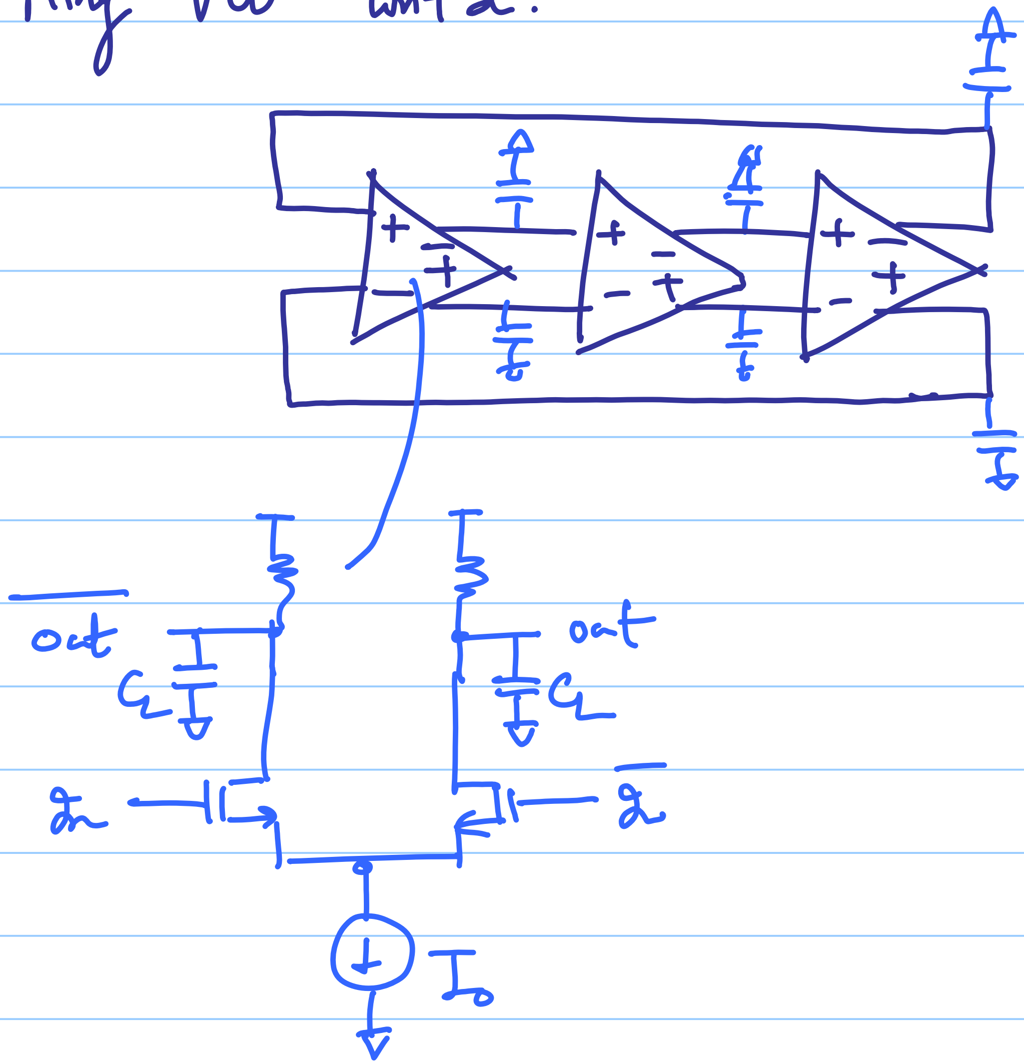
ECE 518 - Lecture 16

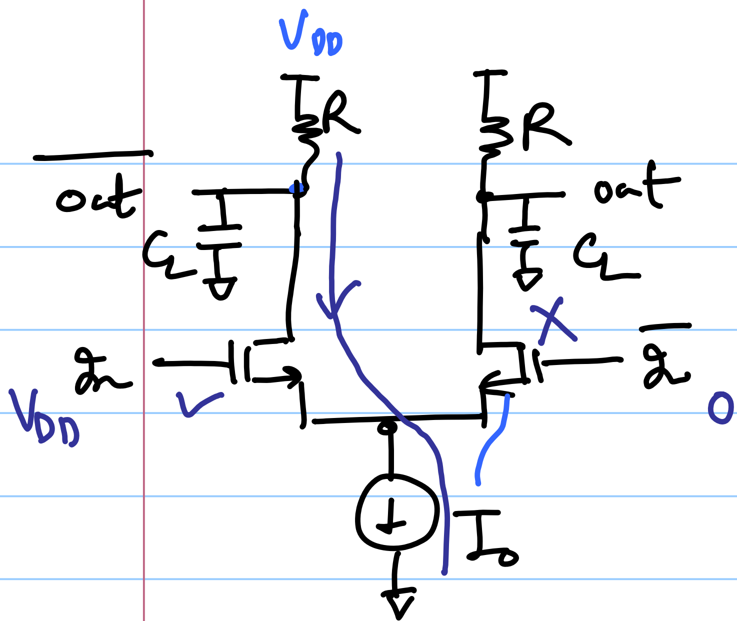
Note Title 3/10/2015

Ring VCO contd.

