ECEN325: Electronics
Spring 2024

Current Mirrors

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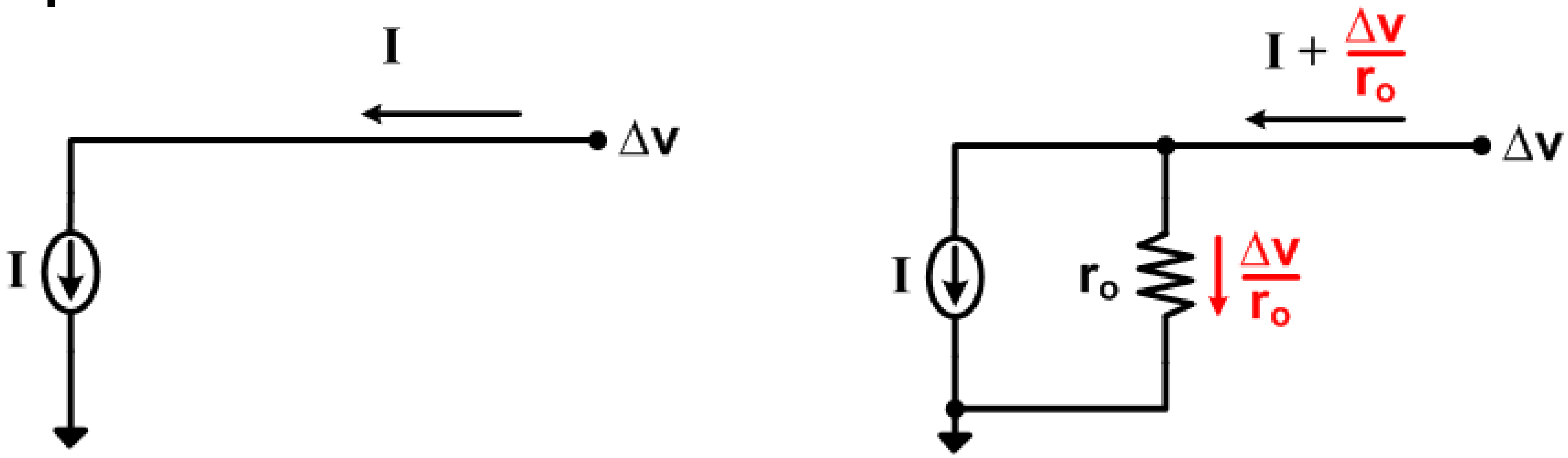
Announcements

- HW6 due Apr 25
- Exam 3 Review Session Apr 23 in class
- Exam 3 is May 7 1PM-3PM
  - Primary focus is MOSFET material

Current Source Properties

- Output Resistance



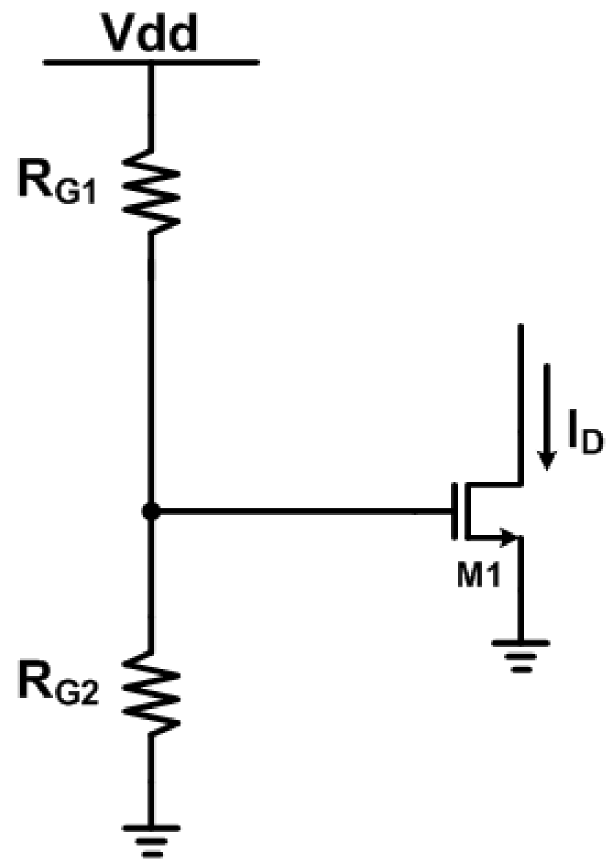
  - Finite output resistance degrades current source accuracy and amplifier gain
- Other important properties:
  - Voltage headroom (compliance voltage)
  - Accuracy
  - Noise

How Should We Bias Our Circuits?

