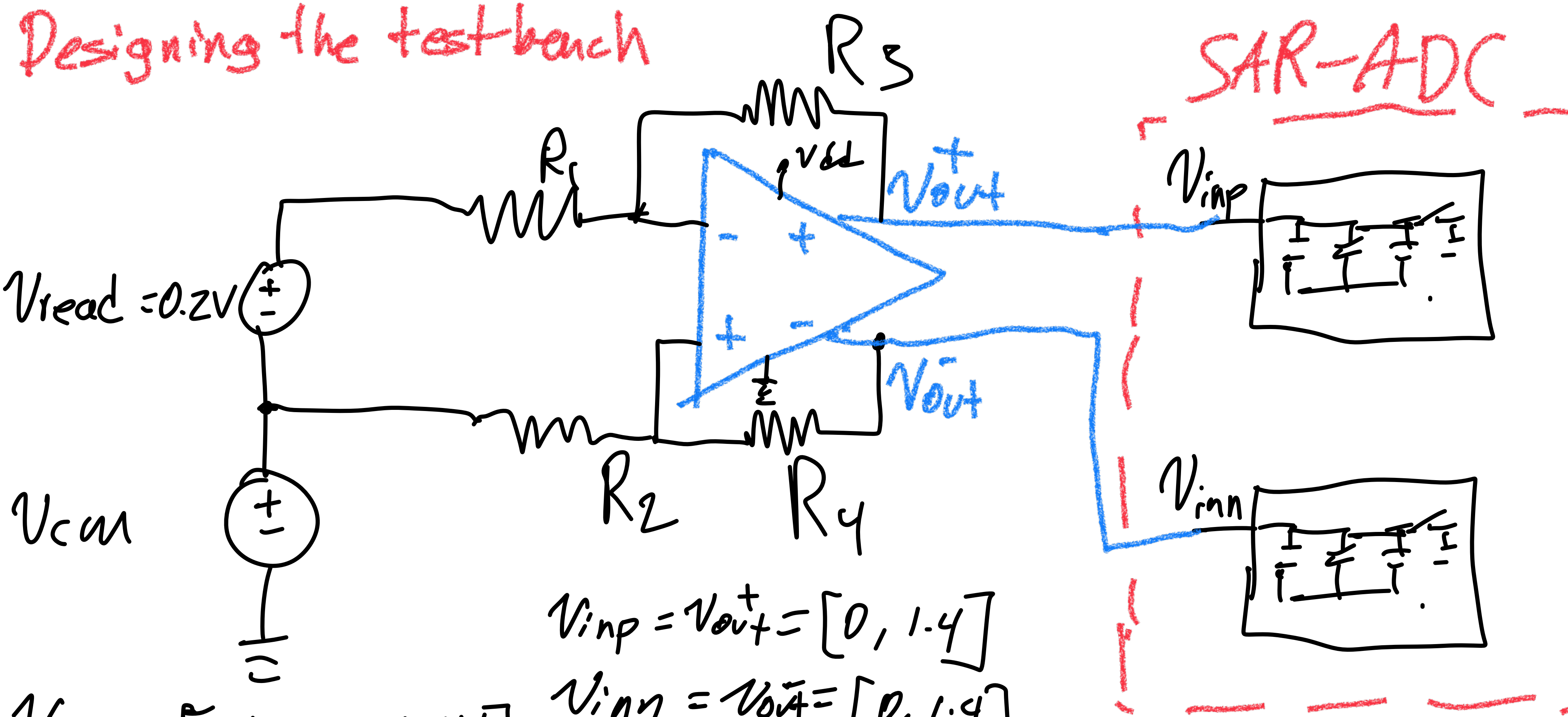
Associative Proc.

