EE 420 / ECG 620

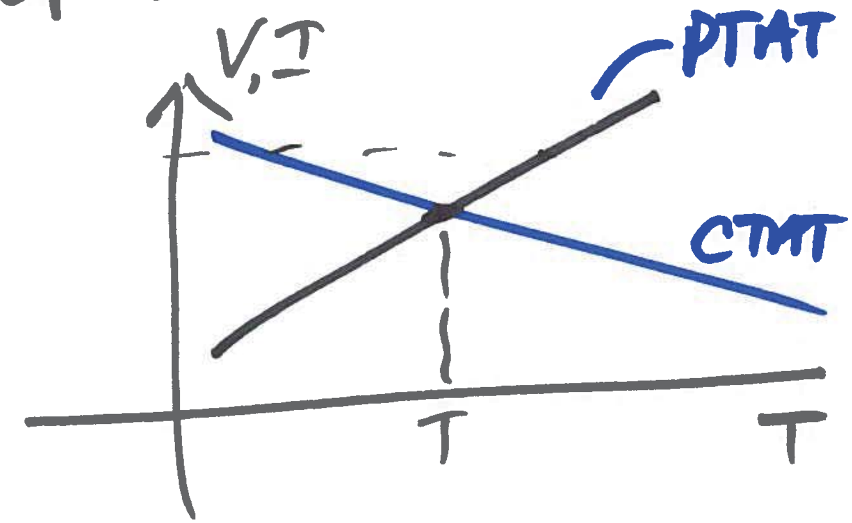
Analog IC Design

Lecture 19

March 29, 2017

complimentary

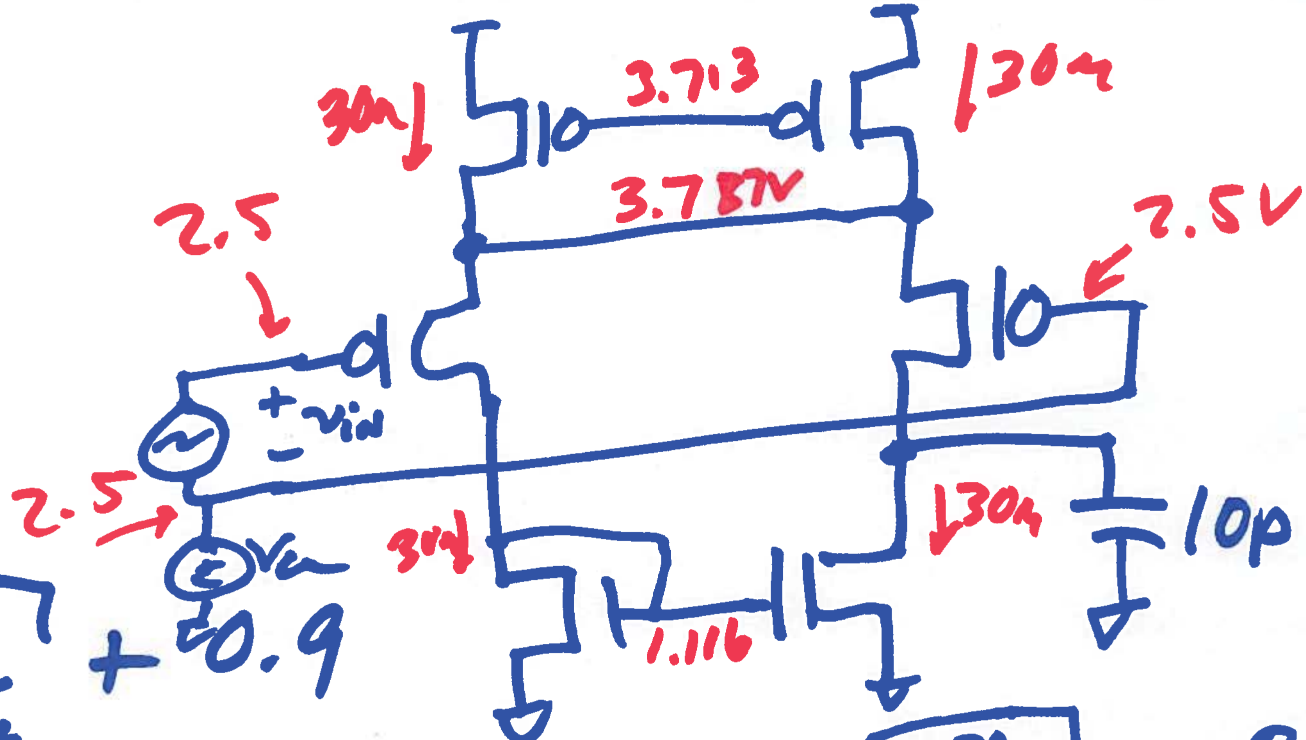
Proportional to absolute temp.



