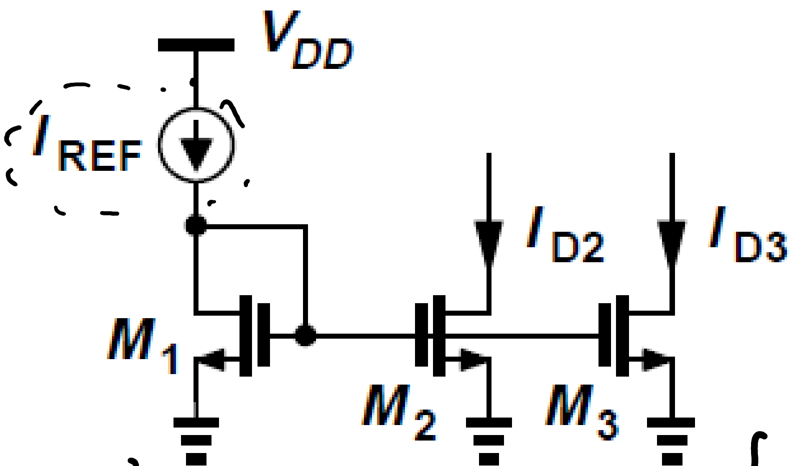
Lecture #8, Jan 24th, 2022

- Read Chapter 12.
- CAD 2 due next tomorrow.
- Homework 2 and Project 1 coming shortly.
- Class will be virtual this week.
- Quiz Today in 2nd half of class.
- Reference Voltage Design.
  - Current References
  - Process Voltage and Temperature Dependence.
  - Constant Voltage (Temp)
  - Proportional to Absolute Temperature (PTAT)
  - Constant Gm (Temp).

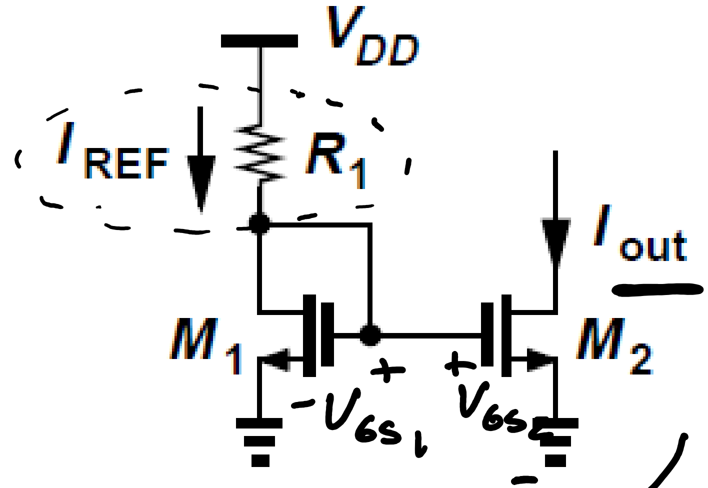
Online Quiz and Midterm Format

- Please have your camera on for the quiz/midterm.
- You have 5 minutes for the download.
- You have 26 minutes for the quiz.
- Please type in your ***start time and stop time in the Zoom chat***.
- You have 5 minutes to upload the quiz/midterm in Canvas

Designing IREF



MIRRORS FROM CHAPTER 5



SIMPLE C-SOURCE.

ASSUME $\lambda = 0$

$$I_{REF} = \frac{V_{DD} - V_{GS1}}{R_1}$$

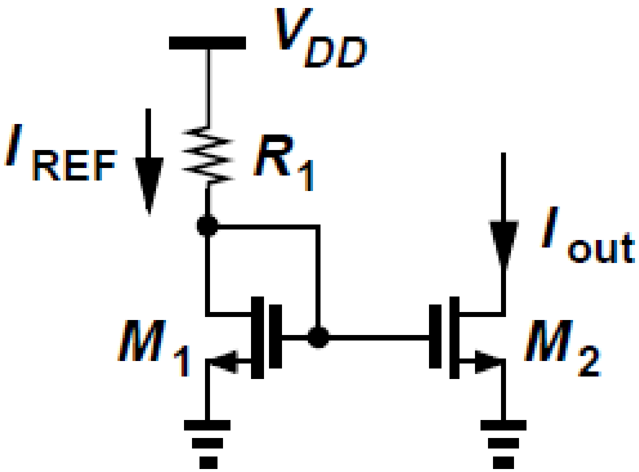
$$I_D = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)\left(V_{GS_1} - V_{thn}\right)^2$$

$$I_{D1} = I_{REF}$$

$$V_{GS1} = \sqrt{\frac{2 I_{REF}}{\mu_n C_{ox}\left(\frac{W}{L}\right)}} + V_{thn}$$

$$I_{REF} = \frac{V_{DD} - \left(\sqrt{\frac{2 I_{REF}}{\mu_n C_{ox}\left(\frac{W}{L}\right)_1}} + V_{thn}\right)}{R}$$