Activity Report

Alejandro Juárez Lora, December 4, 2023

Designing the testbench



$V_{inp} = V_{out}^{+} = [0, 1.4]$

$V_{inn} = V_{out}^{-} = [0, 1.4]$

$V_{cm} = 0.7V$

$V_{pp} \in [-1.4V, 1.4V]$

$V_{pp} = 2.8V$

Two stage opamp

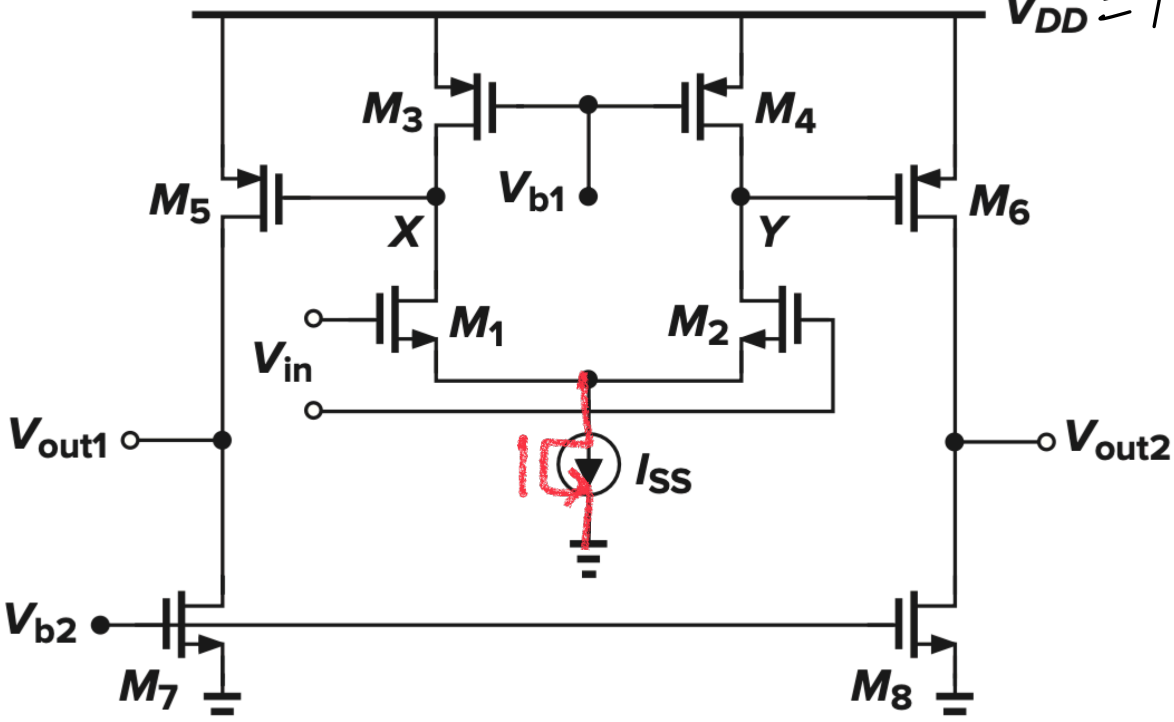


Figure 9.23 Simple implementation of a two-stage op amp.

$V_{DD} = 1.8V$

$V_{SS} = 0$ $\quad V_{PP} = 2.8V$

(from the ADC)

$P_{budget} = 1\ \mu W$ (Proposed)