$V_T = \frac{kT}{q}$ = Thermal voltage

$\frac{\delta V_T}{\delta T} = \frac{k}{q} = 0.085 \frac{mV}{°C}$

V_{THN} T↗ ↓V_{THN}



$$V_{SG} = \sqrt{\frac{2 \cdot 30\mu}{\frac{20}{2} \cdot 40\mu}} + 0.9$$

$$V_{SG} = \sqrt{\frac{3}{20}} + .9 = 1.287$$

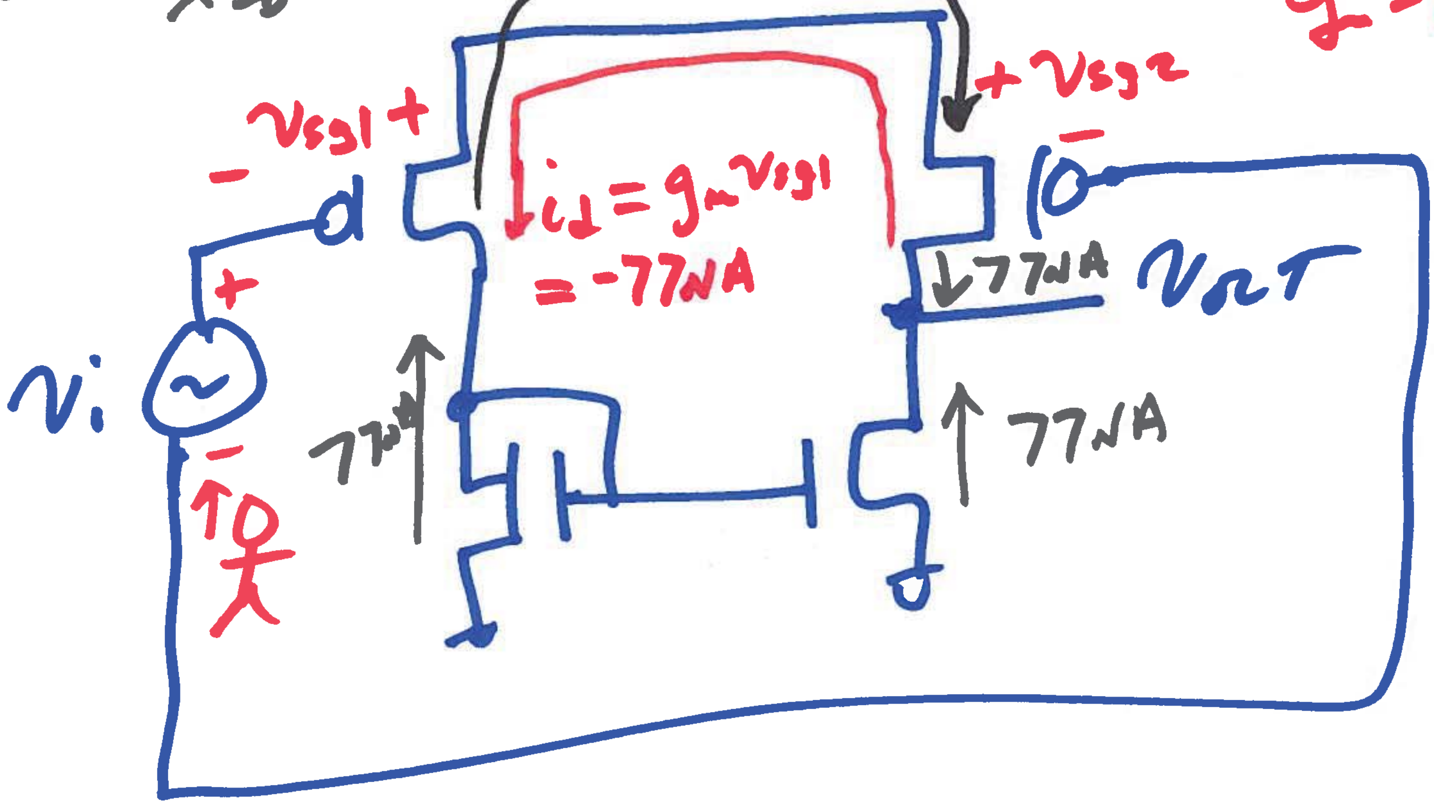
$$V_{SD,SAT} = 0.387$$

$$V_{GS} = \sqrt{\frac{2 \cdot 30\mu}{\frac{10}{2} \cdot 120\mu}} + 0.8$$

$$V_{GS} = 1.116V$$

$$V_{DS,SAT} = 0.3116$$