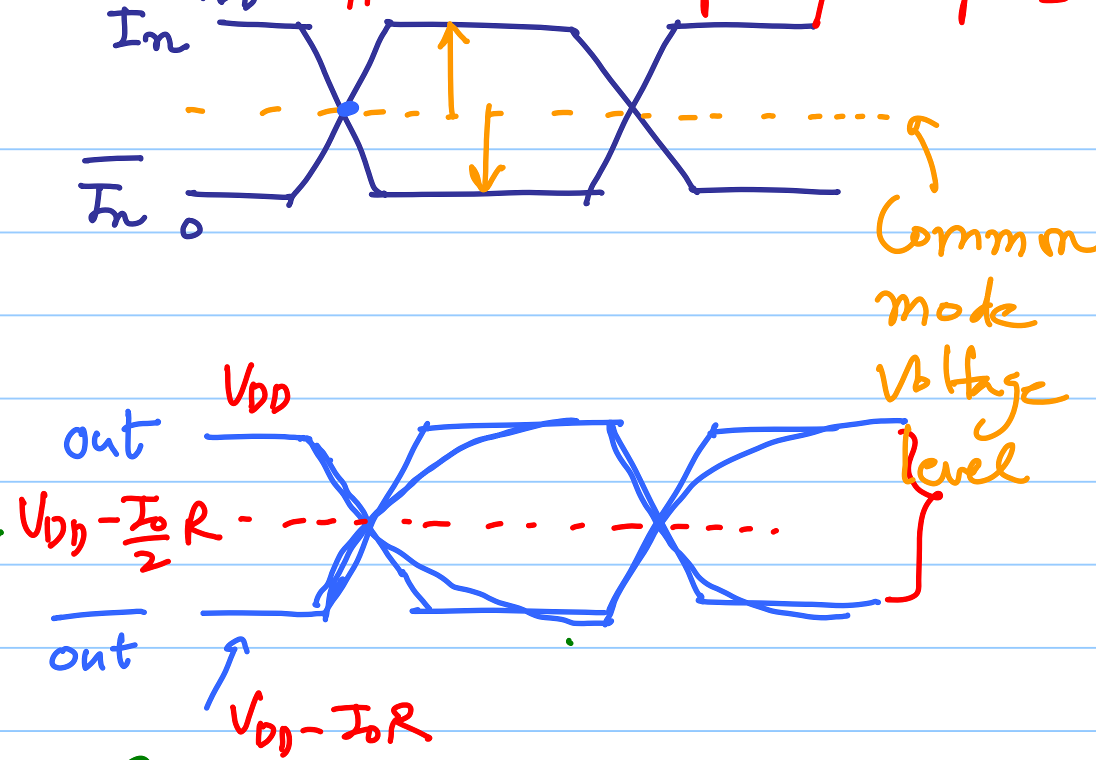


→ Low swing

→ Large swing



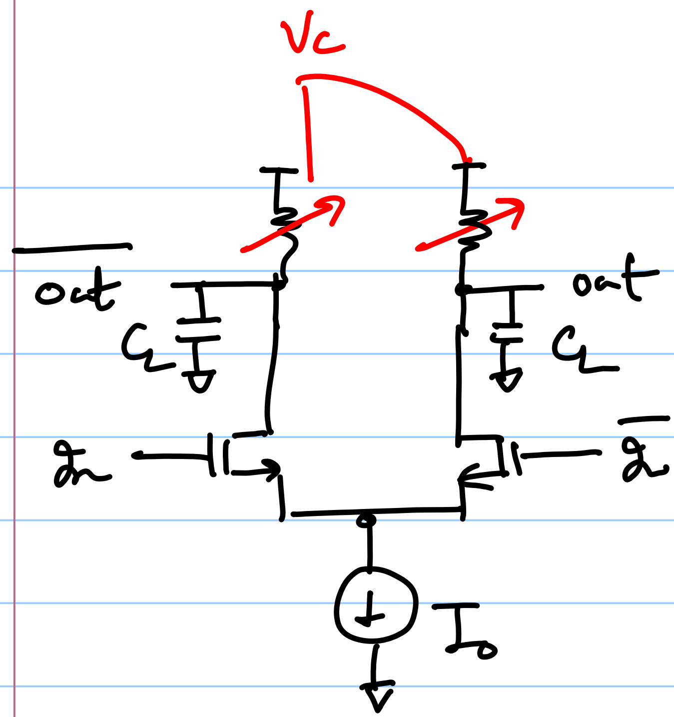
Differential inputs/outputs

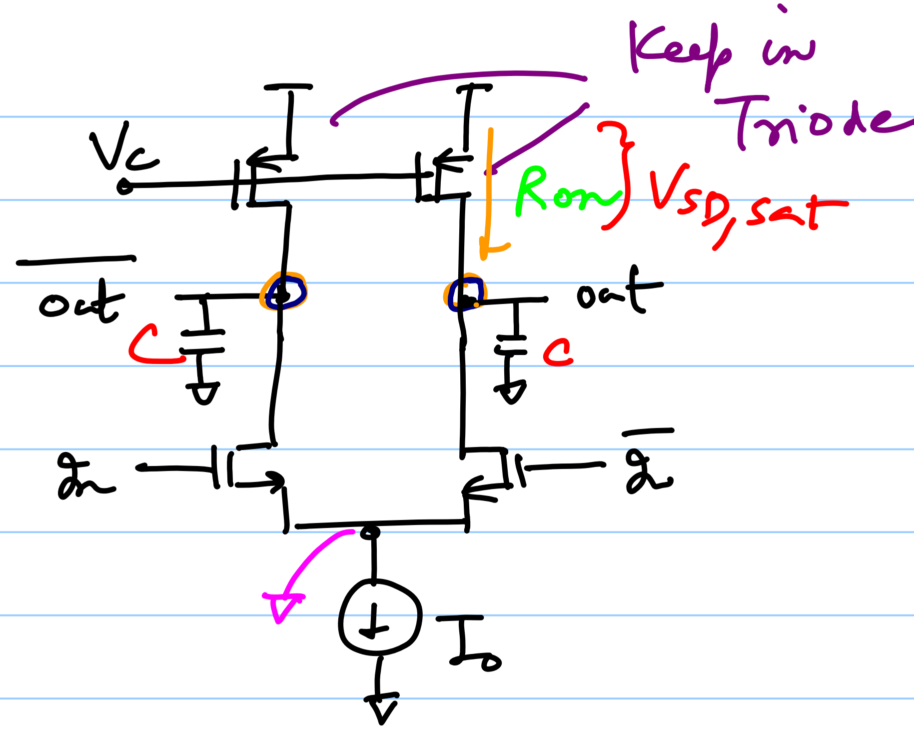


output swings between V_{DD} & $(V_{DD} - I_0 R)$

common-mode level (average of out & $\overline{out}$)