$|V_{th,p}| = V_{thn} = 0.65V$

(from Sky 130

Computing Overdrive voltages

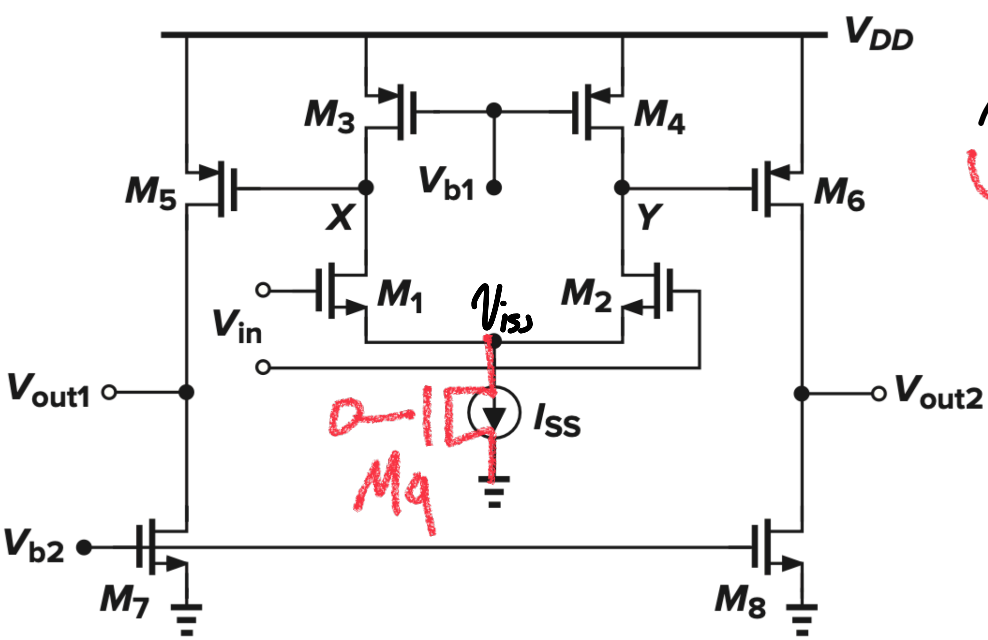


Figure 9.23 Simple implementation of a two-stage op amp.

Voltage at inner branch

$V_{DD} = |V_{OD3}| + V_X + V_{OD1} + V_{OD9}$

with $V_X = 0.1\,V_{PP} = 0.1 \cdot 1.4 = 0.14$

$\underbrace{V_{OD1} + |V_{OD3}| + V_{OD9}}_{V_{inbranch}} = 1.8V - 0.14$

$V_{inbranch} = 1.66\,V$

Asigning $V_{OD9} = (0.2) \cdot 1.66 = 0.33V$

$V_{OD3} = (0.55) \cdot 1.66 = 0.415$ ✓

$V_{OD1} = (0.25) \cdot 1.66 = 0.3\,V$ ✓

Computing Overdrive voltages

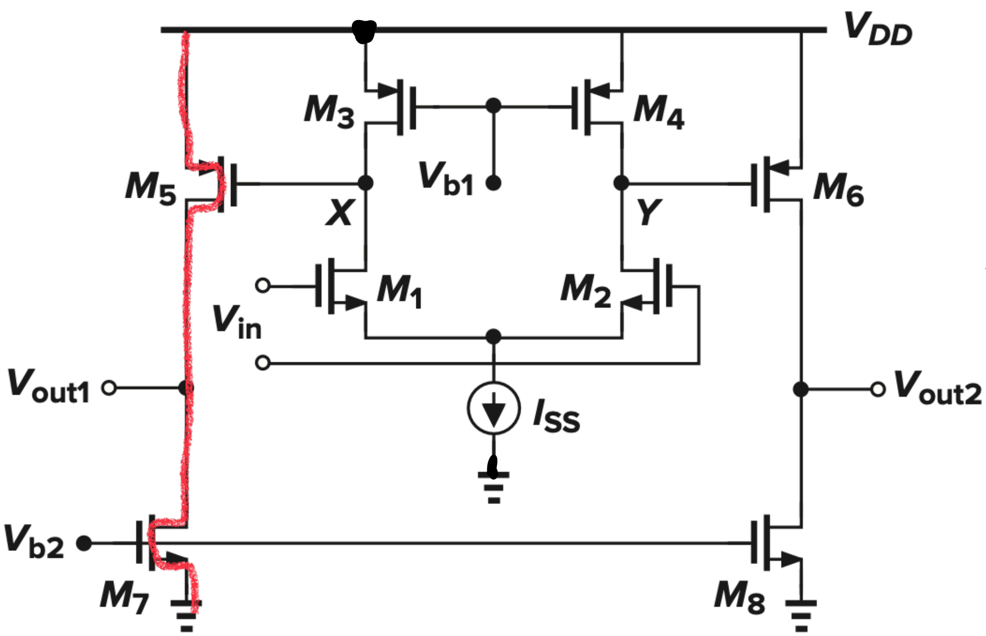


Figure 9.23 Simple implementation of a two-stage op amp.

