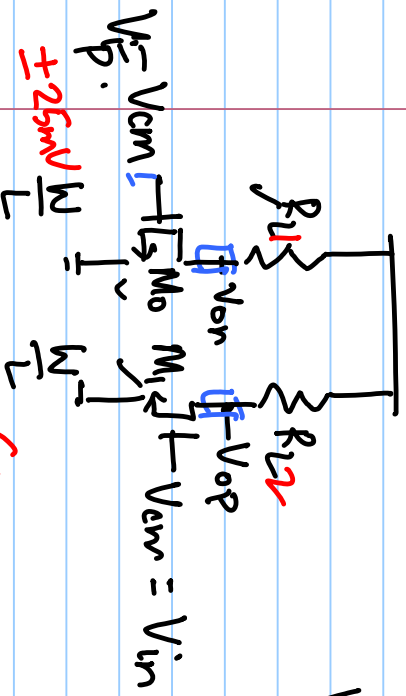


Lecture # 39

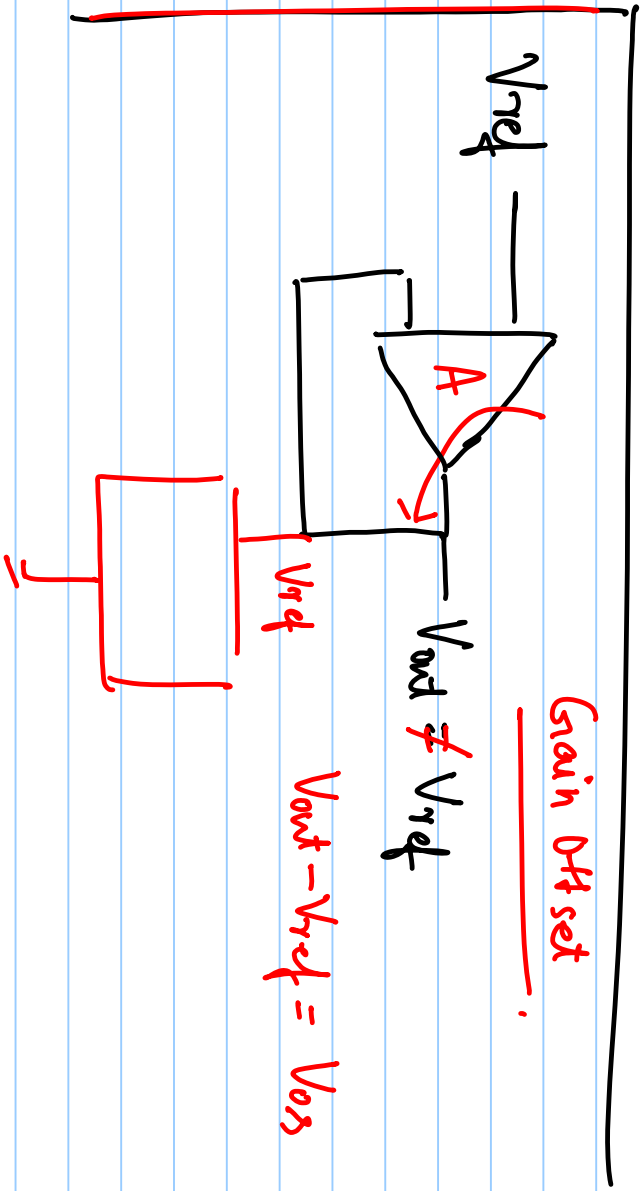
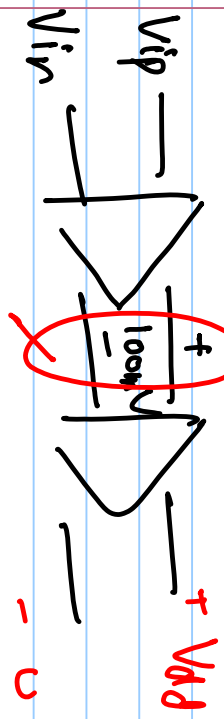
Offset — Ideal op ckt.