$$= V_{DD} - \frac{I_0}{2} R$$



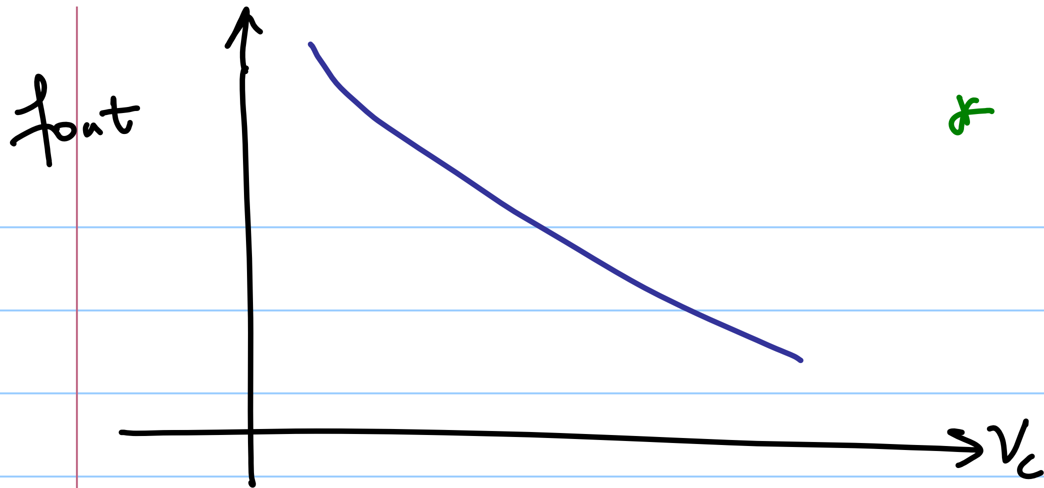


$$\tau \simeq R_{on}C = \frac{C}{Kp_n \cdot \frac{W}{L}\left(V_{SG} - |V_{THP}|\right)} = \frac{C}{Kp_n \frac{W}{L}\left(V_{DD} - V_C - |V_{THP}|\right)}$$

$$f_{out} \propto \frac{1}{\tau} \propto \frac{Kp_n \frac{W}{L}\left(V_{DD} - V_C - V_{THP}\right)}{C}$$

$V_C \uparrow$

$f_{out} \downarrow$



* Valid only when the load transistors are in triode

$$V_{SD} < V_{SD,sat}$$

$$V_{SD} = I_o R_{on} = \frac{I_o}{KP_n \frac{W}{L}(V_{DD} - V_C - V_{THP})} < \underbrace{V_{DD} - V_C - V_{THP}}_{V_{SD,sat}}$$

$$(V_{DD} - V_C - V_{THP}) > \sqrt{\frac{I_o}{KP_n \cdot \frac{W}{L}}}$$

If this is not satisfied, then the load transistors enter saturation

→ VCO characteristics saturate

→ output common mode voltage is undefined.

