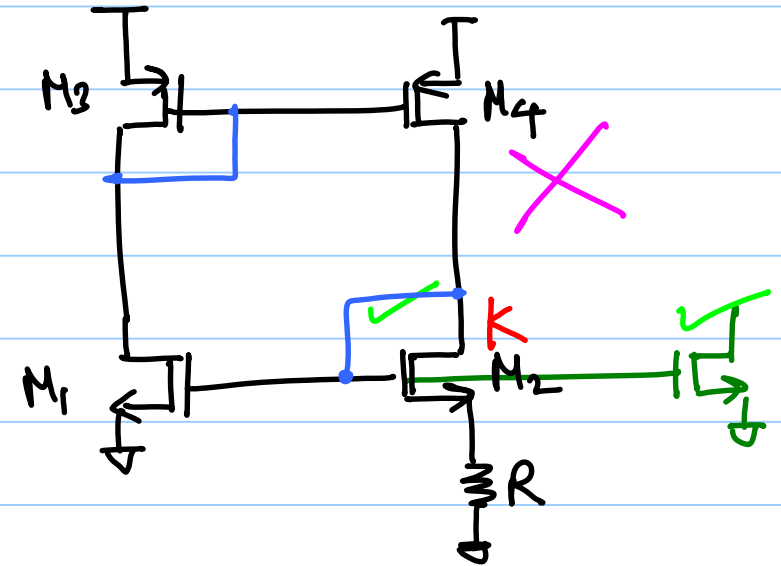
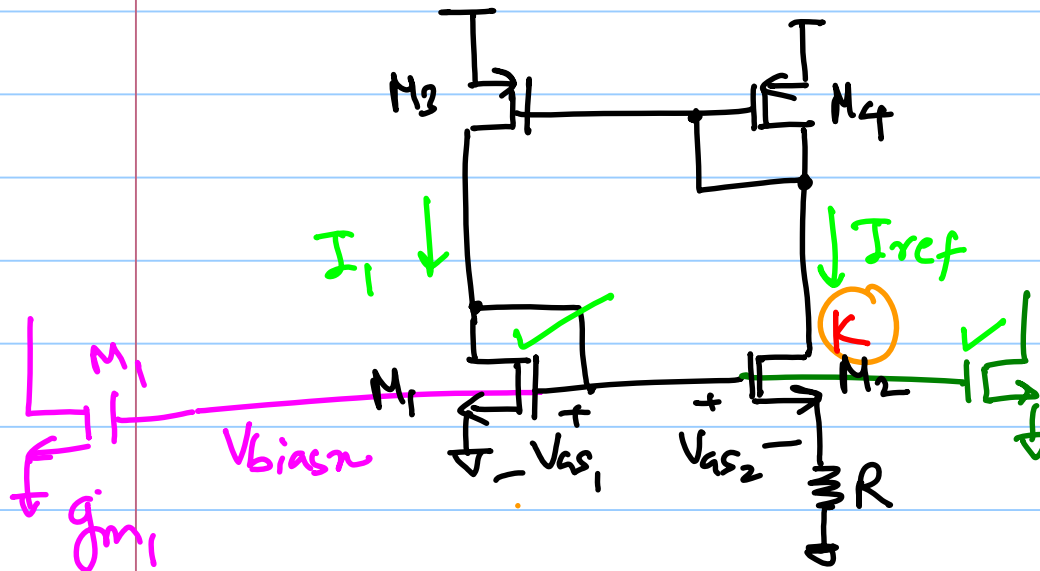


ECE 511 - Lecture 6

Note Title

2/3/2015



$$V_{GS1} = V_{GS2} + I_{ref} R \leftarrow$$

I_{ref} is indep of V_{DD}

$$I_{ref} = \frac{2}{\beta R^2} \left(1 - \frac{1}{\sqrt{K}} \right)^2, 0$$

$$g_{m1} = \sqrt{2 \beta I_{ref}} = \sqrt{2 \cancel{\beta} \cdot \frac{2}{\cancel{\beta} R^2} \left(1 - \frac{1}{\sqrt{K}}\right)^2}$$

$$g_{m1} = \frac{2}{R} \left(1 - \frac{1}{\sqrt{K}}\right) \longrightarrow \text{indep of PV variation}$$