Real op ckt } =



$V_{op} - V_{on} \neq 0$
 $V_{ip} = V_{in} = V_{cm}$

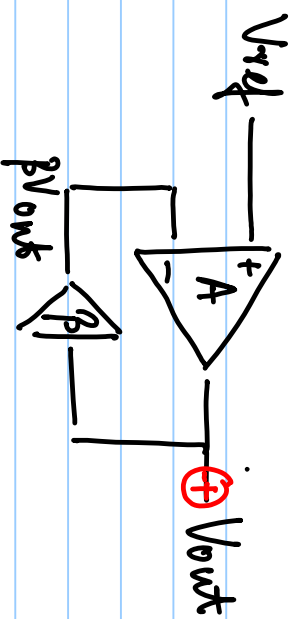
$V_{op} - V_{on} = 100\text{ mV}$
 $I = 10\text{ mA}$
 $V_{ip} = V_{in} = 0$



Gain Offset

$V_{out} - V_{rd} = V_{os}$

Gain Offset



$$(V_{ref} - \beta V_{out}) A = V_{out}$$

$$V_{out} = \frac{A}{1 + A\beta} V_{ref}$$

$$V_{out} = \frac{1}{\beta + \frac{1}{A}} V_{ref}$$

$$\underbrace{V_{out, id.}} = \frac{V_{ref}}{\beta} \quad \beta = 1'$$

$$V_{out, id.} - V_{out}$$

$$V_{os} = V_{ref} \left[\frac{1}{\beta} - \frac{A}{1 + A\beta} \right]$$

$$V_{os} = \frac{1}{(1 + A\beta)\beta} V_{ref}$$

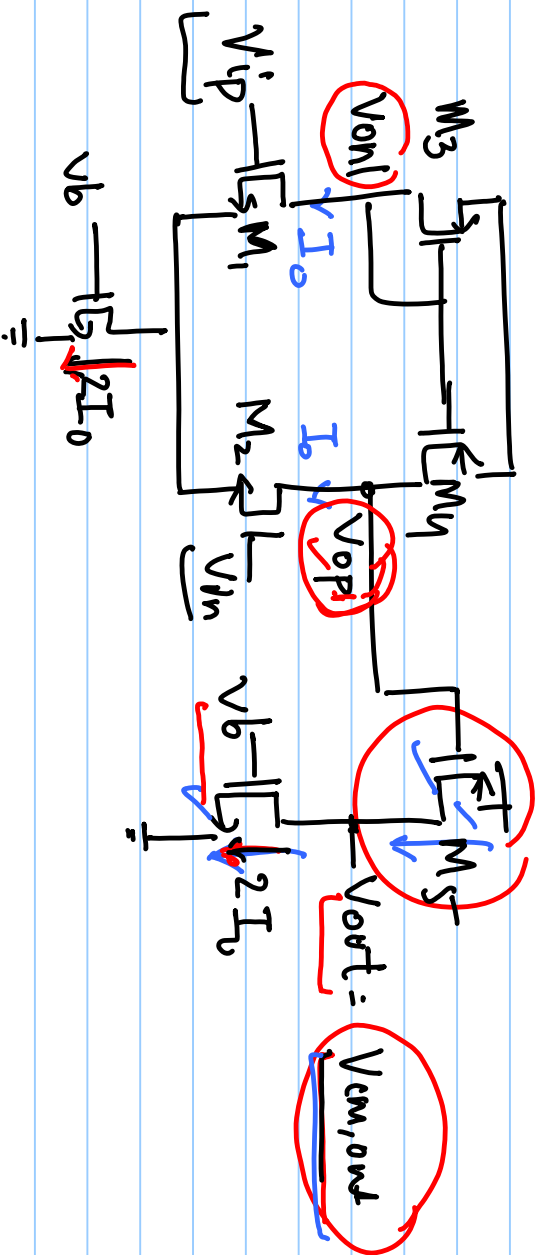
$$= \underbrace{\left(\frac{1}{1 + A\beta} \right)} \underbrace{\left(\frac{V_{ref}}{\beta} \right)}$$

$$= \frac{V_{ref}}{1 + A}$$

$$\frac{V_{os}}{V_{ref}} = \frac{1}{1 + A} < 0.1$$

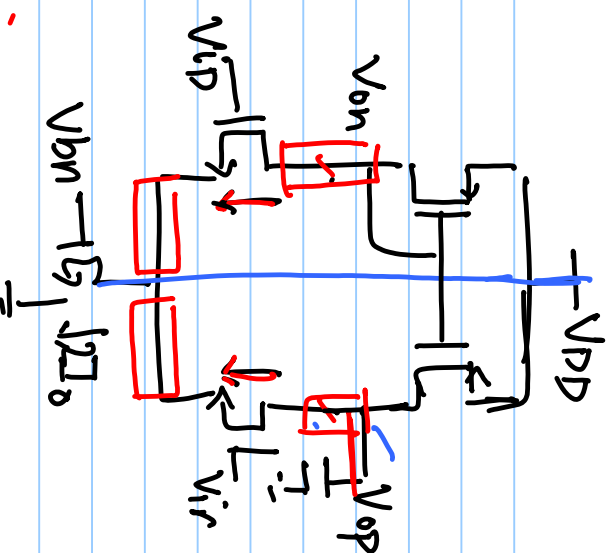
$$< 0.01$$

Systematic Offset.