* $V_{swing} = I_o R_{on} \propto \frac{I_o}{f_{out}} \propto \frac{1}{f_{out}}$

Frequency dependent swing

$f_{out} \propto \frac{1}{R_{on}C}$

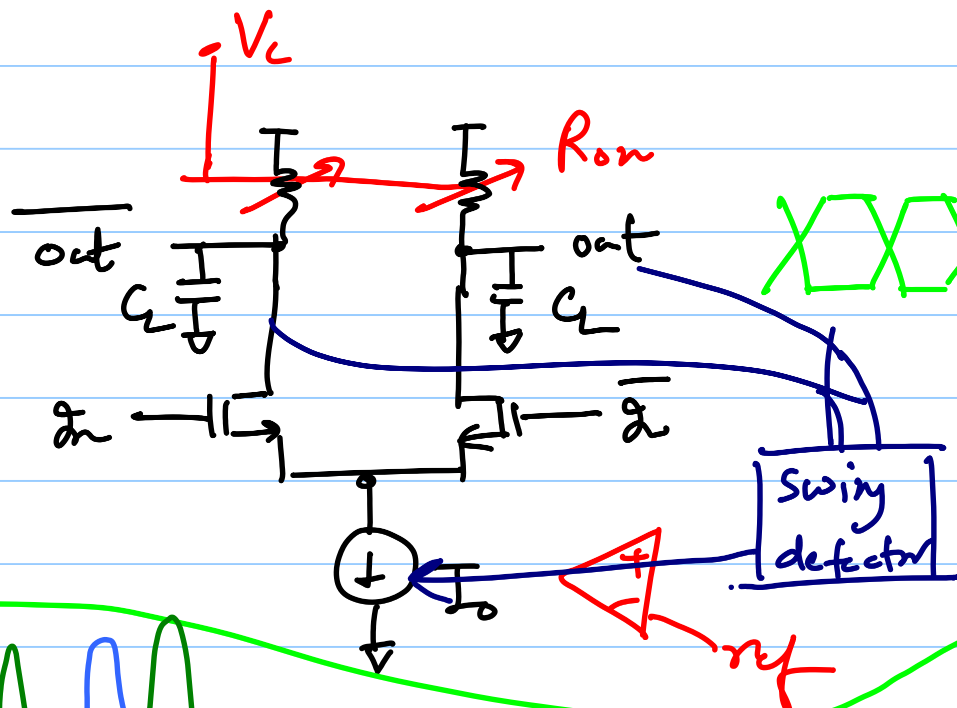
$R_{on} \propto \frac{1}{f_{out}}$

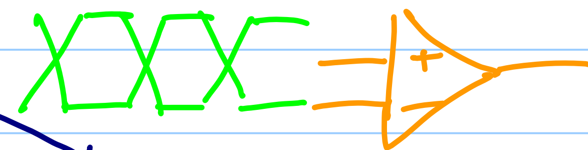
~~R_{on}~~ →

$V_c \uparrow \Rightarrow R_{on} \uparrow$

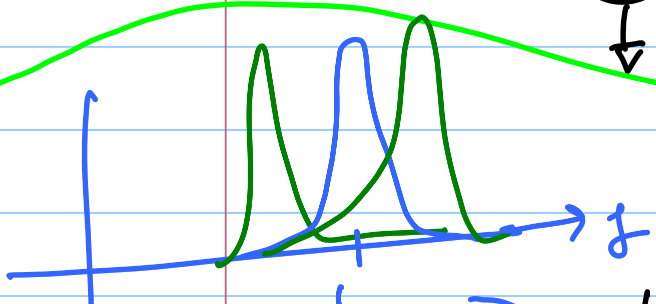
$f_{out} \downarrow$

swing $\uparrow$

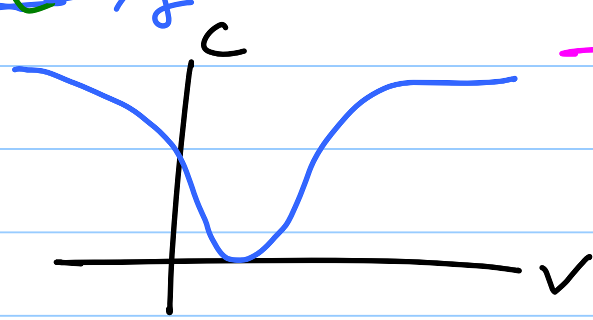


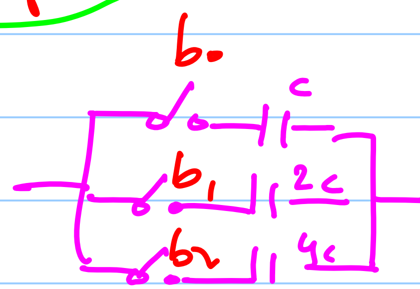


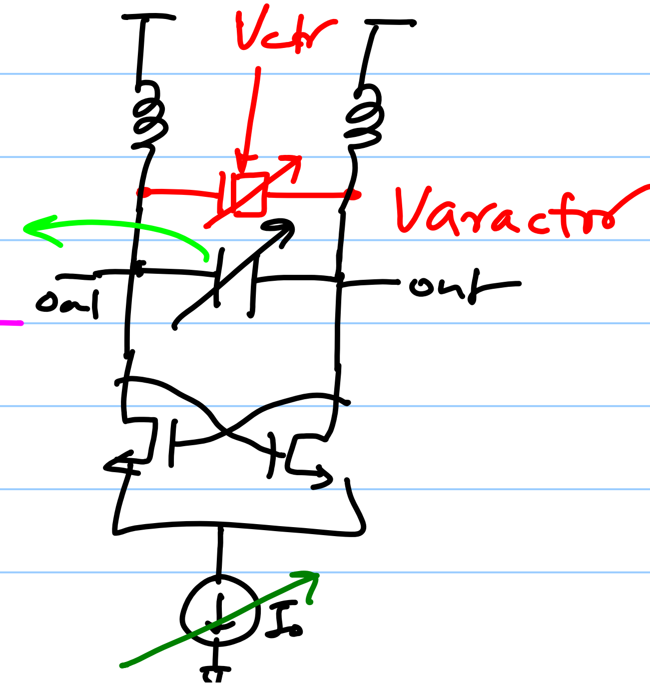
ASIDE



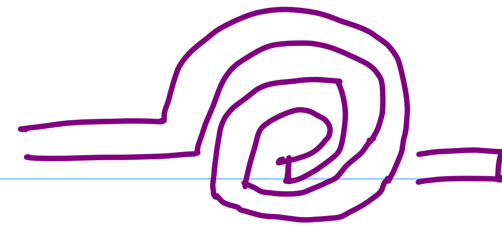
