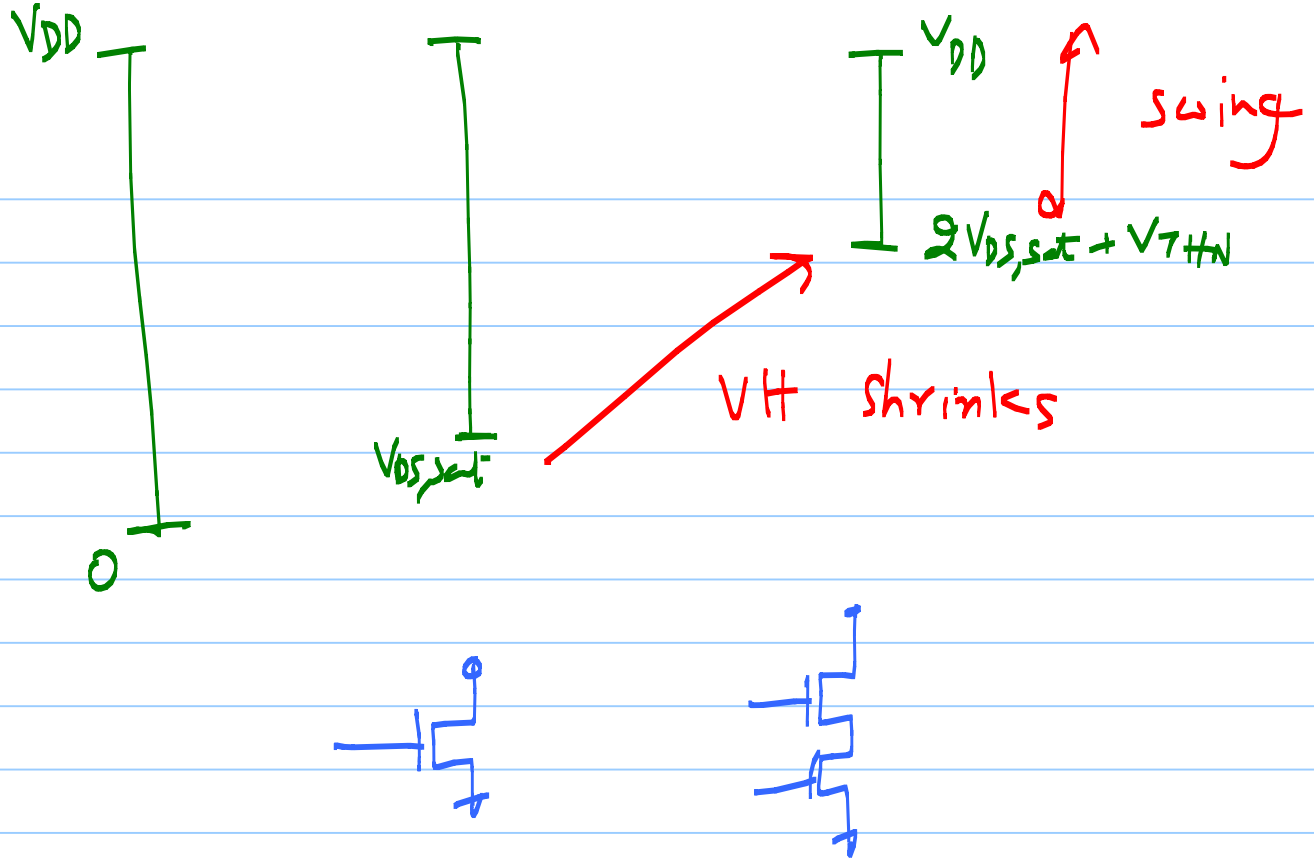
$\Rightarrow$ Same W/L

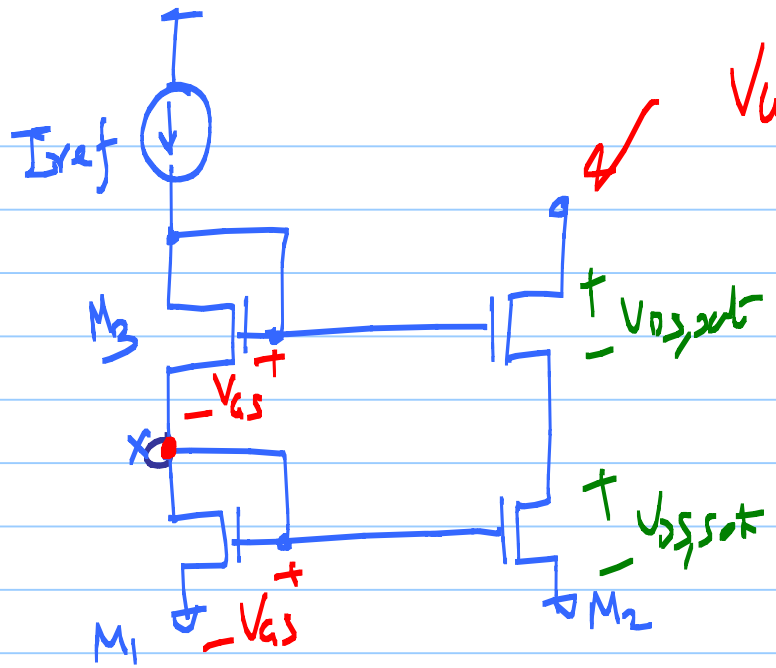
$$I_D = \frac{k_n}{2}\frac{W}{L}(V_{GS} - V_{THN})^2$$





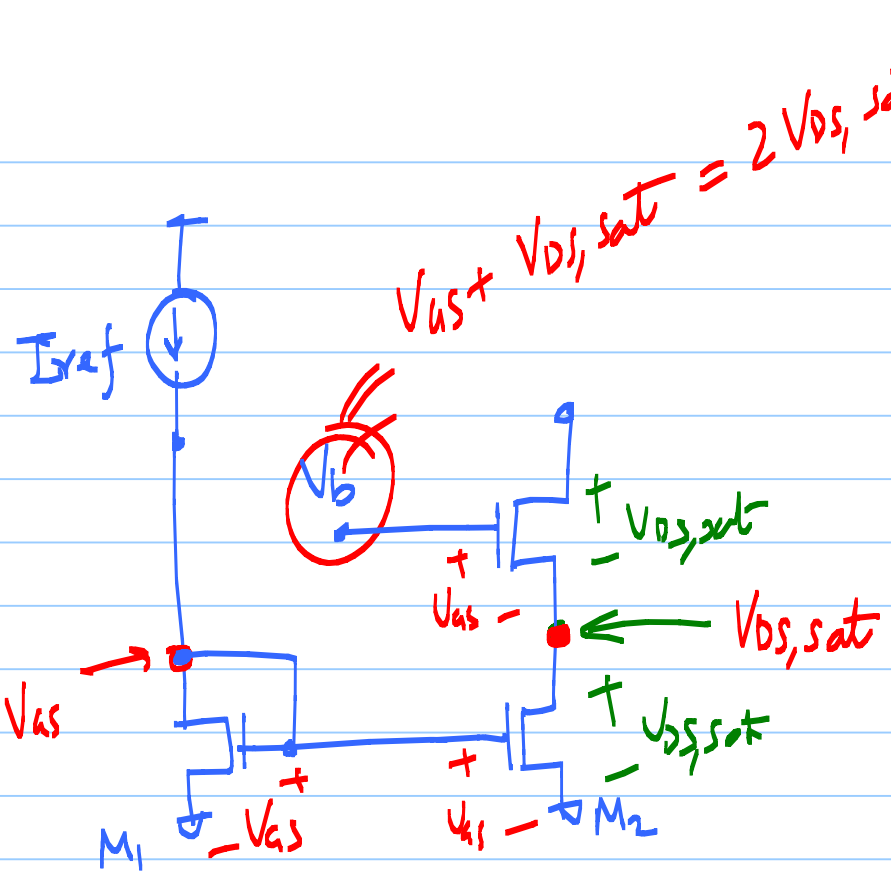
All NMOS are identical


V_{DD}
0
$V_{DS,sat}$
V_{DD}
$2V_{DS,sat} + V_{THN}$
swing
VH shrinks



$V_{GS} + V_{DS,sat} = 2V_{DS,sat} + \cancel{V_{THN}}$

Wide-Swing Biasing



① How to generate V_{GS}

② $V_{DS_1} \neq V_{DS_2}$

V_{GS} $\quad$ $V_{DS,sat}$