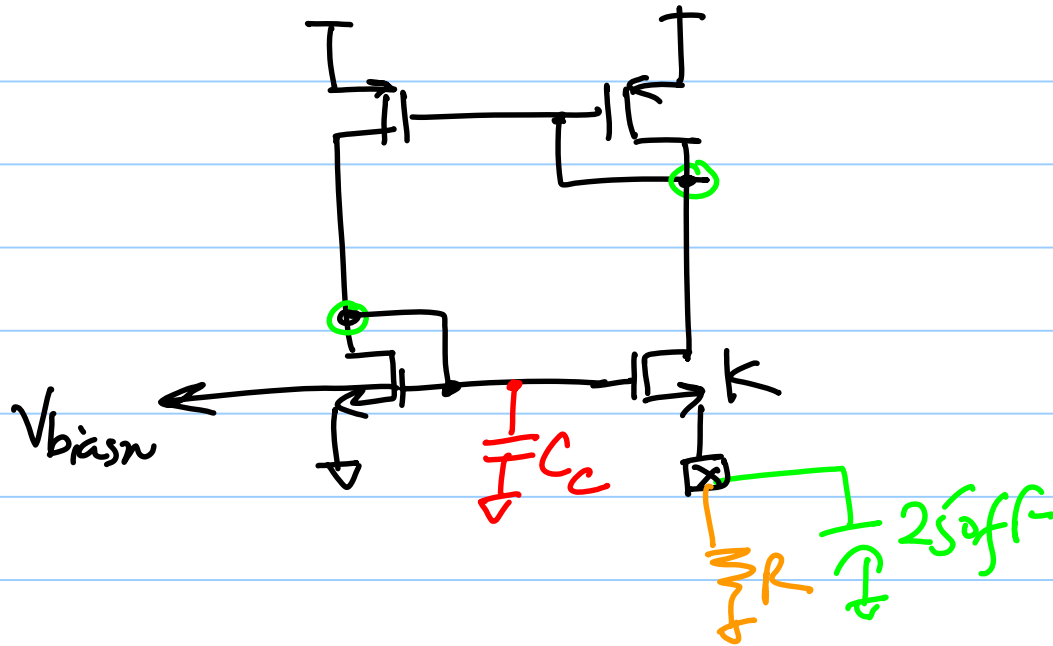
Constant- g_m Bias Circuit

Beta Multiplier Circuit (BMC)