$$f = \frac{1}{2\pi\sqrt{LC}}$$

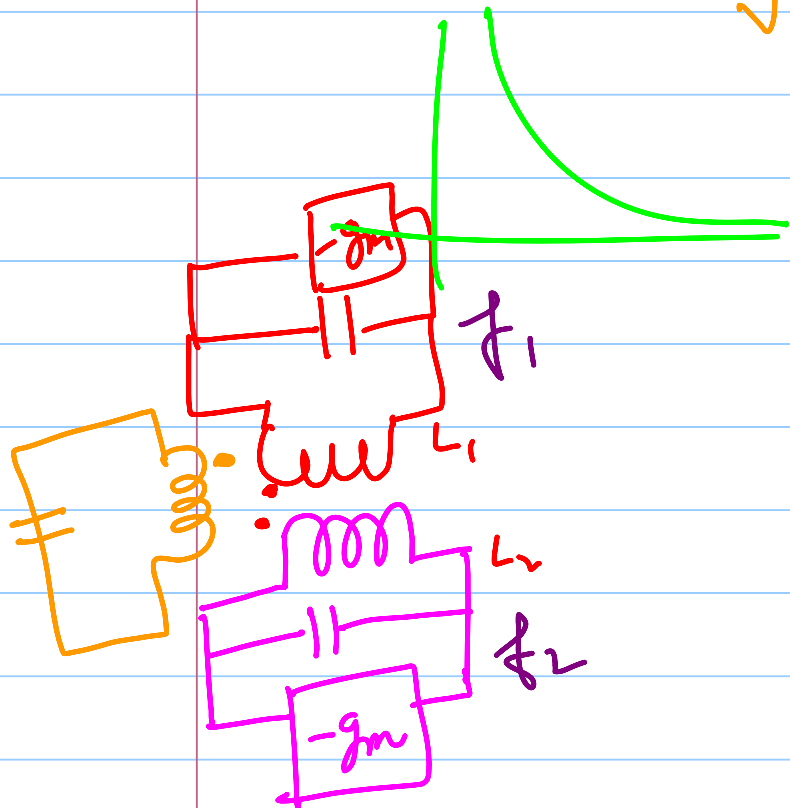


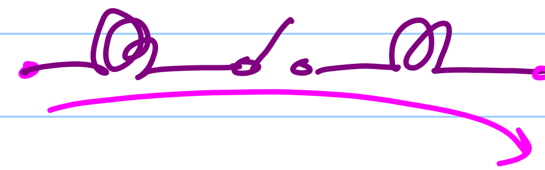


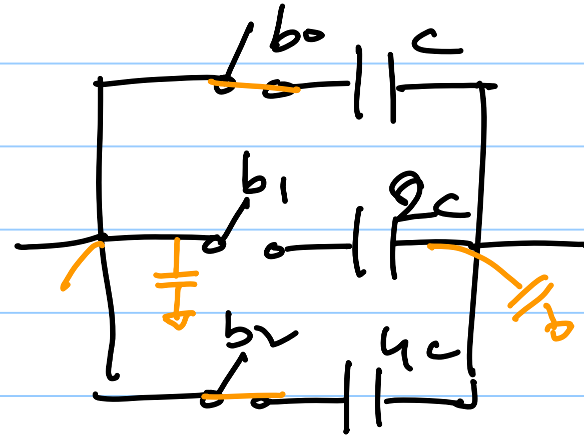


$$f_{osc} = \frac{1}{2\pi\sqrt{LC}}$$







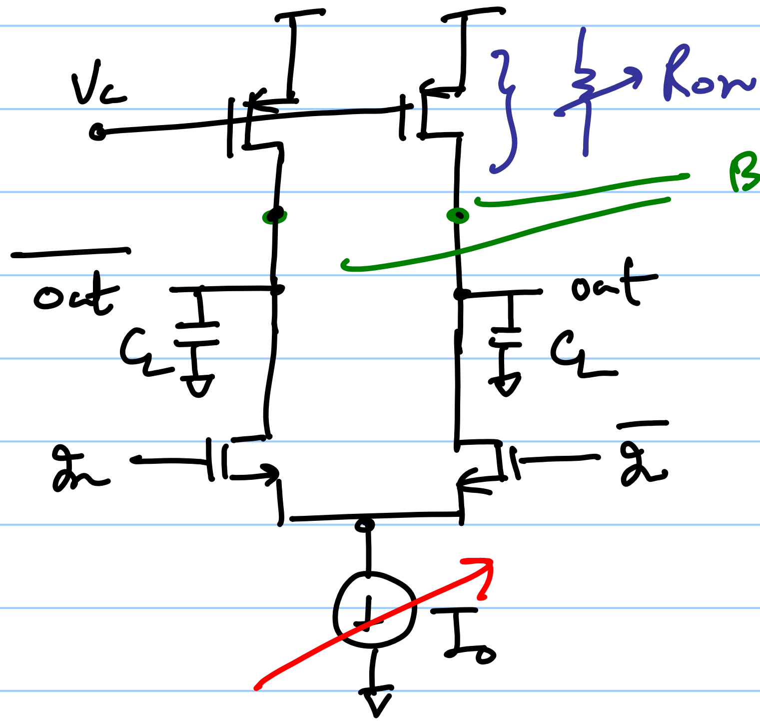


C_{on}

C_{off}

SDR

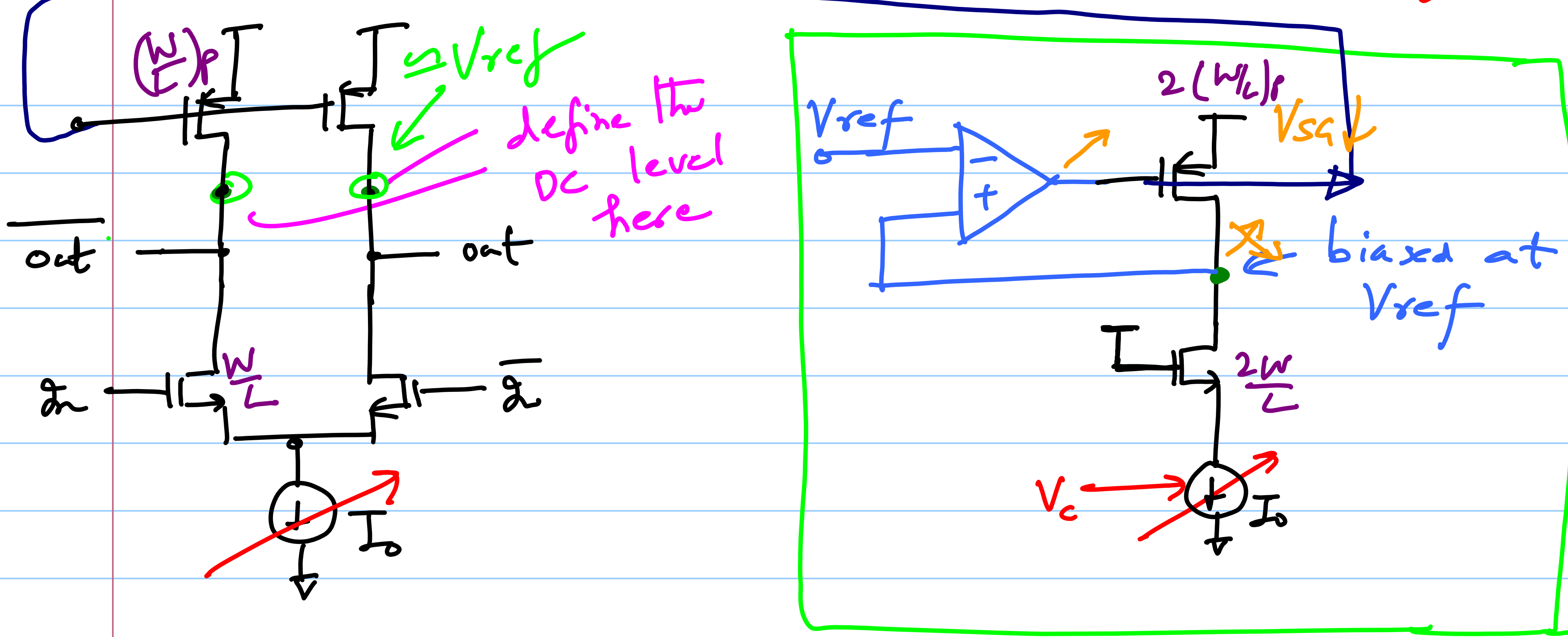
0 — 6 GHz

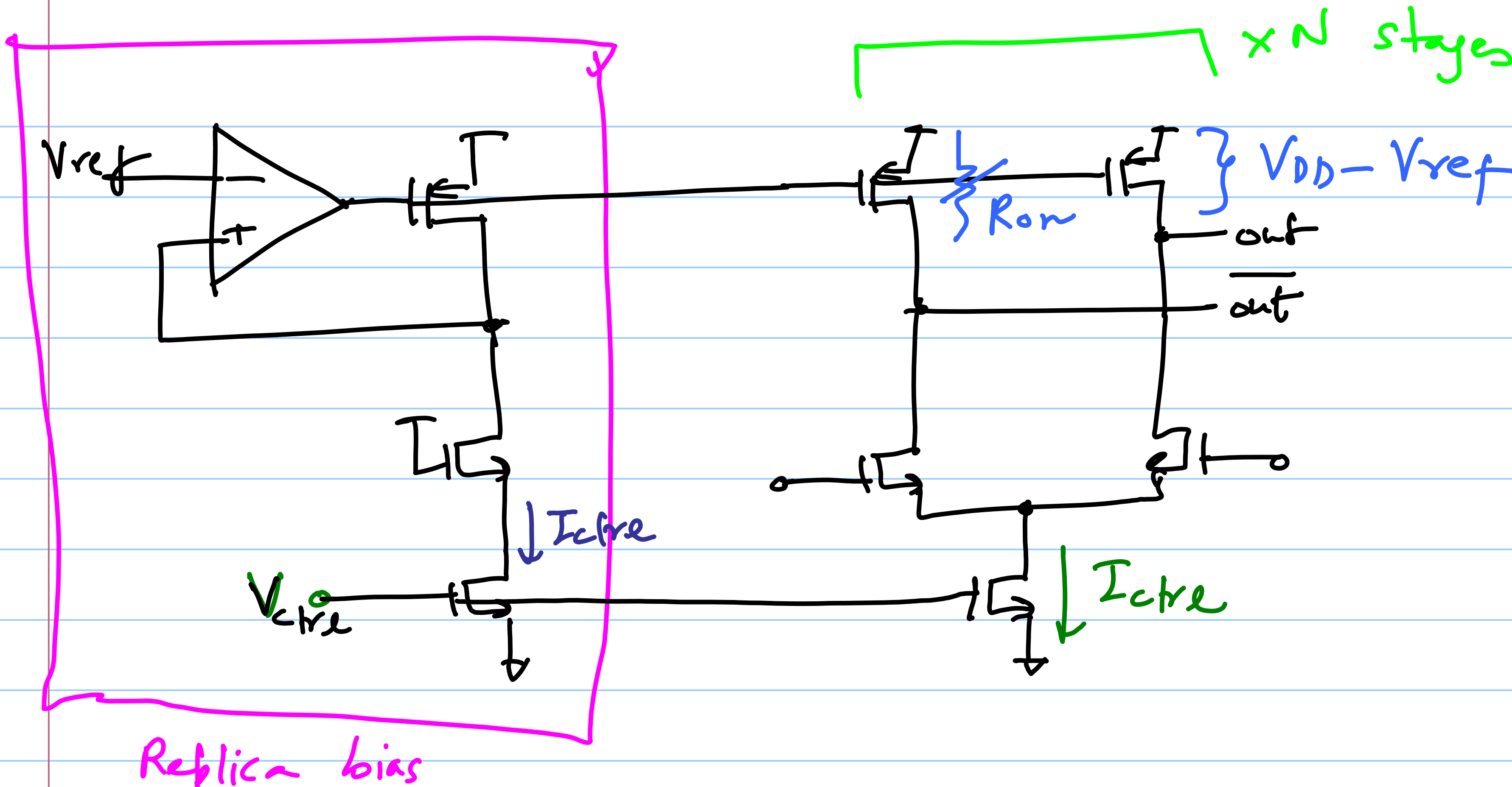


Better fix the CM-level

& control the current for tuning the frequency

Replica Biasing



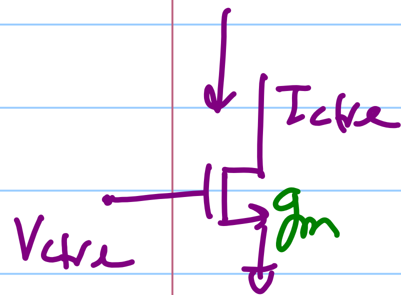


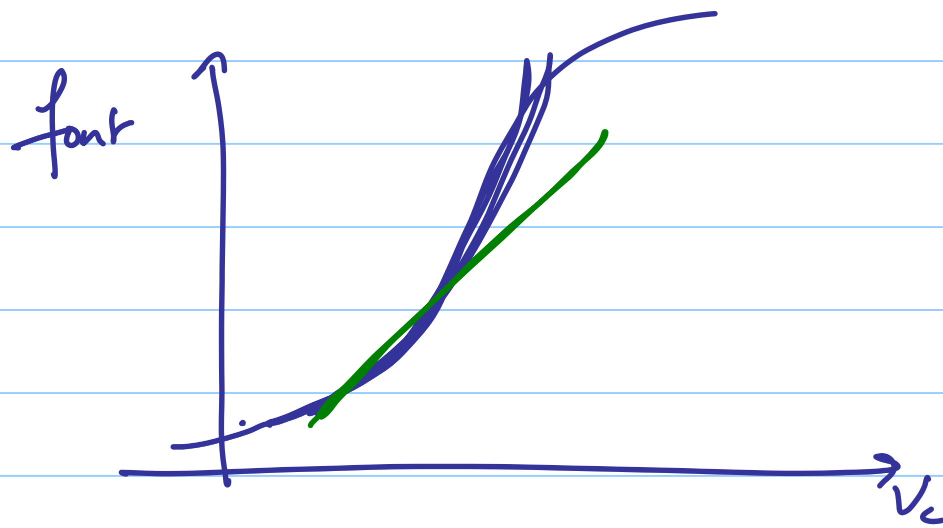
