ECE 504 - Lecture 10

Note Title 9/26/2016

Setup your Cadence accounts

ece-410.engr.uidaho.edu

and go through the tutorials.

3rd-order PLL Design Procedure

① Find K_{VCO} from simulation (units $\frac{Hz}{V}$)

② Choose the desired phase margin (ϕ_M) and find 'b' from Eq ⑥

$$b = 2\left(\tan^2\phi_M + \tan\phi_M\sqrt{1+\tan^2\phi_M}\right)$$

$\phi_M = 60°$

③ Choose the $\omega_{u,loop}$ and find ω_z from Eq ③

Gardner's constraint: $\frac{\omega_{ref}}{20} \longrightarrow \omega_{u,loop} = \left(\sqrt{b+1}\right)\omega_z$ ← ??

(4) Select I_o & C_1 such that F_i ⁿ (4) is satisfied

$$\frac{K_{VCO} \cdot I_o}{N} = \frac{(b+1)^{3/2}}{b} C_1 \cdot \omega_g^2$$

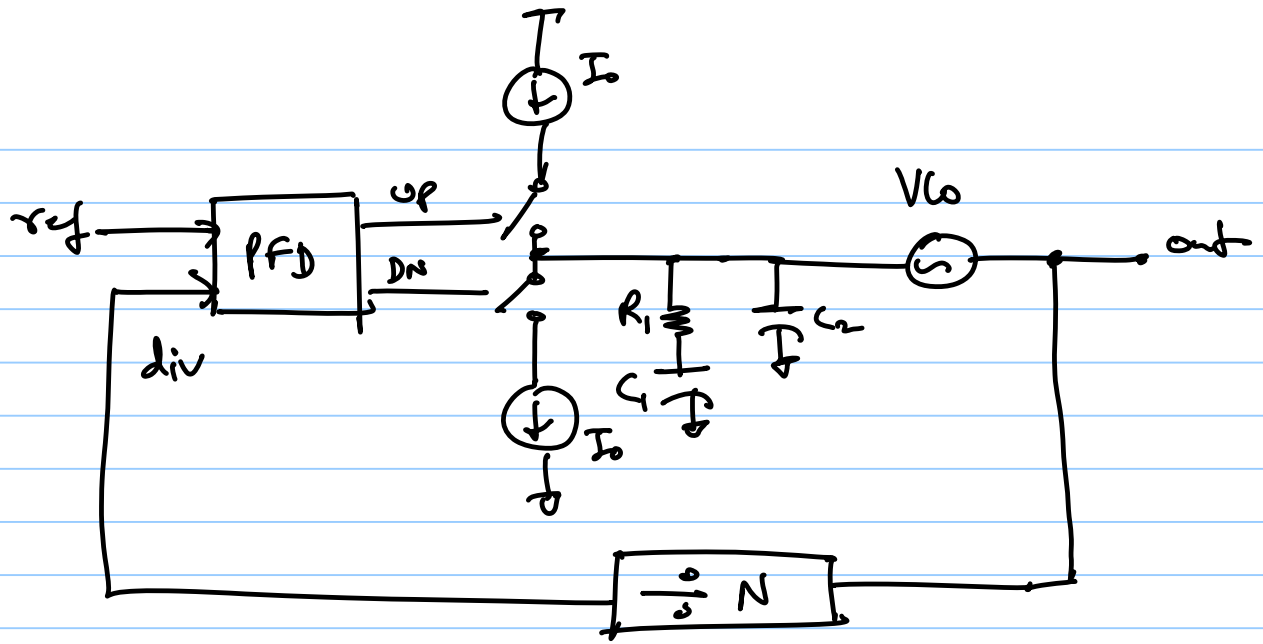
$\omega_g = \frac{1}{R_1 C_1}$

(5) Calculate R_1, and then estimate the noise contribution

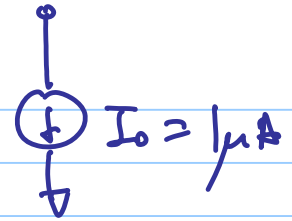
↳ If design is 'noisy' then goto step (4) and increase C_1