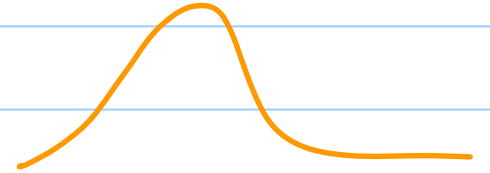
for $K=4$

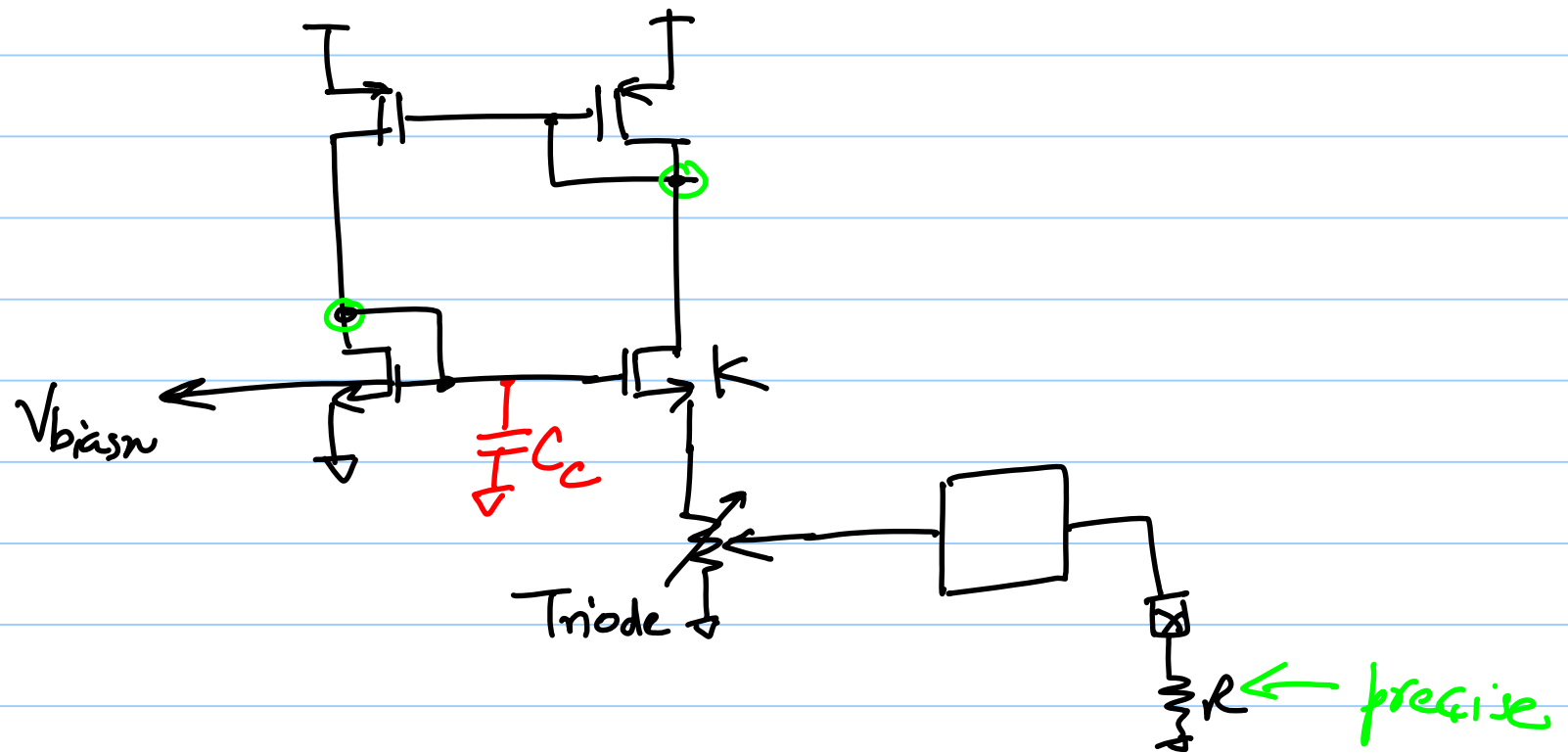
$$g_m = \frac{1}{R}$$