Using a Simple Resistor to Gen I_{REF}



$$I_{REF} = \frac{V_{DD} - \left(\sqrt{\frac{2 I_{REF}}{\mu_n C_{ox} \left(\frac{W}{L}\right)_1}} + V_{thn}\right)}{R_1}$$

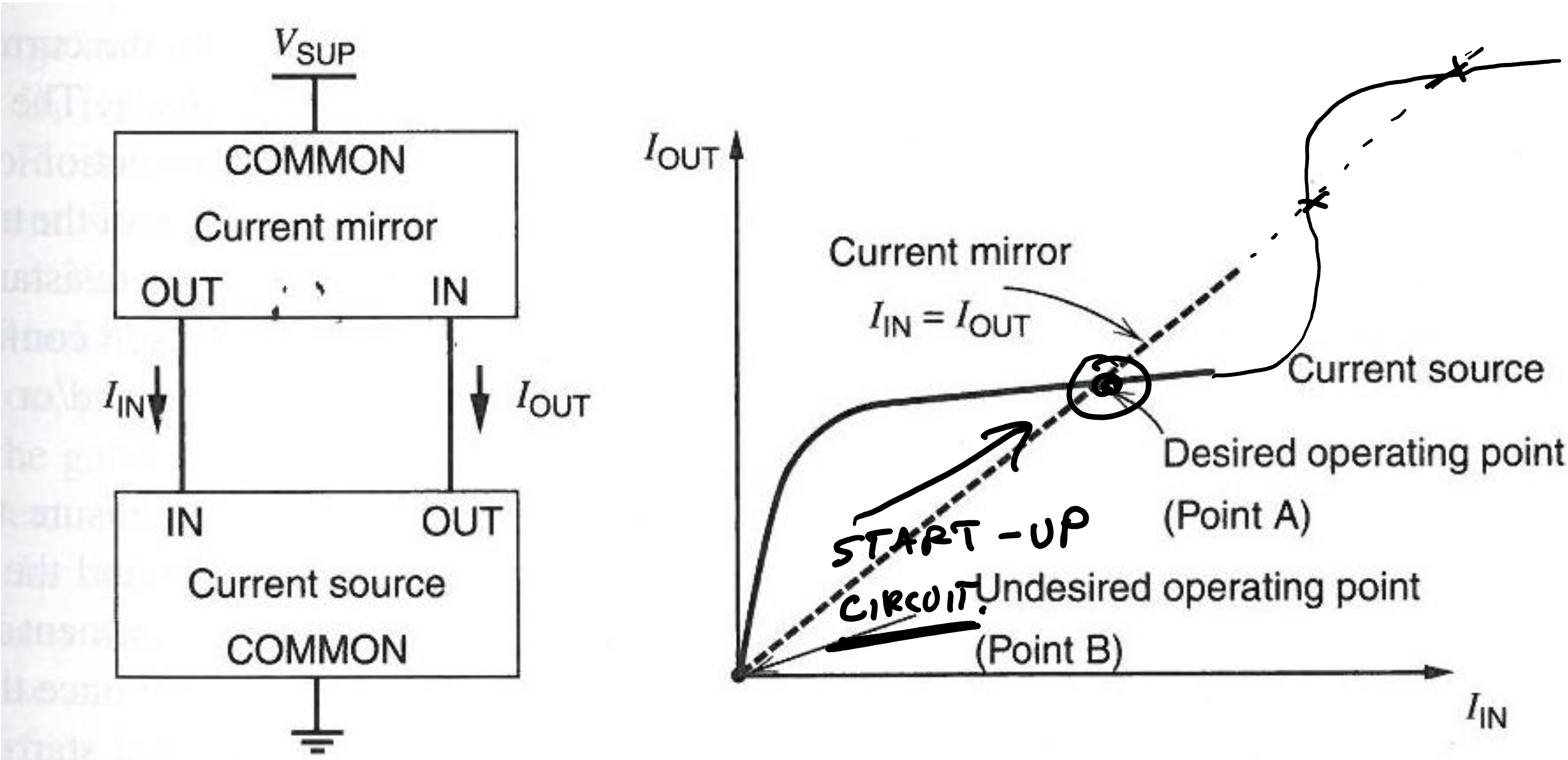
BOOK GIVES

$$\Delta I_{OUT} = \frac{\Delta V_{DD}}{R_1 + 1/g_{m1}} \cdot \frac{\left(\frac{W}{L}\right)_2}{\left(\frac{W}{L}\right)_1}$$