$r_{on} = \frac{1}{\lambda I_D} = \frac{1}{.01 \cdot 30nA}$



$g_m = \beta(V_{SG} - V_{THP})$

$= \beta \cdot V_{SD,SAT}$

$= 40\mu \cdot \frac{20}{2} \cdot 387$

$= 400\mu \cdot .387$

$= 154 \frac{\mu A}{V}$

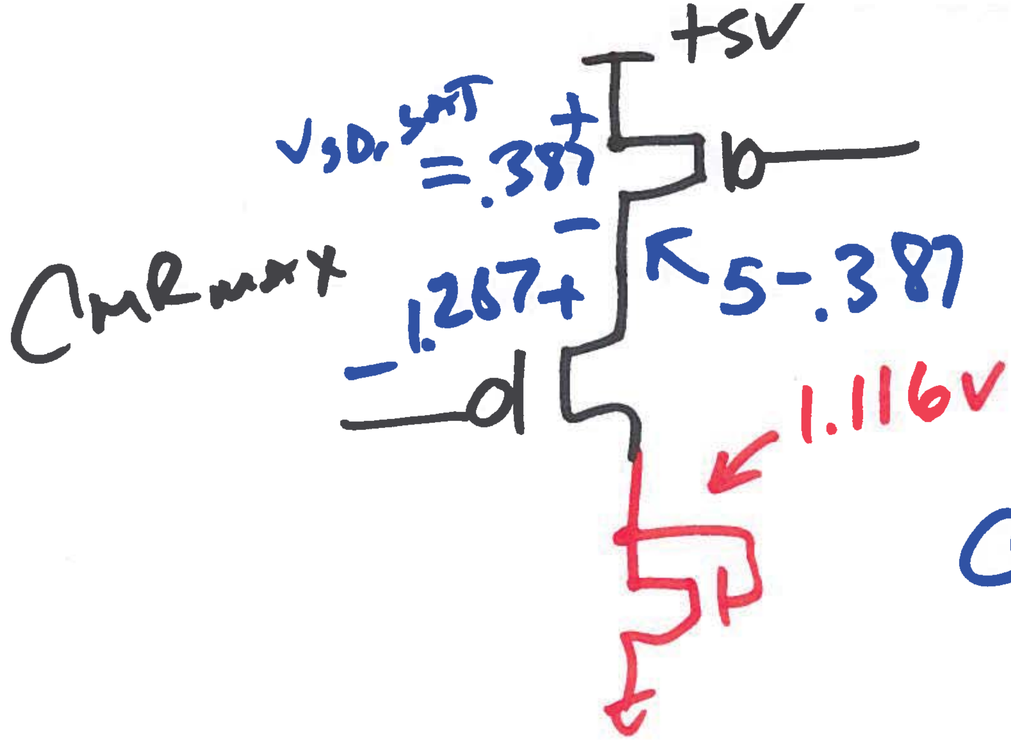
$v_i + v_{sg1} - v_{sg2} = 0$

$v_i = -(v_{sg1} - v_{sg2}) = -2v_{sg1}$

$v_{sg1} = -\frac{v_i}{2} = -\frac{1}{2} mV$

$v_{out} = 154\,nA \cdot 1.5MEG$

$= 230\,mV$