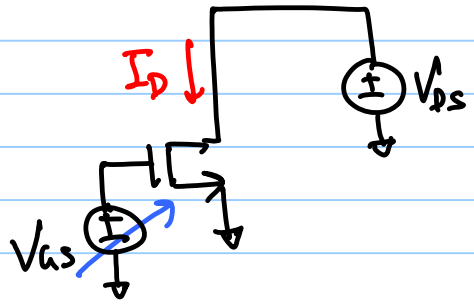
$\overline{v_n^2} = 4kTR$

$\overline{i_n^2} = \frac{4kT}{R}$ ⟶ See the paper for 4th-order loop analysis.

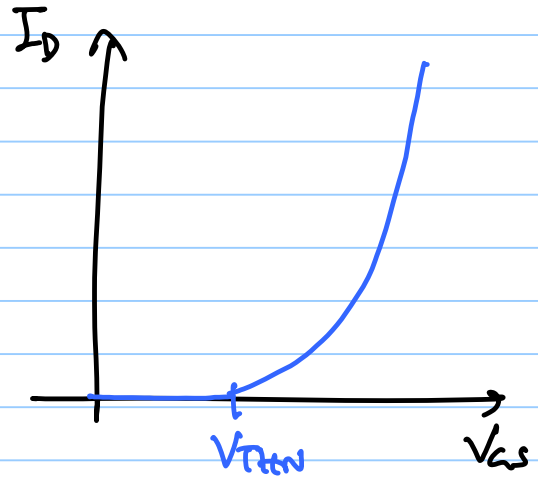

ref
PFD
up
DN
div
I_0
I_0
R_1
C_1
C_2
VCO
out
$\frac{1}{N}$

http://lumerink.com/courses/ece5410/f10/Lectures.htm



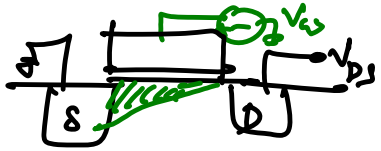


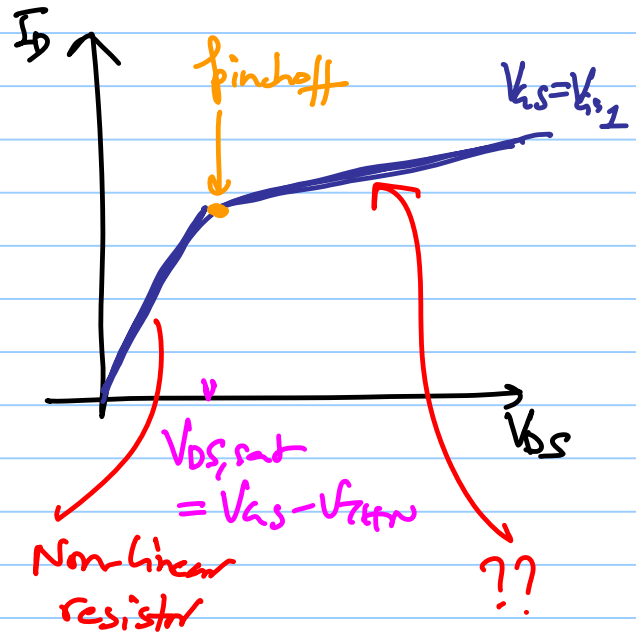
$$I_D = f(V_{GS}, V_{DS})$$

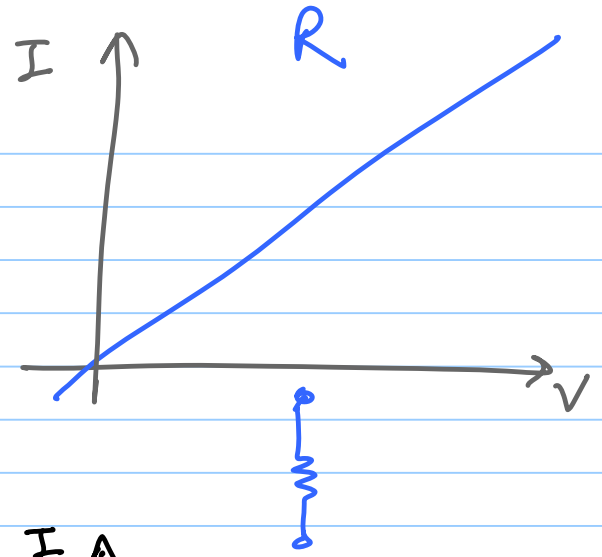


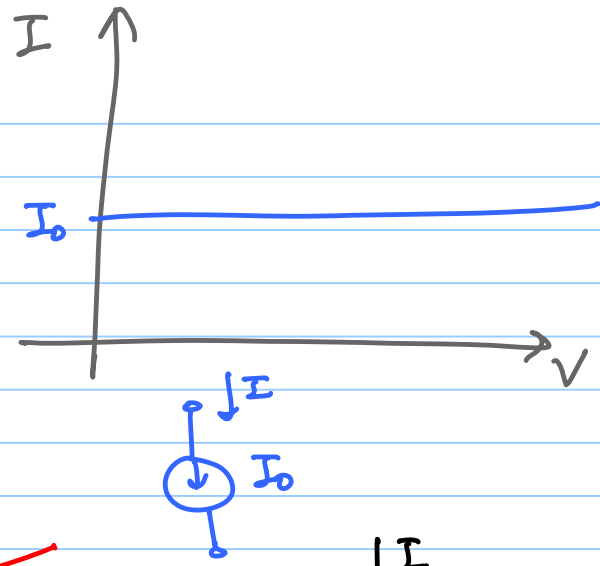
$$I_D = \frac{K_{Pn}}{2}\frac{W}{L}(V_{GS} - V_{THN})^2$$