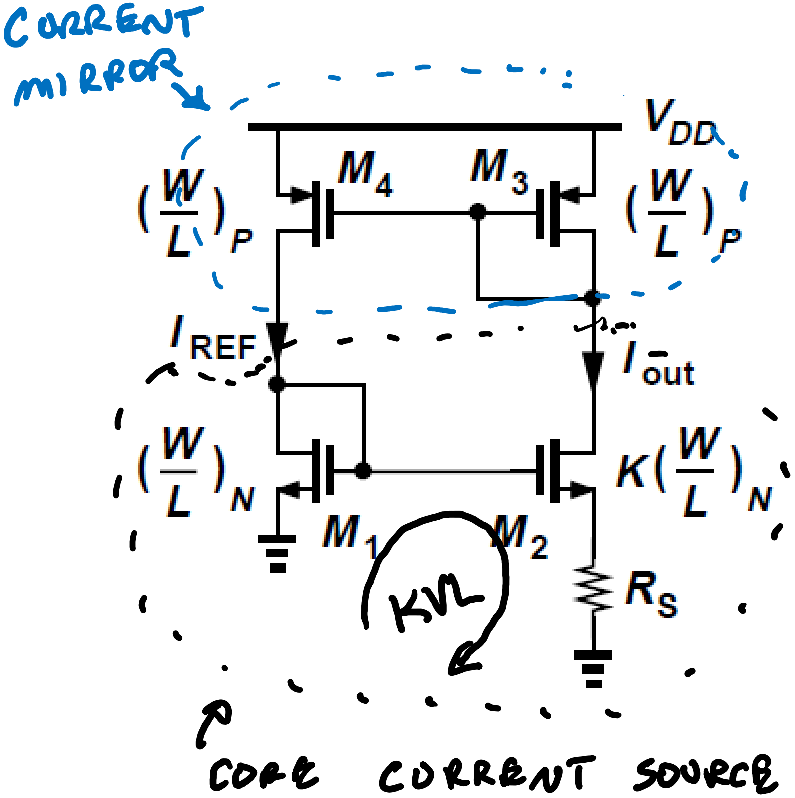
$$\Delta I_{OUT} \propto \Delta V_{DD}$$

· HIGHLY DEPENDENT ON V_{DD} !!!

Self-Biased/Referenced Circuits
"Bootstrapped" Biasing



Intuition Behind ΔV_{GS} Circuit



ASSUME

- $\mu_{n_1} C_{ox} = \mu_{n_2} C_{ox}$
- SQ. LAW DEVICES
- IGNORE $\lambda = 0. \Rightarrow r_o = \frac{1}{\lambda I_D}$
- ALL XSISTORS IN SAT.

$$I_{D1,2} = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)_{1,2}\left(V_{GS_{1,2}} - V_{tn}\right)^2$$

- FURTHER ASSUME $V_{tn_1} = V_{tn_2}$

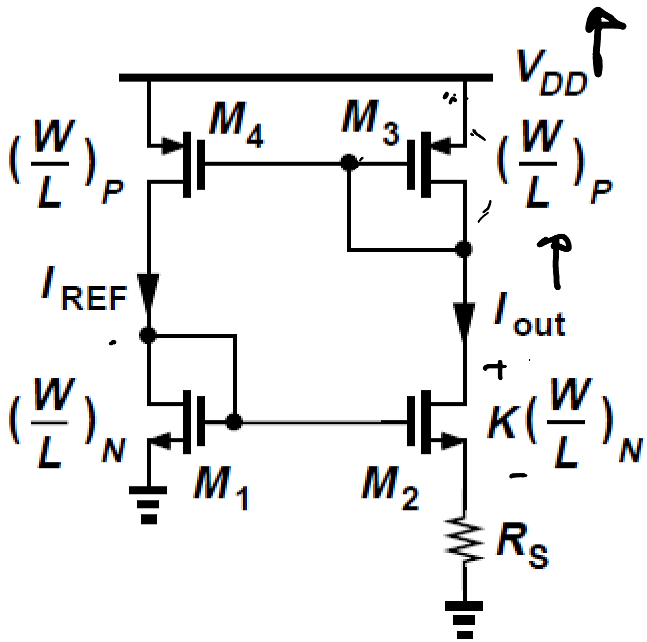
KVL

$$V_{GS1} - V_{GS2} - I_{OUT} \cdot R = 0$$

$$V_{GS} = \sqrt{\frac{2 I_D}{\mu_n C_{ox} \left(\frac{W}{L}\right)}} + V_{th}$$

$$\sqrt{\frac{2\,REF}{\mu_n C_{ox}\left(\frac{W}{L}\right)}} + V_{tn} - \sqrt{\frac{2 \cdot I_{OUT}}{\mu_n C_{ox} K\left(\frac{W}{L}\right)}} - V_{tn} - I_{out} \cdot R = 0$$

Intuition Behind ΔV_{GS} Circuit



$$I_{out} = \frac{2}{\mu_n C_{ox}\left(\frac{W}{L}\right)} \cdot \frac{1}{R^2}\left(1 - \frac{1}{\sqrt{K}}\right)^2$$

$\mu_n(T)$

$R(T)$