The Replica bias forces $R_{on} = \dfrac{(V_{DD} - V_{ref})}{I_{ctrl}}$

$$f_{out} \propto \frac{1}{R_{on}C} \propto \frac{I_{ctrl}}{(V_{DD}-V_{ref})C}$$

$$I_{ctrl} = f(V_{ctrl}) = \beta \frac{(V_{ctrl}-V_{THN})^2}{2}$$

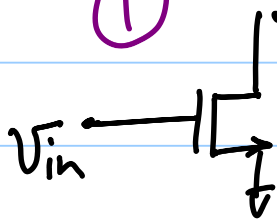
$$\simeq g_m V_{ctrl} \text{ for small signal}$$

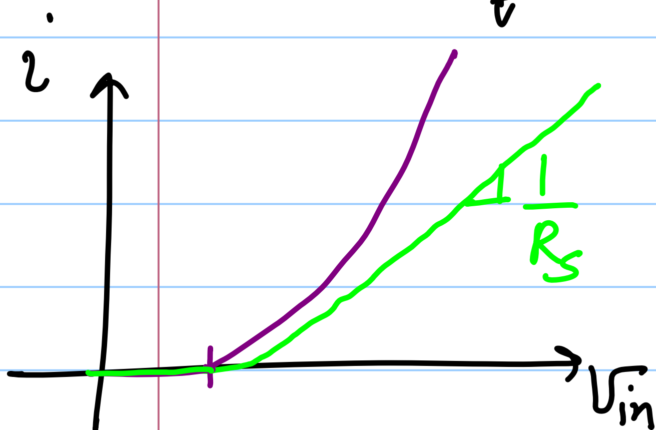




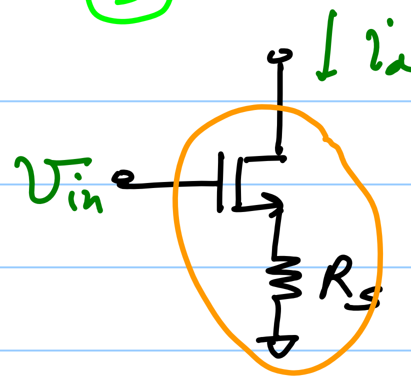
Source Degeneration

① $i_d = g_m v_{in}$





②



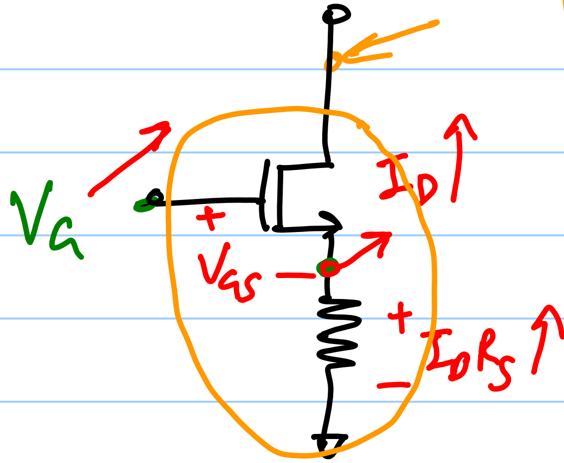
$$i_d = \underbrace{\left(\frac{g_m}{1+g_m R_s}\right)}_{G_m} v_{in}$$