f_x g_m

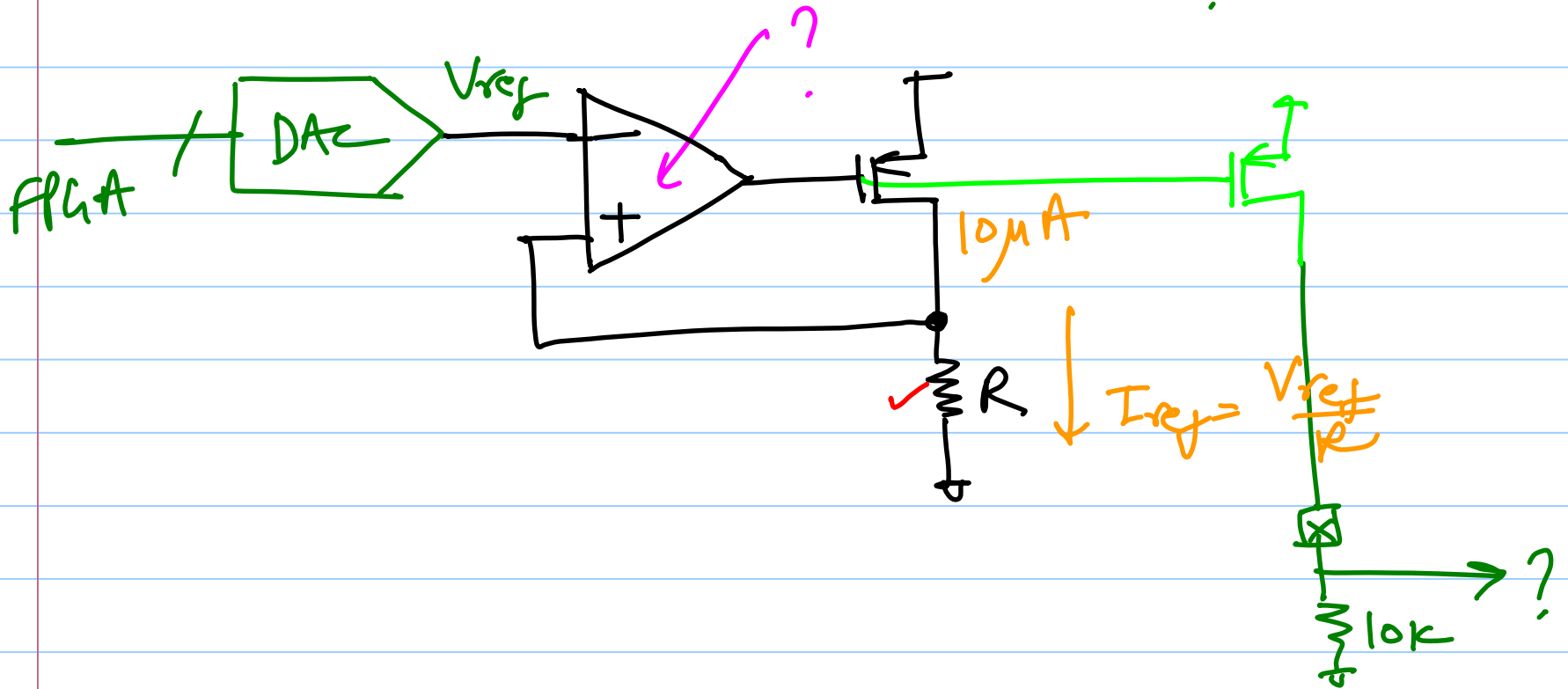


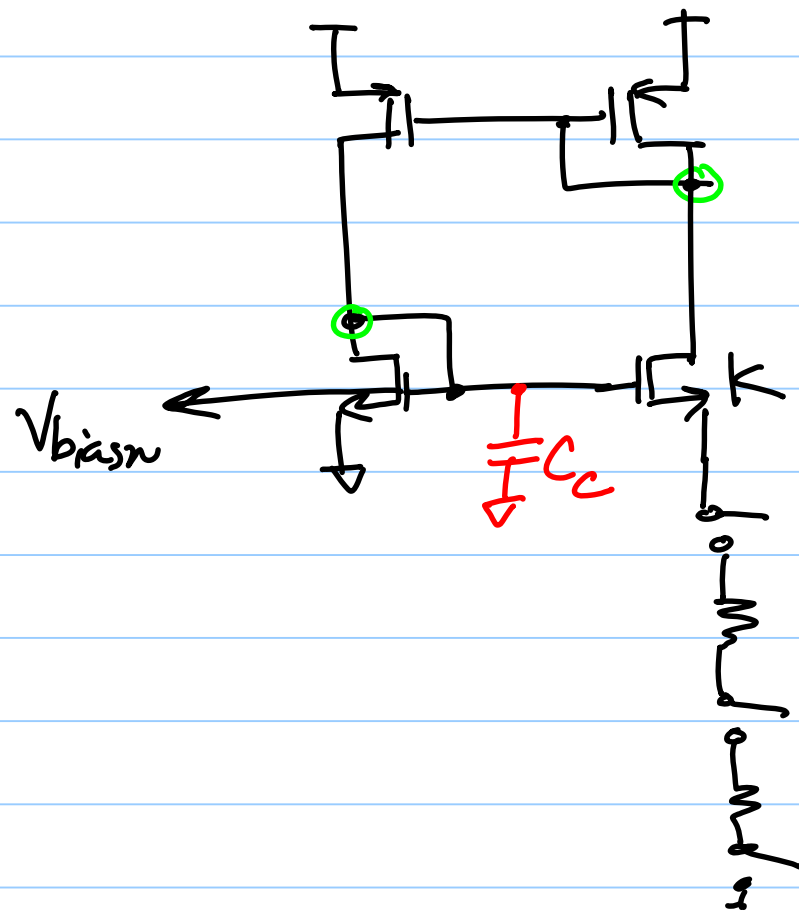
R $\left\{ \begin{array}{l} \pm 5\% \text{ on 1 die} \\ \pm 30\% \text{ across} \\ \text{wafers} \end{array} \right.$