Voltage at outer branch

$$V_{dd} - V_{ss} = |V_{OD5}| + V_{out1} + V_{OD7}$$

$$\therefore |V_{OD5}| + V_{OD7} = V_{DD} - V_{SS} - V_{out1}$$

Setting $V_{out1} = 0.5\,V_{pp} = 1.4\,V$

$$|V_{OD5}| + V_{OD7} = 1.8 - 0 - 1.4 = 0.4$$

Assigning

$$|V_{OD5}| = (1/4) \cdot 0.4 = 0.1\,V$$

$$V_{OD7} = (3/4) \cdot 0.4 = 0.3\,V$$

Computing Bias voltages

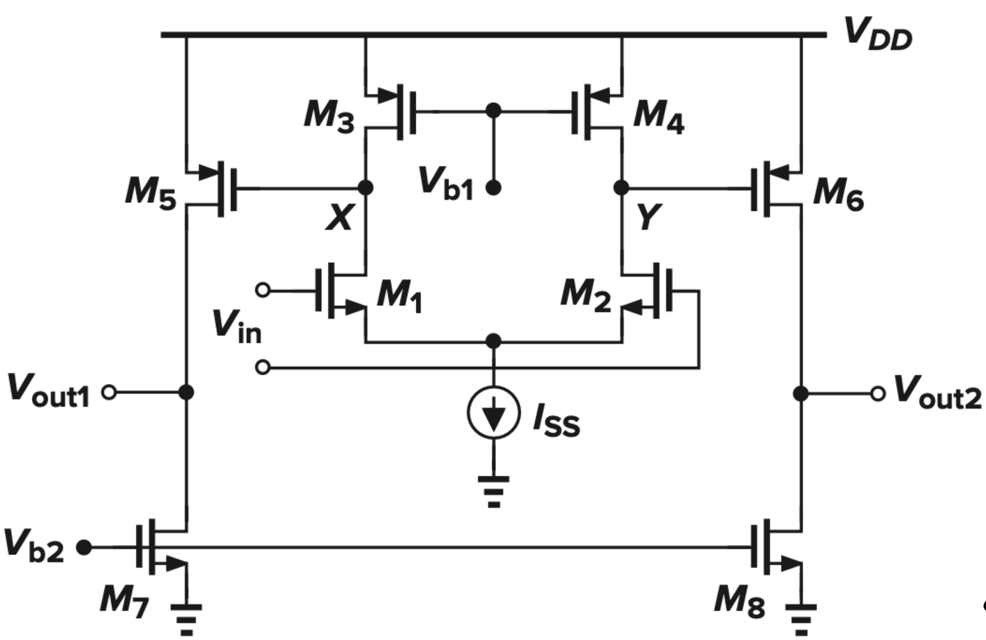


Figure 9.23 Simple implementation of a two-stage op amp.