- Resistive Biasing
  - Assuming saturation

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(V_G - V_{Tn}\right)^2$$

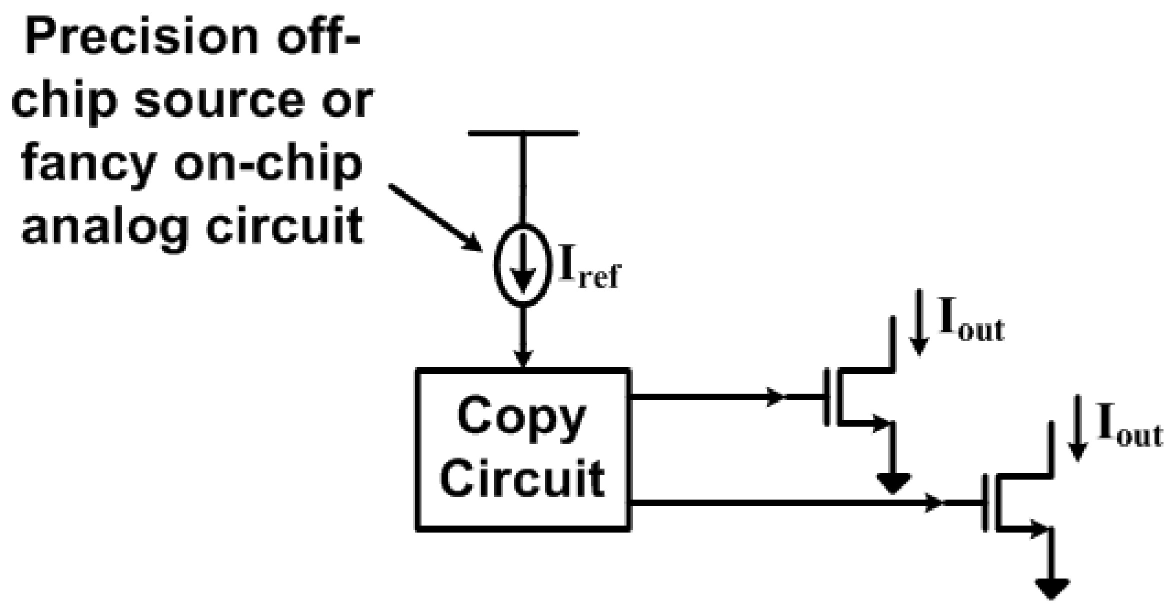
$$= \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(\frac{R_{G2}}{R_{G1}+R_{G2}}Vdd - V_{Tn}\right)^2$$



- I_D is sensitive to
  - Supply (Vdd)
  - Process (V_{Tn} and $\mu_n C_{ox} W/L$)
  - Temperature (V_{Tn} and μ_n)

IC Biasing

- In IC design we often assume that we have **one** precise current source and we copy its value to our circuits



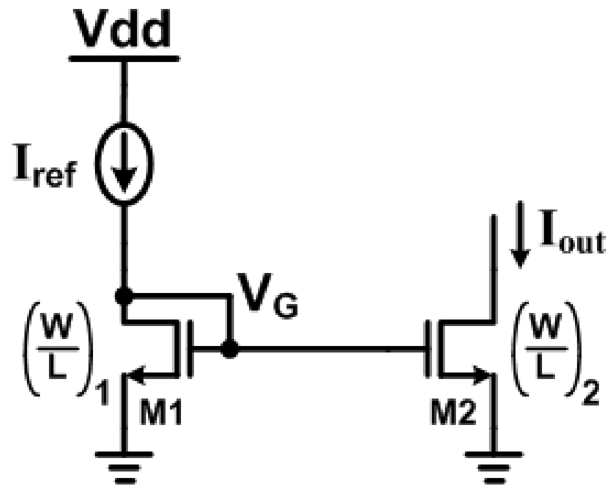
Simple Current Mirror

- That copy circuit is a current mirror
- Simple Current Mirror

What is V_G ?

$$I_D = I_{REF} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_1 (V_G - V_{Tn})^2$$

$$V_G = \sqrt{\frac{2I_{REF}}{\mu_n C_{ox}\left(\frac{W}{L}\right)_1}} + V_{Tn}$$

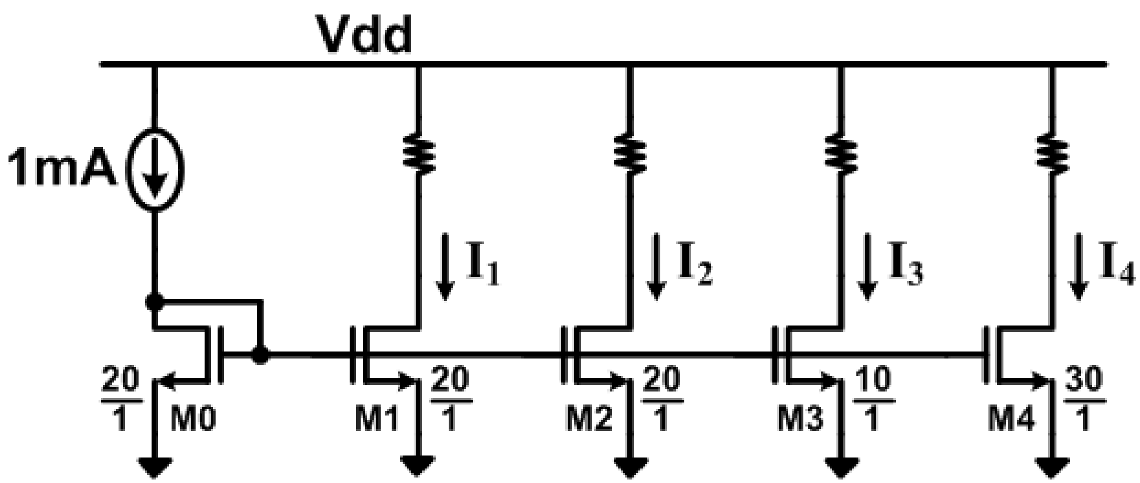


- If VG is applied to another transistor

$$I_{out} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_2 \left(\sqrt{\frac{2I_{REF}}{\mu_n C_{ox}\left(\frac{W}{L}\right)_1}} + V_{Tn} - V_{Tn}\right)^2$$