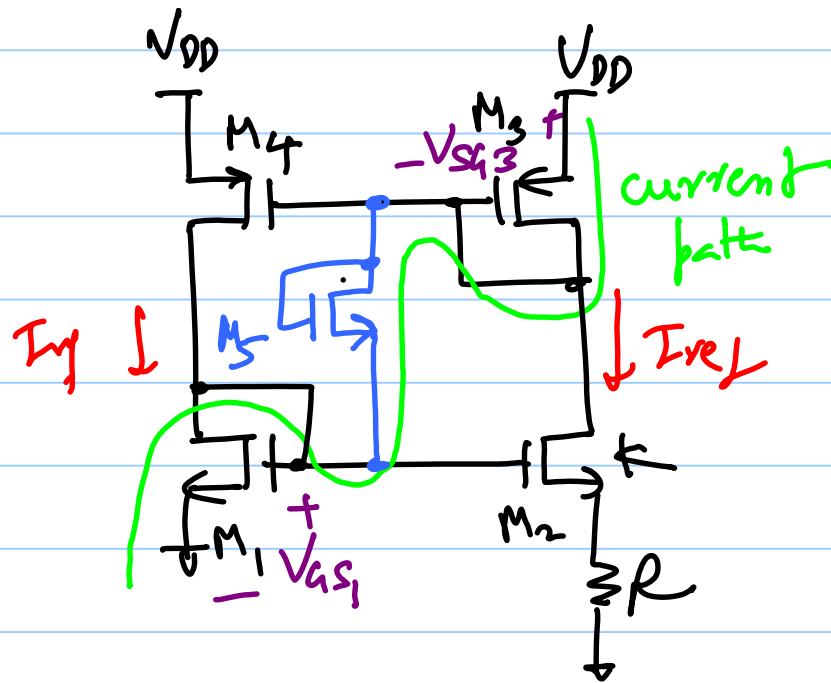


$V_{op} - R$





digital timing



$$\underline{I_{ref} = 0}$$

Start up circuit

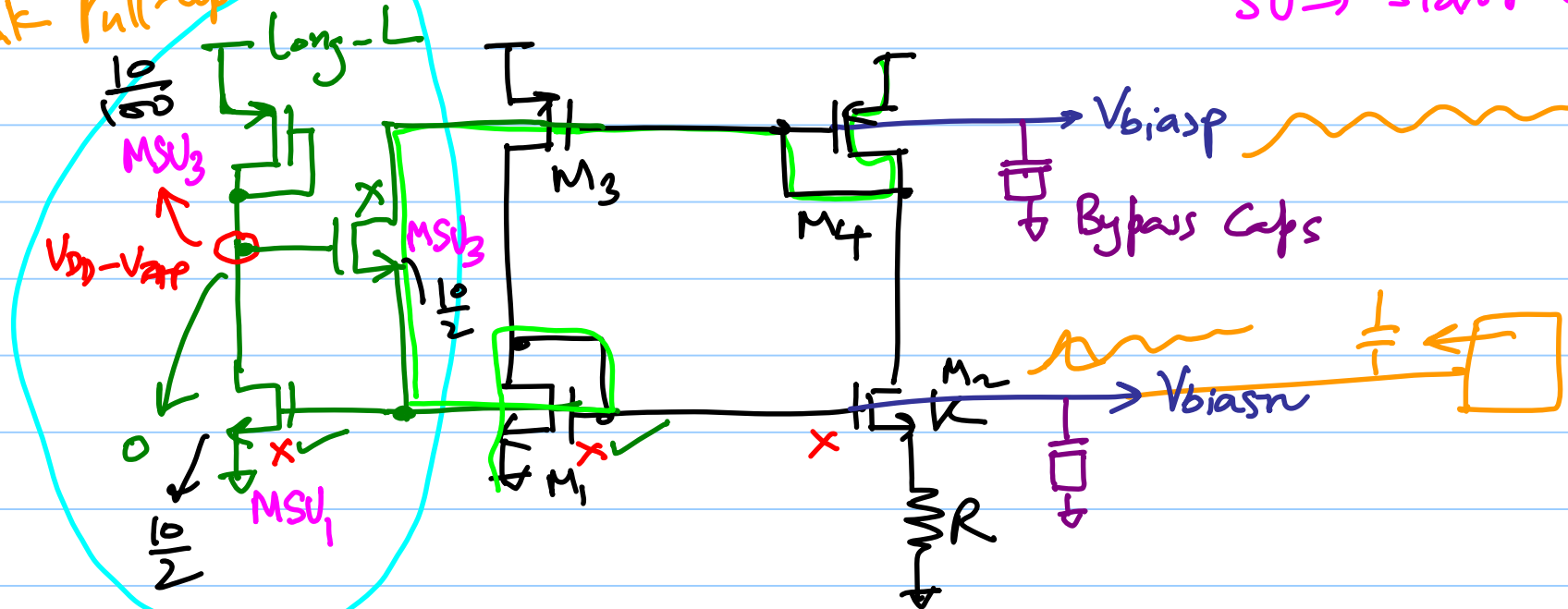
turn-on: $\checkmark \checkmark \checkmark$ $V_{TH3} + V_{TH5} + V_{TH1} < V_{DD}$: Start up condition