$$V_{b1} = V_{dd} + V_{ss} - (V_{OD3} + V_{thp})$$

$$= 1.8V + 0V - (0.415 + 0.624)$$

$$V_{b1} = 0.263V$$

$$V_{b2} = V_{dd} + V_{ss} - (V_{OD5} + V_{OD7} + V_{thn})$$

$$V_{b2} = 0.631V$$

Assigning currents

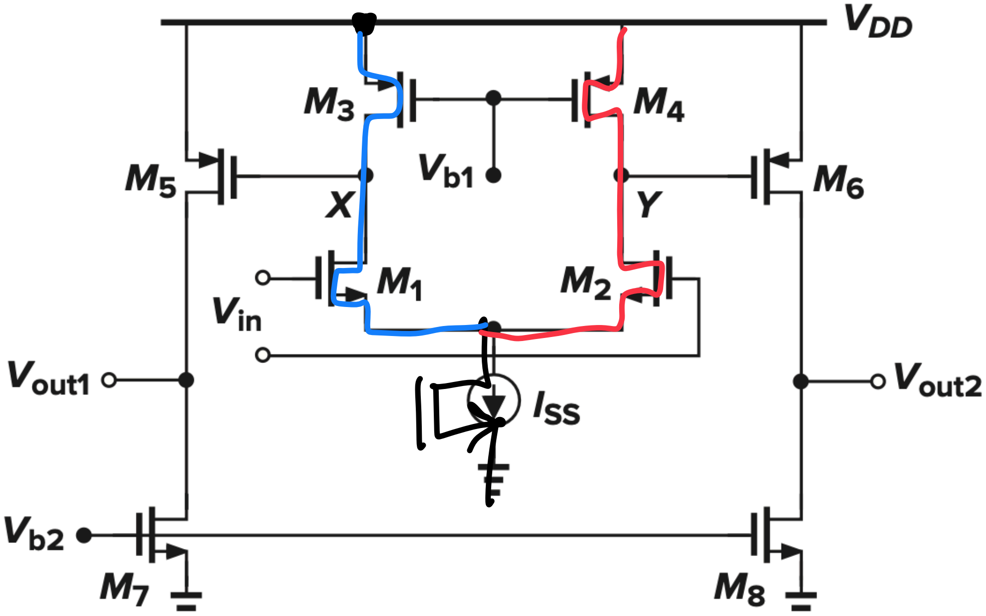


Figure 9.23 Simple implementation of a two-stage op amp.

Current in $M_9 = I_{Left} + I_{right}$

Getting the available current

$$I_{budget} = \frac{10\,mW}{1.8\,V} = 5.5\,mA$$

Asigning bias current equally to $M_1 \ldots M_8$

$$I_{M_1-M_8} = \frac{I_{budget}}{8} = 69.4\,\mu A$$

$$= 2\cdot(69.4\,\mu A)$$

$$= 138.8\,\mu A$$

Computing Sizes

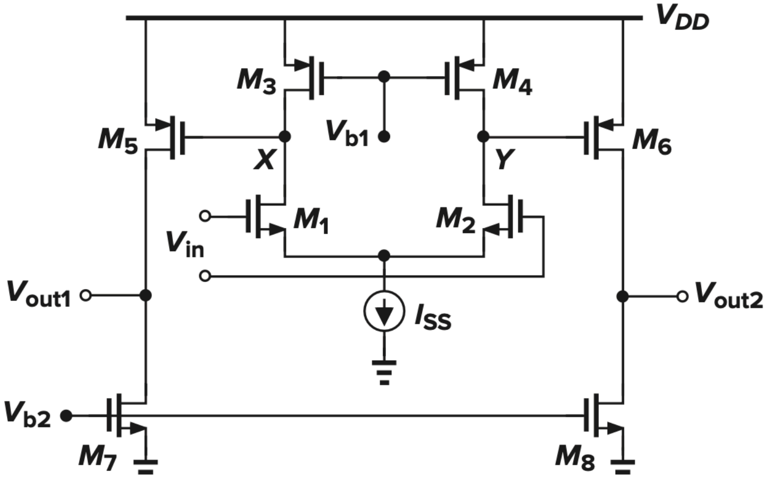


Figure 9.23 Simple implementation of a two-stage op amp.