$$G_m = \frac{g_m}{1+g_m R_s} = \frac{\cancel{g_m}}{\cancel{g_m} R_s} \simeq \frac{1}{R_s}$$

for $g_m R_s \gg 1$

$\Rightarrow g_m \gg \frac{1}{R_s}$

$$V_D > (V_{GS} - V_{THN}) + I_D R_S$$

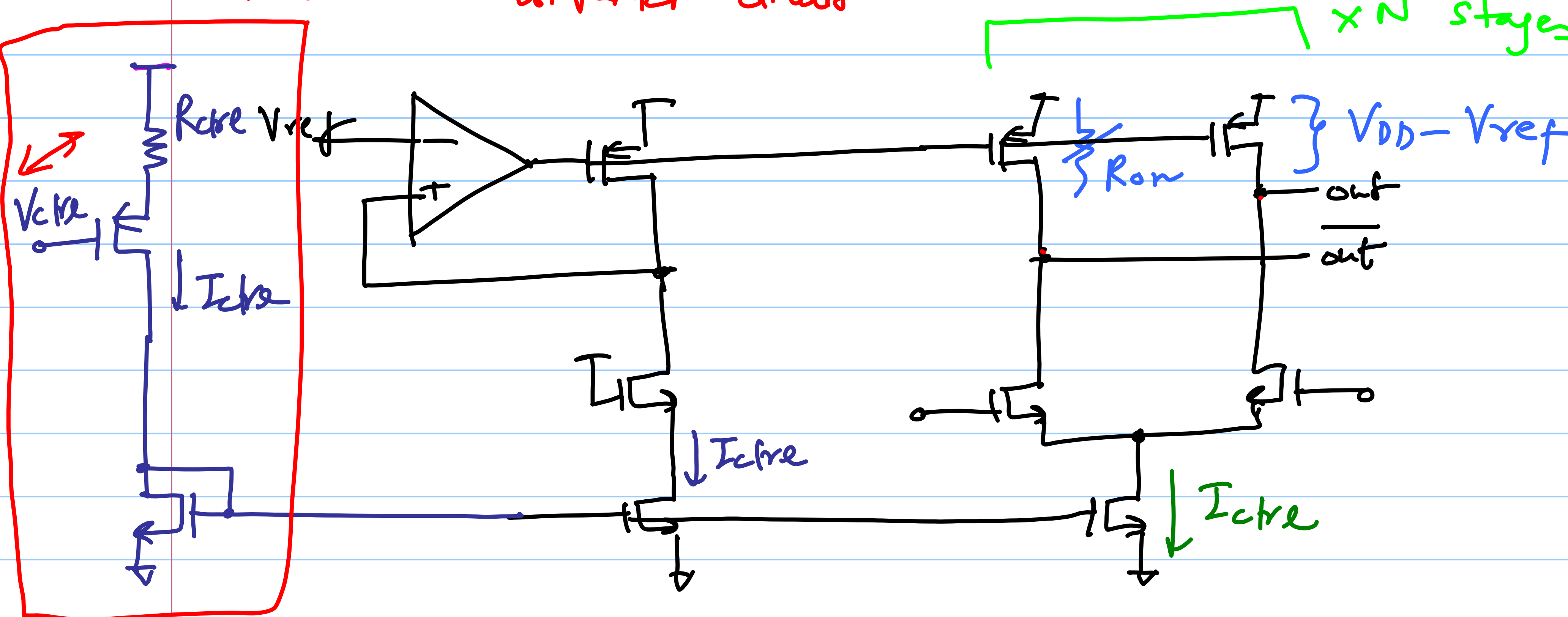


$$V_{DS} > V_{GS} - V_{THN}$$

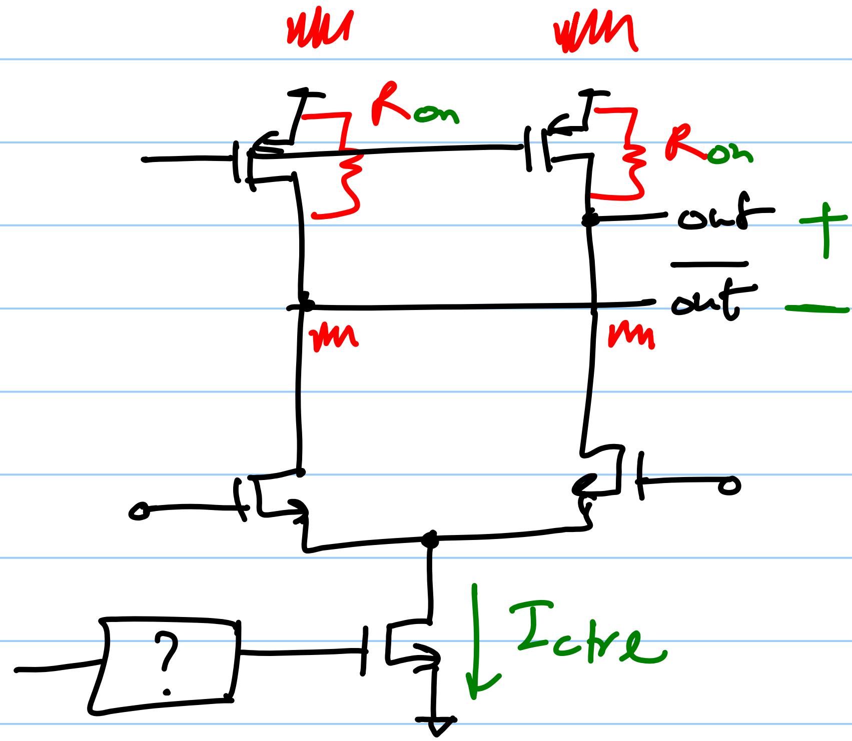
$$V_D - I_D R_S > V_G - I_D R_S - V_{THN}$$