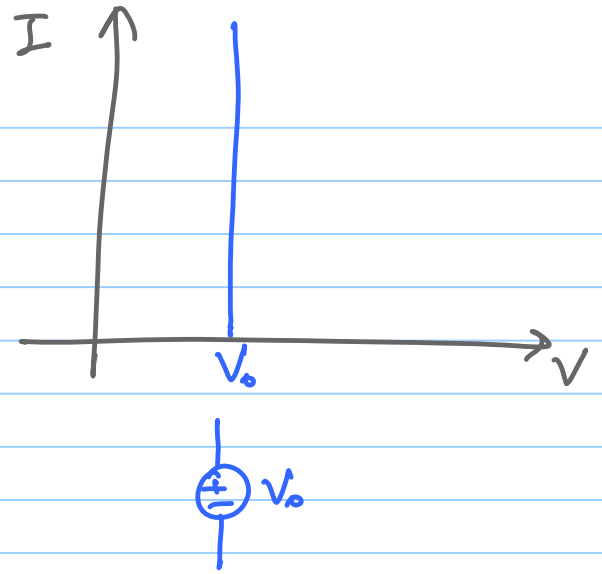
sat

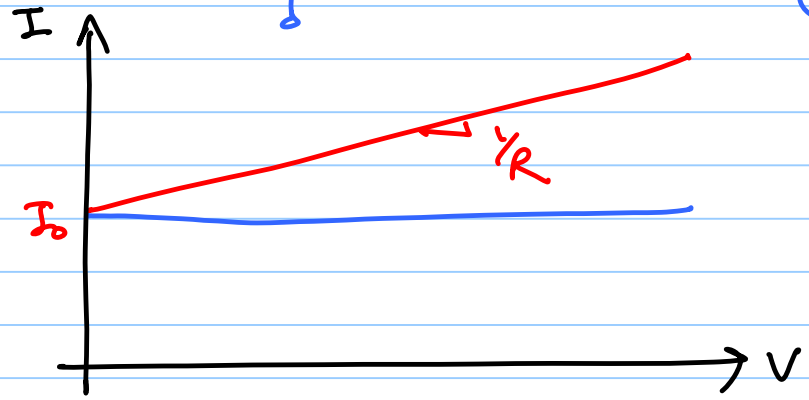


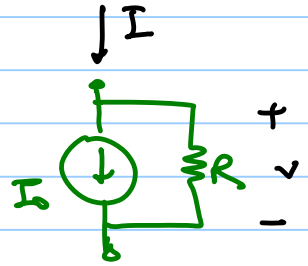


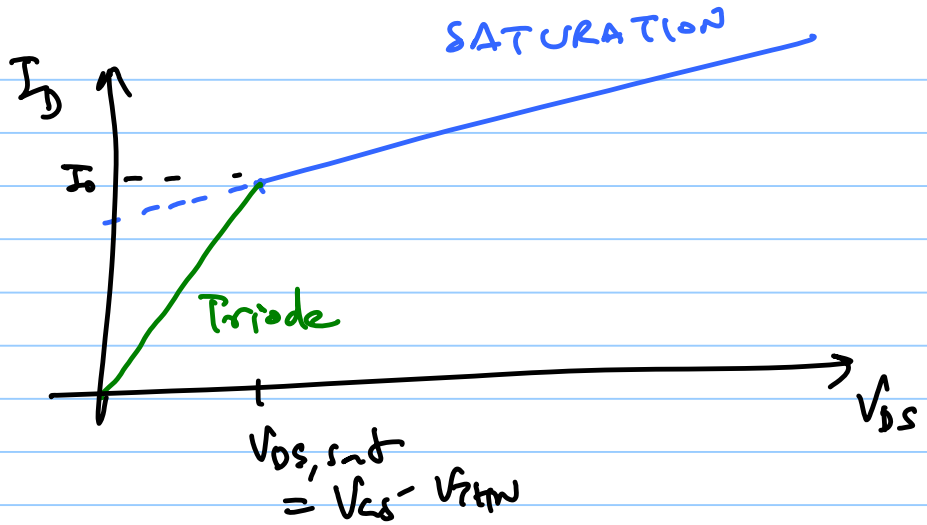

I
R
V

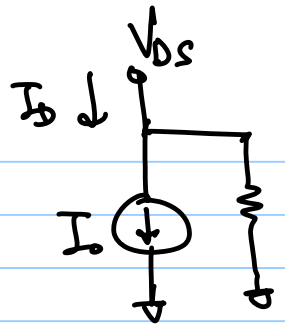

I
I_0
V
I
I_0