$V_{SG} = 1.287$

$V_{SD,SAT} = 0.387$

$CMR_{MAX} = 5 - .387 - 1.287 = 3.326V$

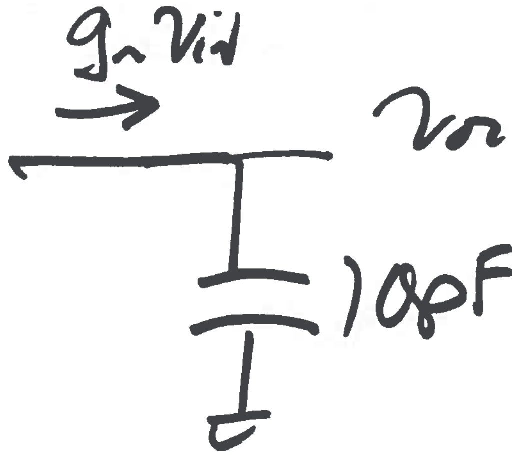
$V_{SD} \geq V_{SG} - V_{THP}$

$V_D \leq V_G + V_{THP}$

1.116   0.9

$V_{DS,SAT} + V_{THN}$

$CMR_{MIN} = 1.116 - .9 = 0.216$



$$v_{out} = g_m v_{in} \cdot \frac{1}{j\omega\, 10pF}$$

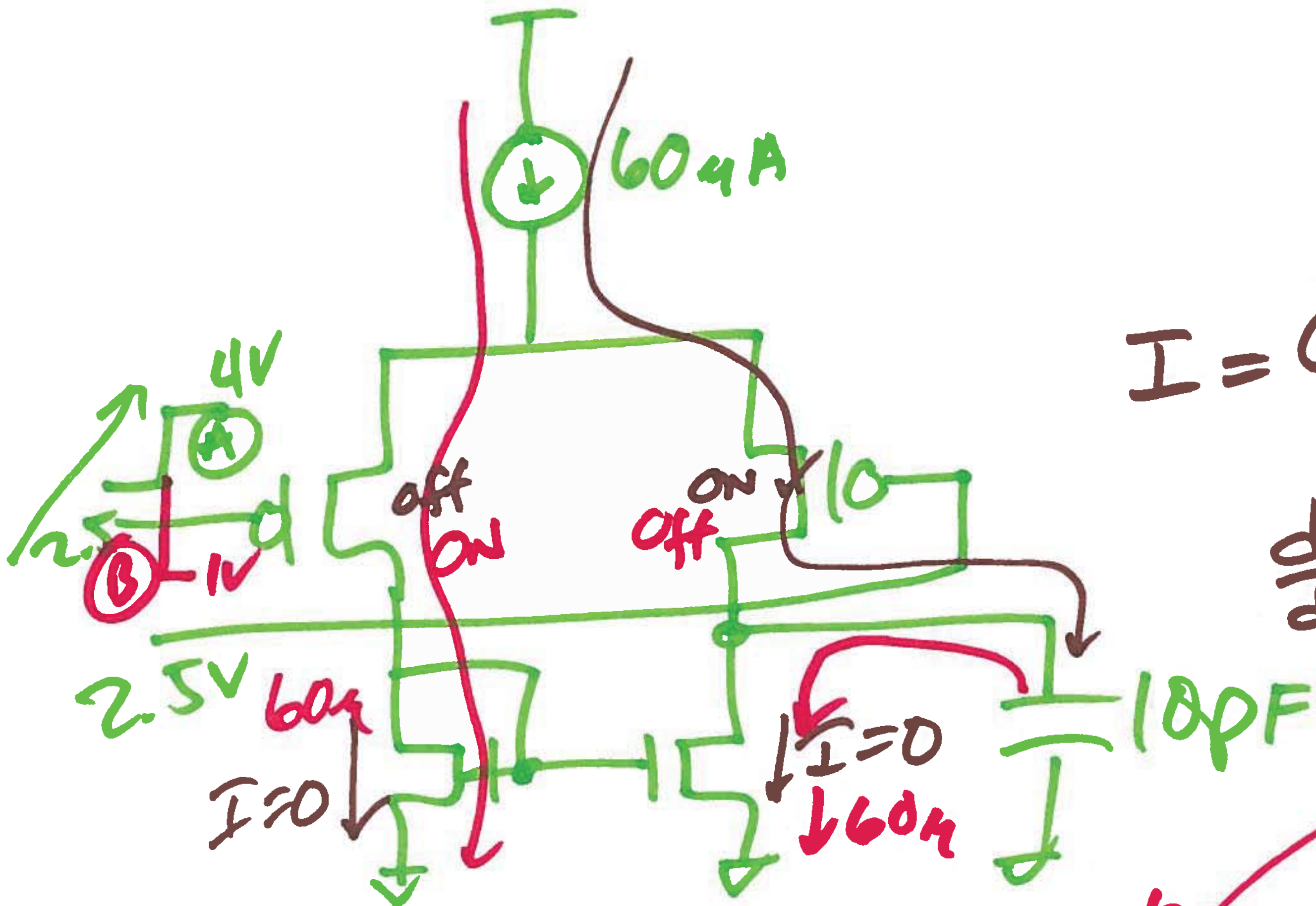
$$1 = \left|\frac{v_{out}}{v_{in}}\right| = \left|\frac{g_m}{j\omega_{un} 10pF}\right|$$