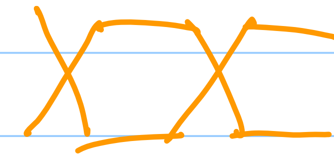
$$V_D > V_G - V_{THN}$$

V2I ← linear voltage to current converter circuit

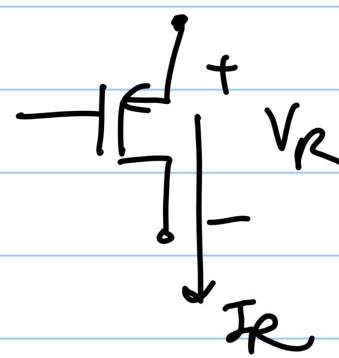


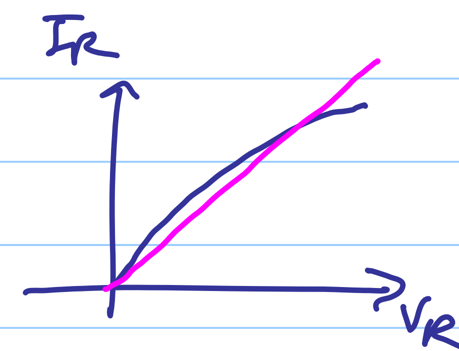
$I_{ctrl} \propto V_{ctrl}$



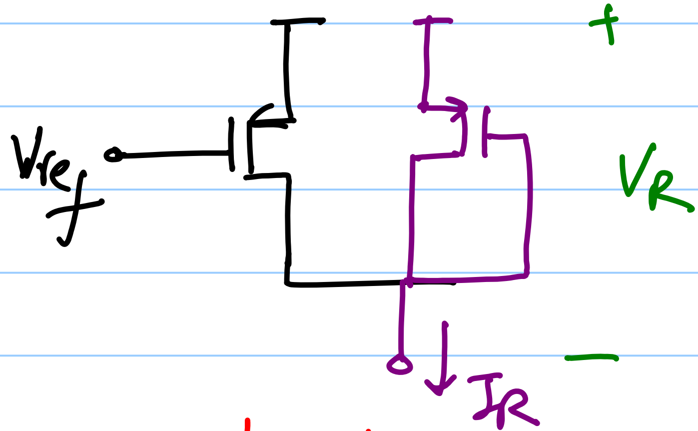


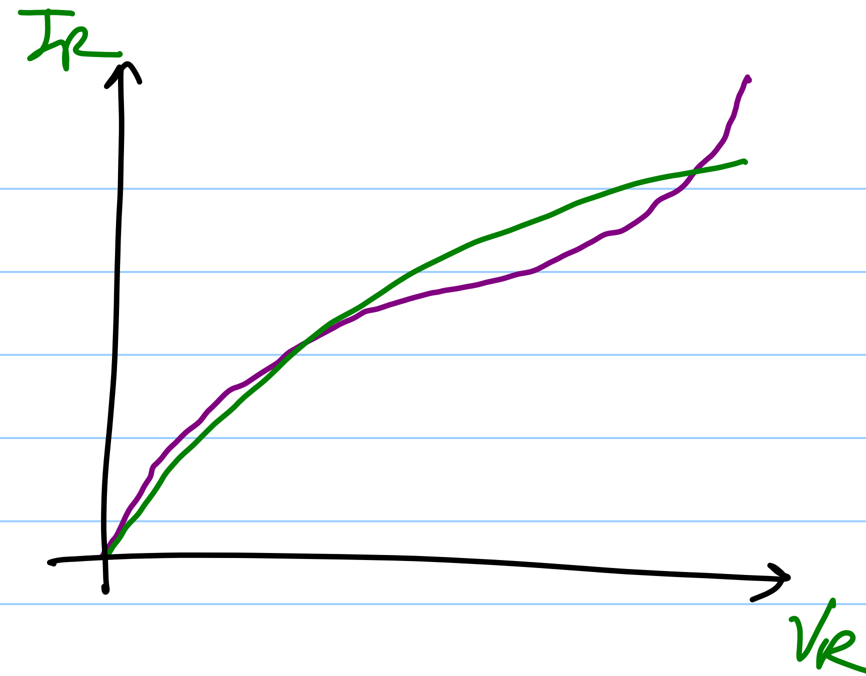
$$R_{on} = R(V_R, I_R)$$



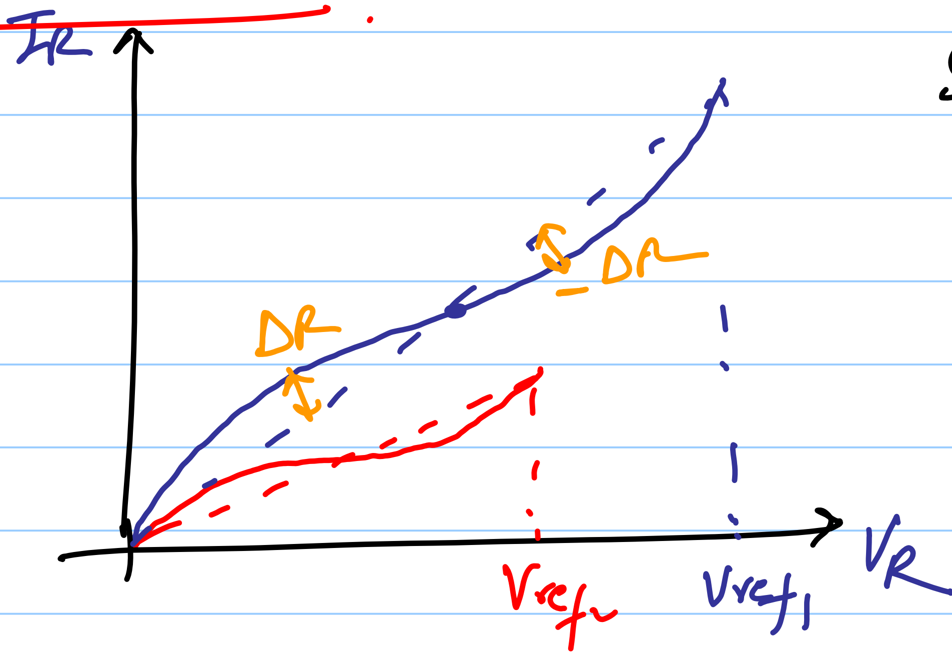


* non-linear resistor converts supply noise to differential noise output
  - ↳ Poor PSRR





Symmetric Loads



Symmetric I-V char

↳ Symmetric resistance

↳ Better PSRR