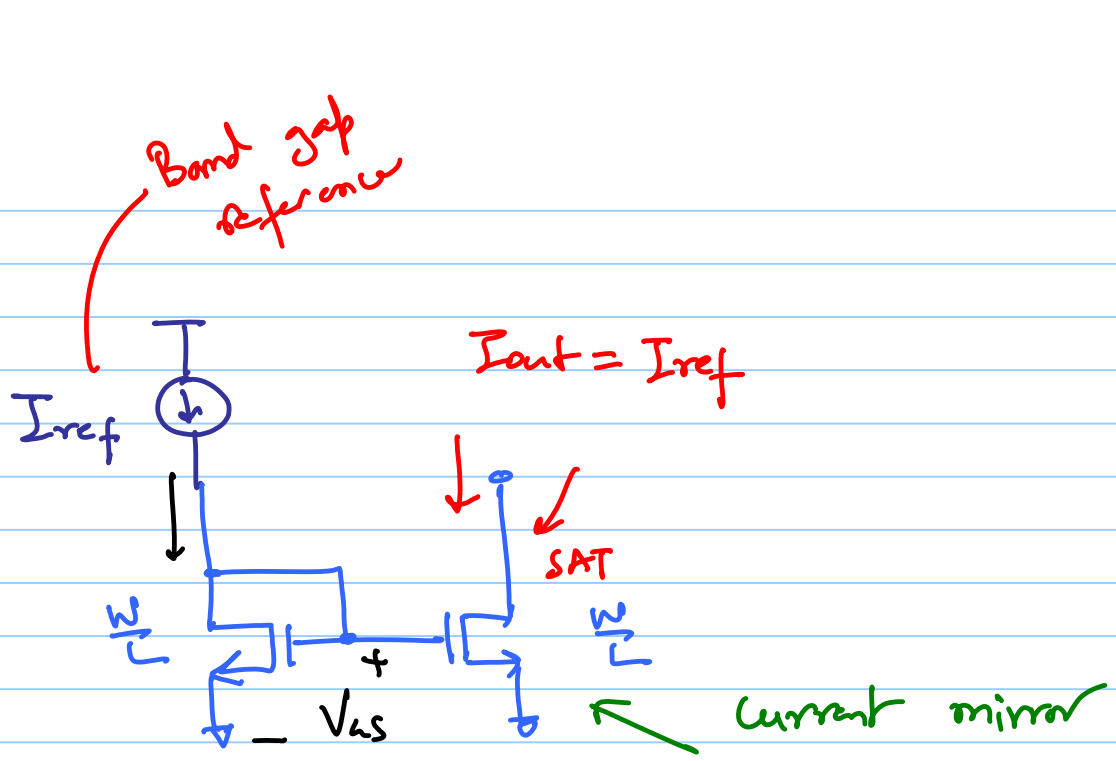

I
V_0
V
V_0

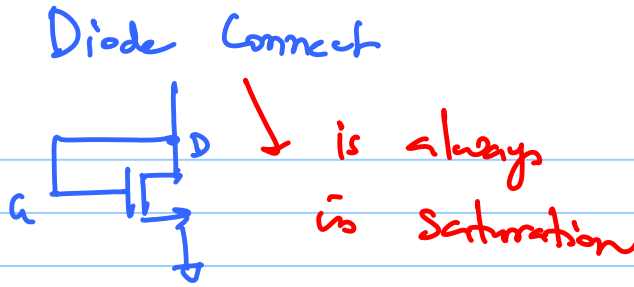

I
I_0
1/R
V


I
I_0
R
+
v
−


SATURATION
I_D
I_0
Triode
V_{DS}
$V_{DS,sat}$
$= V_{GS} - V_{th}$


V_{DS}
I_D
I_0





$V_{DS} = V_{GS} > V_{THN}$