$$I_D = \frac{1}{2}\mu_{n,p} C_{ox}\left(\frac{W}{L}\right)(\underbrace{V_{gs}-V_{th}}_{V_{OD}})^2$$

$$S = W/L = \frac{2I_D}{\mu_n C_{ox} V_{OD}^2}$$

with Sky130 param

$\mu_n = 0.03186 \frac{1}{V}$ $\quad \mu_p = 0.01 \frac{1}{V}$

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.45\times10^{-11}}{4.148\times10^{-9}} = 8.3\times10^{-3}\ F/m^2$$

$\mu_n C_{ox} = 265e^{-6}$

$\mu_p C_{ox} = 83.2e^{-6}$

Exploring options

$$S = W/L = \frac{2I_D}{\mu_n C_{ox} V_{OD}^2}$$

$S_3 = 2.001$

$S_5 = 166.8$

$S_1 = 3.04$

$S_7 = 5.81$

$S_1 = S_2$

$S_3 = S_4$

$S_5 = S_6$

$S_7 = S_8$

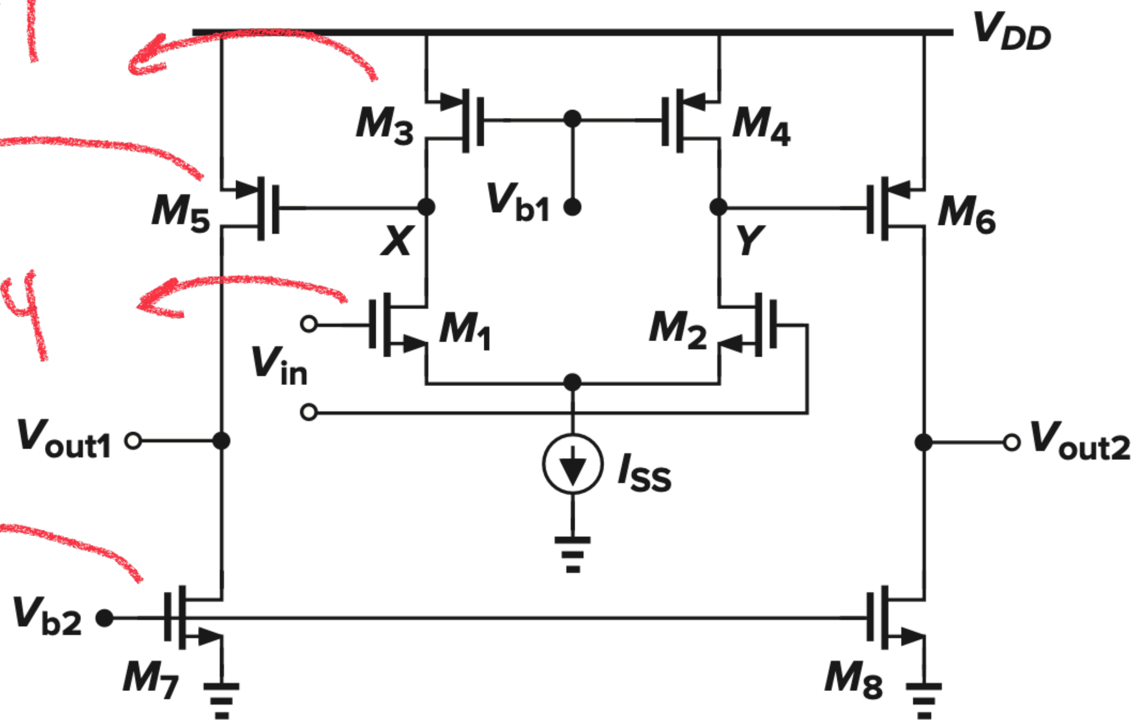
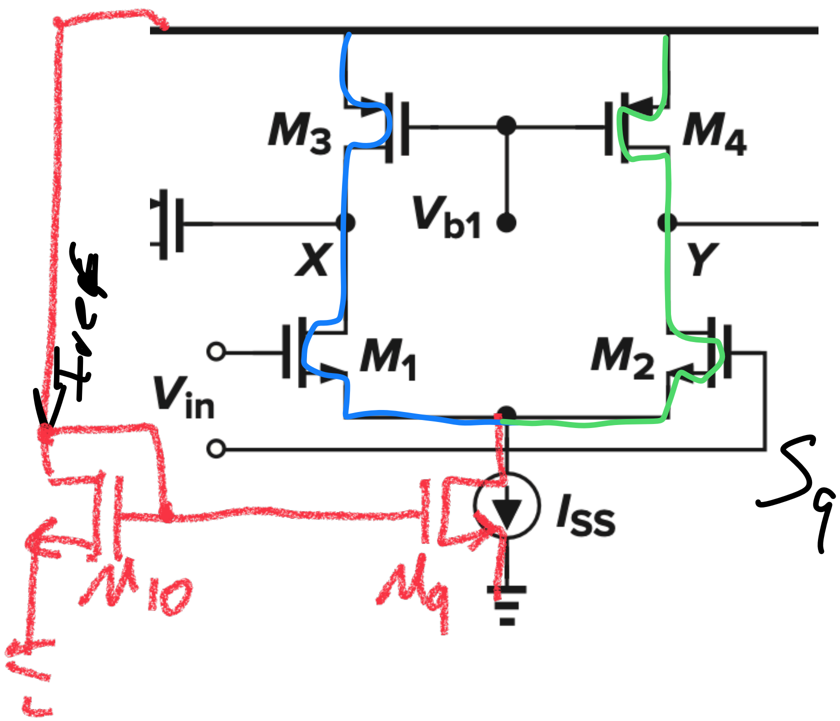