turn-off: $\checkmark$ $V_{GS1} + V_{TH5} + V_{GS3} > V_{DD}$ to turn M5 off

Conditions are very restrictive

Weak Pull-up

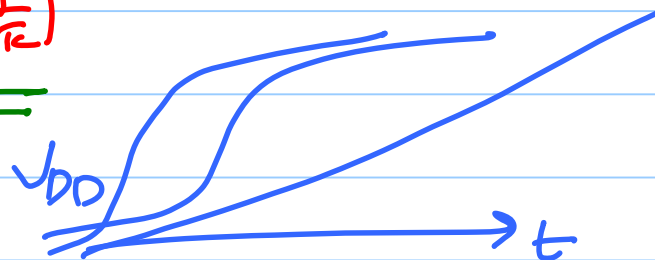
SU $\Rightarrow$ Start up



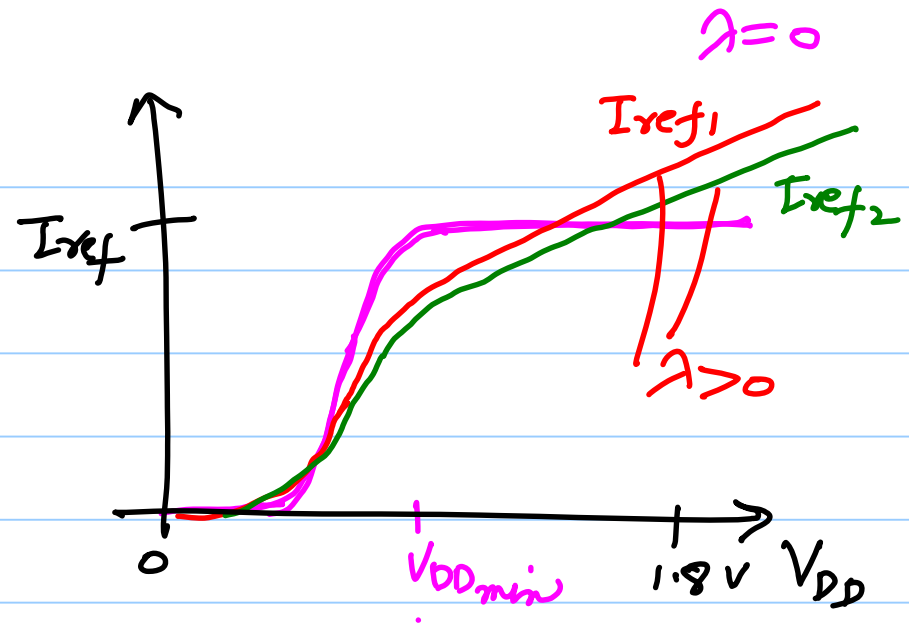
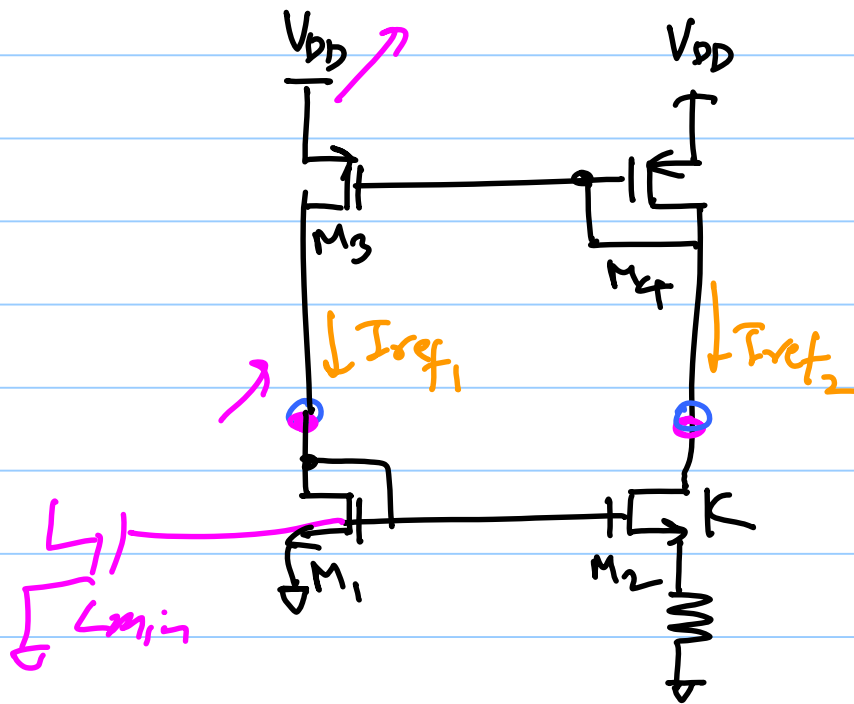
Start up Circuit

$$I_{ref} = 0 \rightarrow \frac{2}{\beta R^2} \left(1 - \frac{1}{\sqrt{2}}\right)^2$$