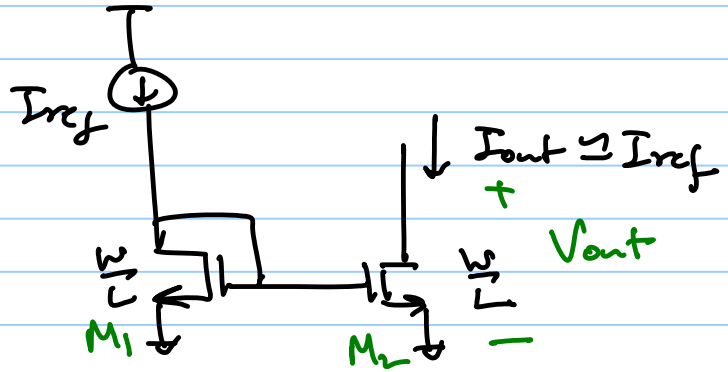
$V_{DS,sat} = V_{GS} - V_{THN}$

$V_{DS} > V_{DS,sat}$

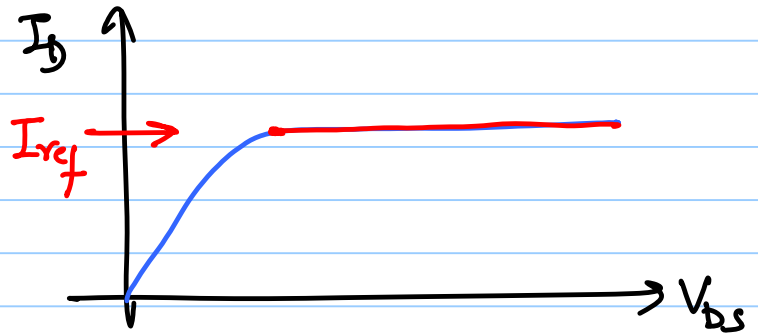
V_{GS} $\qquad$ $V_{GS} - V_{THN}$

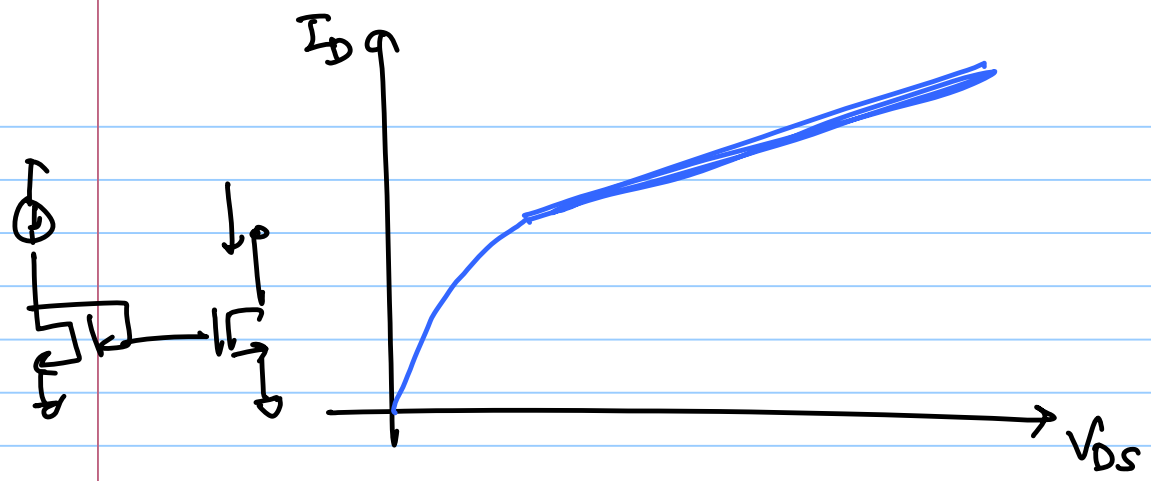