$$M_3, M_4: \left(\frac{W}{L}\right)_p$$

$$M_5: \left(\frac{W}{L}\right)_s = 2 \left(\frac{W}{L}\right)_{3,4}$$

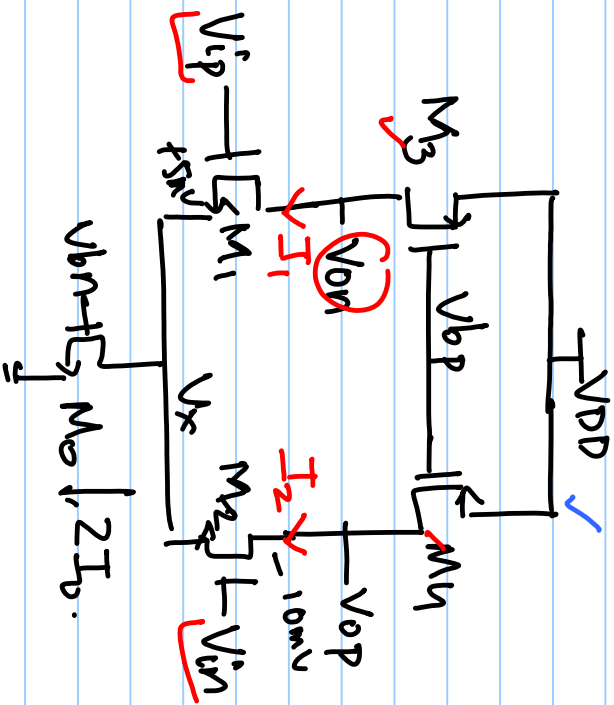


$$\frac{V_{op}}{V_{ip} - V_{in}} = \frac{A_{oc}}{1 + \lambda / \omega_p}$$

$$106M - 80M \lambda_2$$

$$V_{op} = V_{on}$$

Random Offset



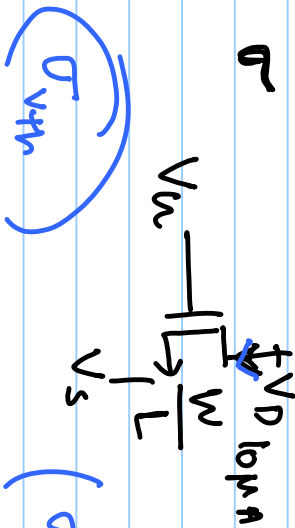
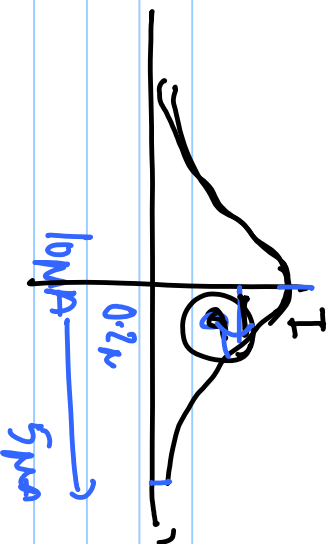
$V_{op} = V_{on}$ when $V_{ip} = V_{in}$

$M_1, M_2: \left(\frac{W}{L}\right)_n$

$M_3, M_4: \left(\frac{W}{L}\right)_p$

$$I_1 = \mu_n C_{ox} \left(\frac{W}{L}\right)_{n1} \left(V_{ip} - V_x - V_{tn1} \right)^2 (1 + \lambda V_{DS})$$

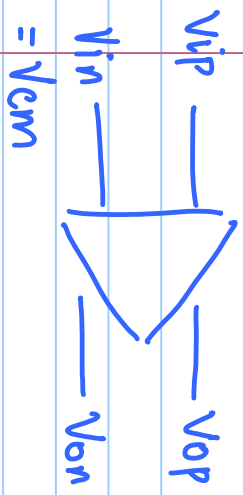
$$I_2 = \mu_n C_{ox} \left(\frac{W}{L}\right)_{n2} \left(V_{in} - V_x - V_{tn2} \right)^2 (1 + \lambda V_{DS})$$



$\left(\sigma_{V_{thn}} \right)$

$\left(\sigma_{(W/L)} \right)$

$\left(\sigma_{V_{thp}} \right)$



$$V_{out} = V_{op} - V_{on}$$

- mismatch-flag.

- Monte Carlo simulation (100)

- dc-op. random variables $\rightarrow V_{op} - V_{on} = \Delta V_o$
 - dc-op random variables $\rightarrow V_{op} - V_{on} = \Delta V_o$

$$-1\sigma \Delta V_{th} = +5mV$$

$$-1\sigma \Delta V_{th} = -1mV$$