Figure 9.23 Simple implementation of a two-stage op amp.

Designing the current mirror



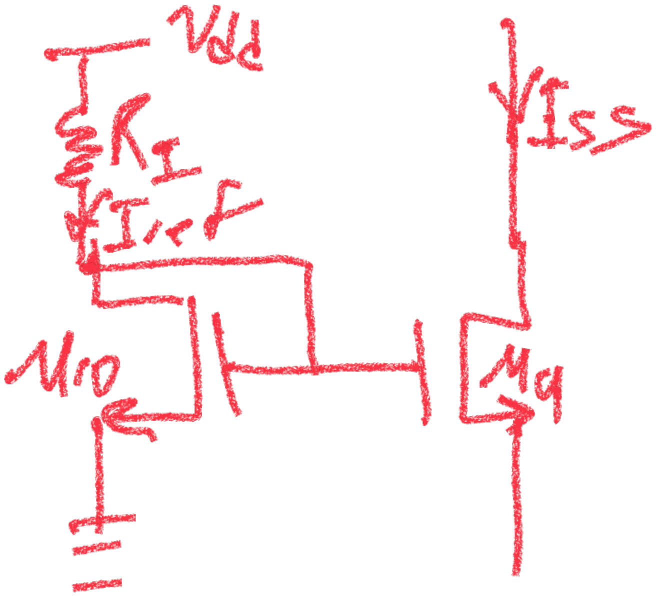
$$I_{SS} = I_{M9} = I_{left} + I_{right}$$

$$= 138\,\mu A$$

With $V_{OD9} = 0.3V$

$$S_9 = \frac{2 I_D}{\mu_n C_{ox} V_{OD}^2} = \frac{2 I_{SS}}{\mu_n C_{ox} V_{OD}^2} = 9.5$$

Designing the current mirror



with

$$I_{ss} = \frac{(W/L)_9}{(W/L)_{10}} I_{ref} \qquad I_{ref} = \frac{V_{dd}}{R_1}$$

$$(W/L)_{10} = (W/L)_9 \frac{I_{ref}}{I_{ss}} = \frac{S_9 \cdot V_{dd}}{R_1 \cdot I_{M9}}$$

$$(W/L)_{10} = \frac{11.39 \quad (1.8V)}{\underbrace{1k\Omega}_{\text{Proposed}} \cdot 138nA} = 123.13$$