$$I_D = \frac{\beta}{2}(V_{GS} - V_{THN})^2$$

$$\Rightarrow V_{GS} = \sqrt{\frac{2I_D}{\beta}} + V_{THN} = \sqrt{\frac{2I_{ref}}{\beta}} + V_{THN}$$



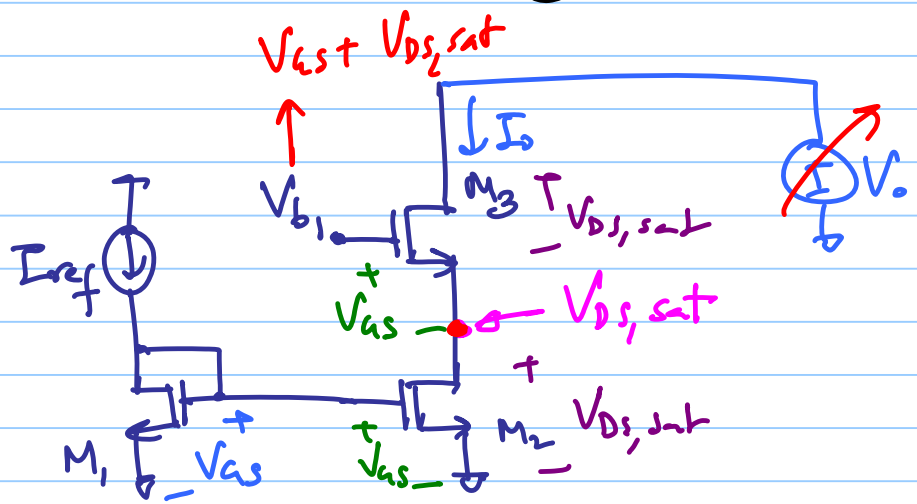
$V_{out} \geq V_{DS,sat}$ to keep M_2 in saturation.