$$\boxed{I_{out} = \frac{\left(\frac{W}{L}\right)_2}{\left(\frac{W}{L}\right)_1} I_{REF}}$$

Ideal Current Mirror Example



I_1=1mA

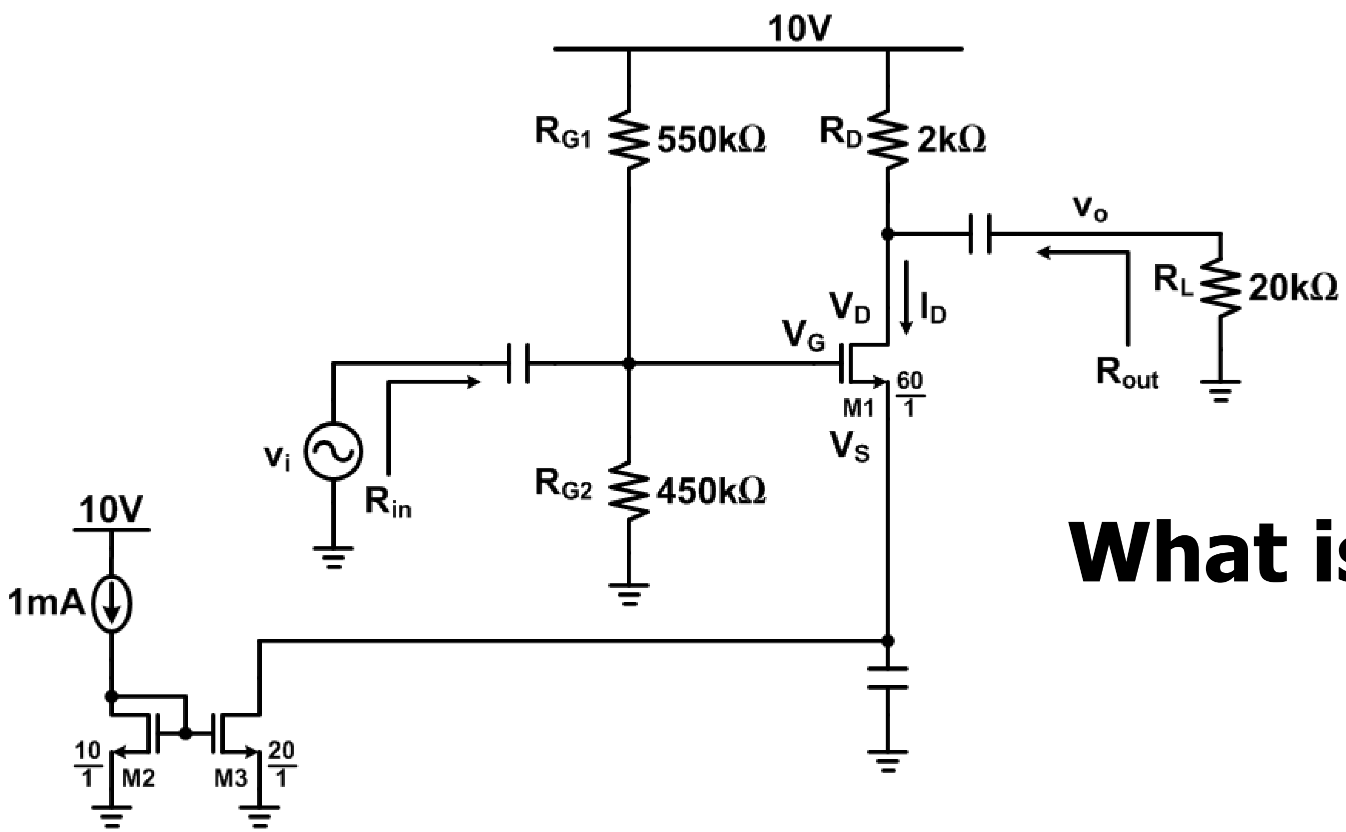
I_2=1mA

I_3=0.5mA

I_4=1.5mA

- This bias scheme reduces sensitivity to process, voltage, and temperature variations

CS Amplifier w/ Current Source



What is I_D?

- Need to insure that M3 remains in saturation

$$V_s = V_G - \left(V_{ov1} + V_{Tn}\right) = \left(\frac{R_{G2}}{R_{G1} + R_{G2}}\right)Vdd - \left(\sqrt{\frac{2I_D}{\mu_n C_{ox}\left(\frac{W}{L}\right)_1}} + V_{Tn}\right)$$