example of a I_{ref} feedback circuit



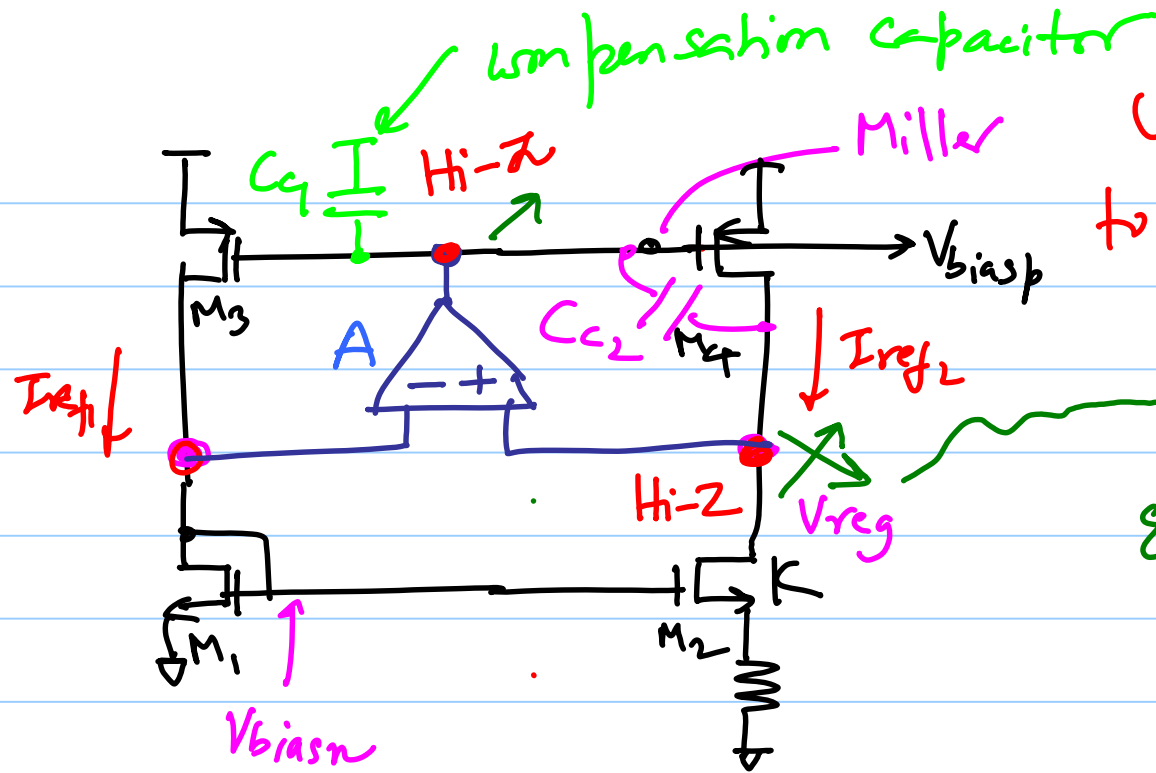
$$V_{DD} \geq V_{SG4} + V_{GS1}$$



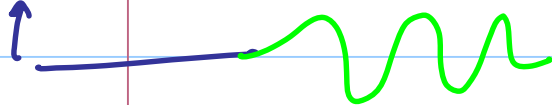
for $\lambda > 0$
 $V_{DD} \uparrow \Rightarrow V_{GS} \uparrow \Rightarrow I_{ref} \uparrow$

To reduce supply sensitivity & current mismatch
 $\hookrightarrow$ reduce the variation in V_{GS} of the transistors

SUP



$V_{DD} - V_{SG}$

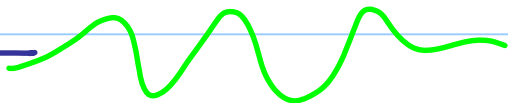


2 High impedance nodes

↳ 2 poles at low-frequency

↳ stability concerns

V_{GS}



$$RC \Rightarrow \tau^{-1}$$

$$\frac{1}{1+s\tau}$$