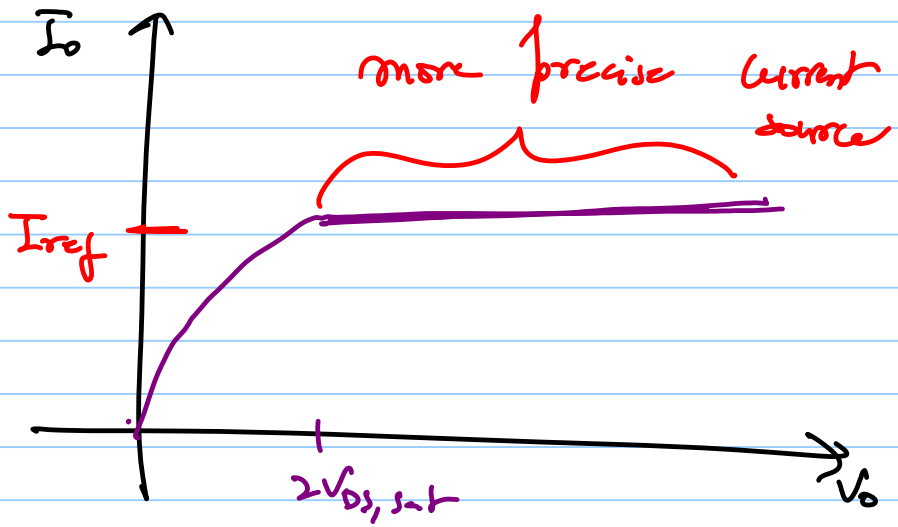




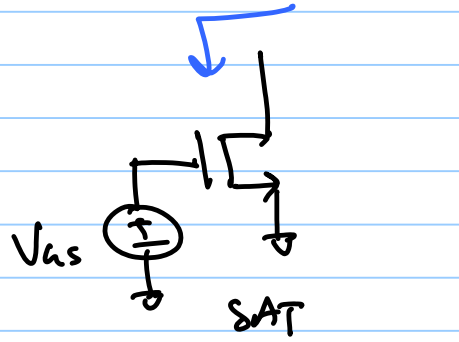
Channel length modulation

Cascoding

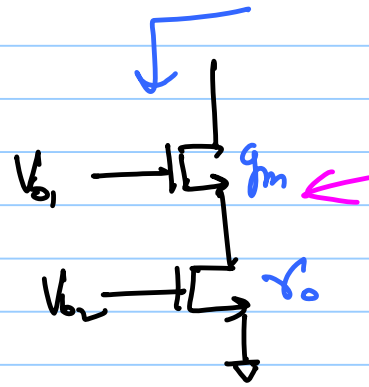

$V_{GS} + V_{DS,sat}$
I_o
V_o
I_{ref}
V_{b1}
M_3
$V_{DS,sat}$
V_{GS}
$V_{DS,sat}$
M_1
V_{GS}
V_{GS}
M_2
$V_{DS,sat}$


I_o
more precise current source
I_{ref}
$2V_{DS,sat}$
V_o

$R_{out} = r_o$

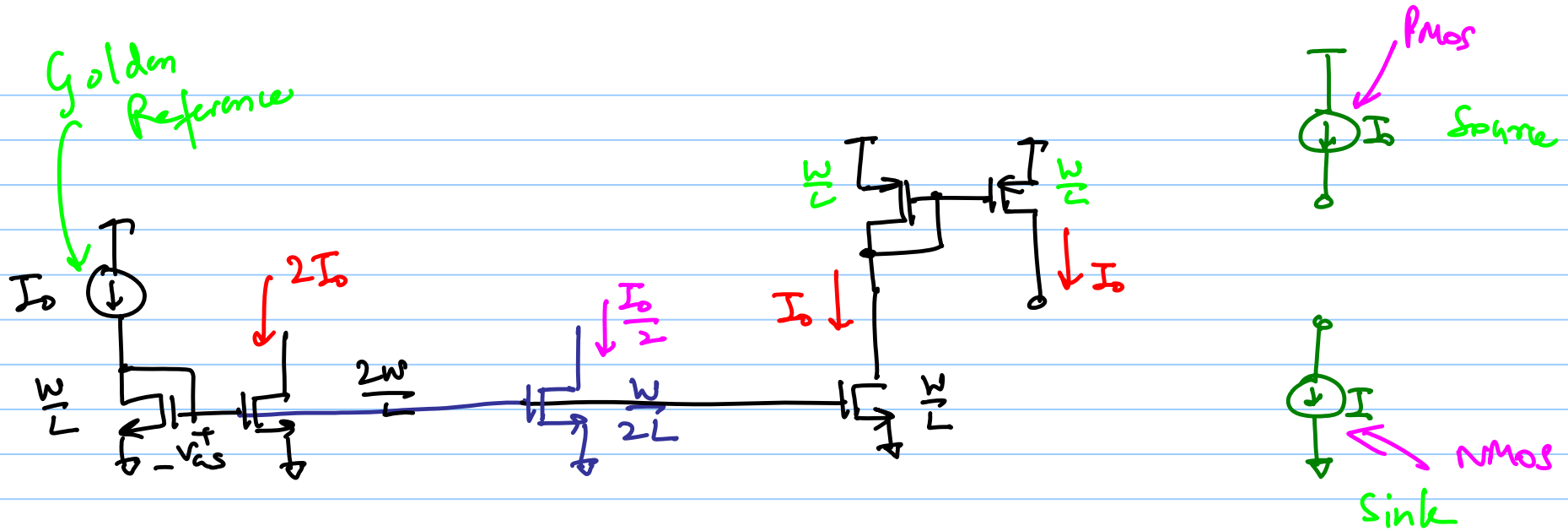


$R_{out} = g_m r_o^2 = (g_m r_o) r_o$



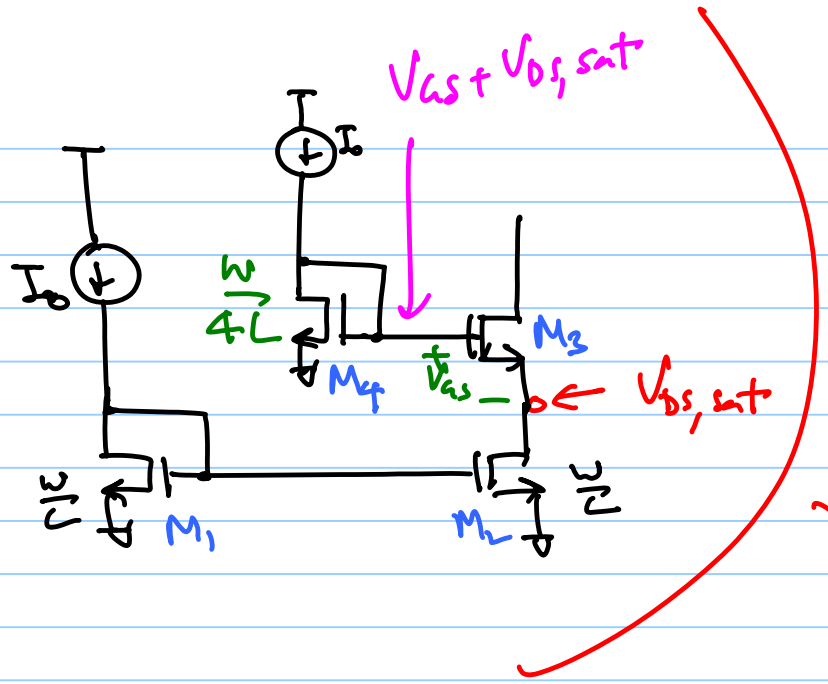
More precise current source

CASCODE CURRENT MIRROR



"Matching"

$$V_{OS,sat} = \sqrt{\frac{2I_D}{k_{Pn}\left(\frac{W}{L}\right)}} \quad \Longleftarrow \quad I_D = \frac{k_{Pn}}{2}\frac{W}{L}\underbrace{\left(V_{GS}-V_{Th,n}\right)^2}_{V_{DS,sat}}$$



$$V_{GS_4} = V_{GS_1} + V_{DS,sat}$$

$$= V_{DS,sat} + V_{THN} + V_{DS,sat}$$

$$= 2V_{DS,sat} + V_{THN}$$

$$\sqrt{\frac{2I_D}{k_n\left(\frac{W}{L}\right)_4}} + V_{THN} = 2\left[\sqrt{\frac{2I_D}{k_n\left(\frac{W}{L}\right)}}\right] + V_{THN}$$

$$\left(\frac{W}{L}\right)_4 = \frac{W}{4L}$$

http://lumerink.com/courses/ece5411/s11/Lectures.htm