$$f_{un} = \frac{\cancel{g_m}\ 154\mu A/V}{2\pi\, 10pF}$$

$$\boxed{f_{un} = 2.45\,MHz}$$

$$f_{3dB} = \frac{1}{2\pi \cdot r_{on} \| r_{op} \cdot 10pF}$$

$$\boxed{f_{3dB} = 10.6\,KHz}$$



$$I = C\frac{dv}{dt}$$

$$\frac{dv}{dt} = \frac{I}{C}$$

$$\frac{60\mu A}{10pF}$$

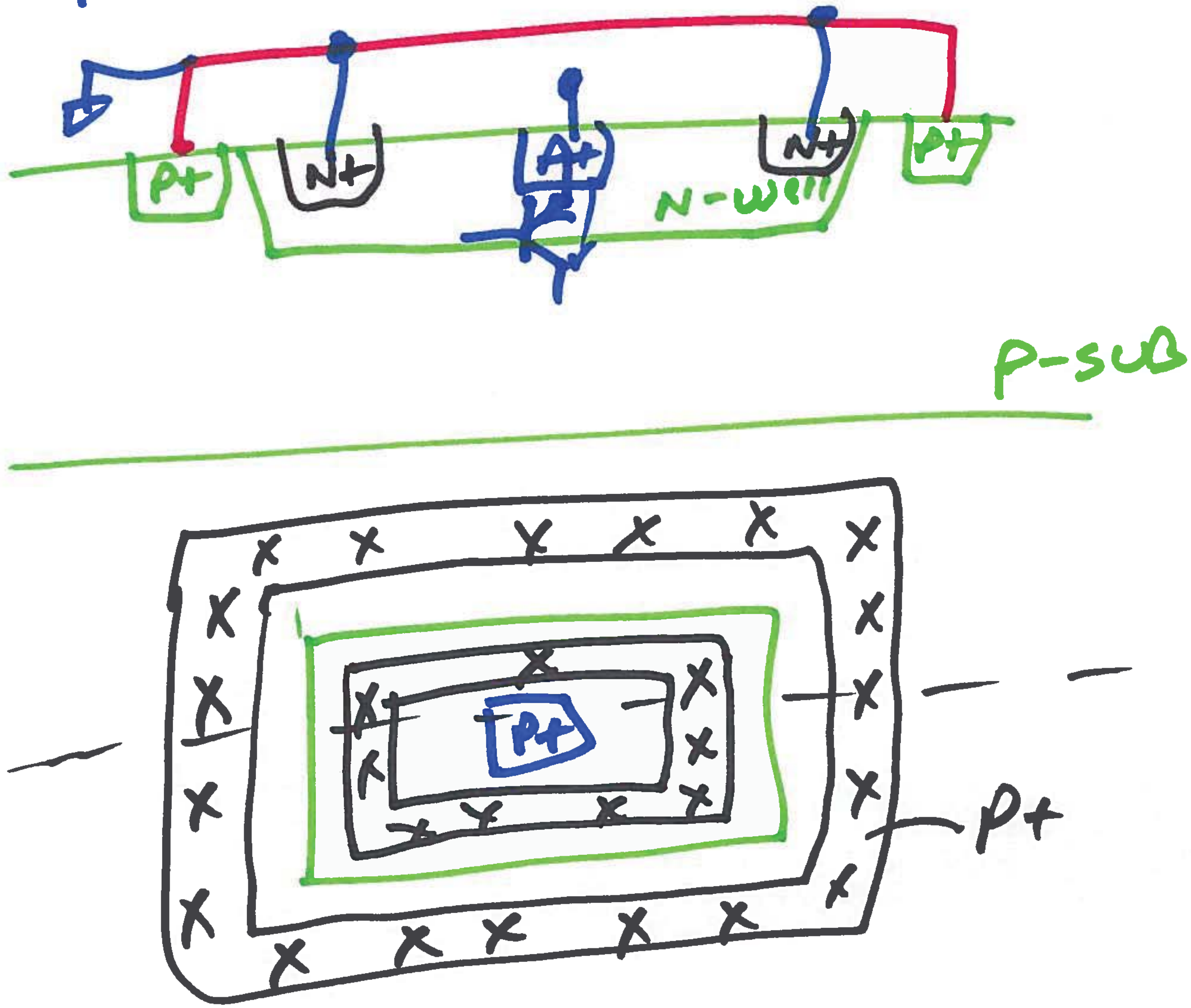
$$\frac{V}{\mu s} = 10^6$$

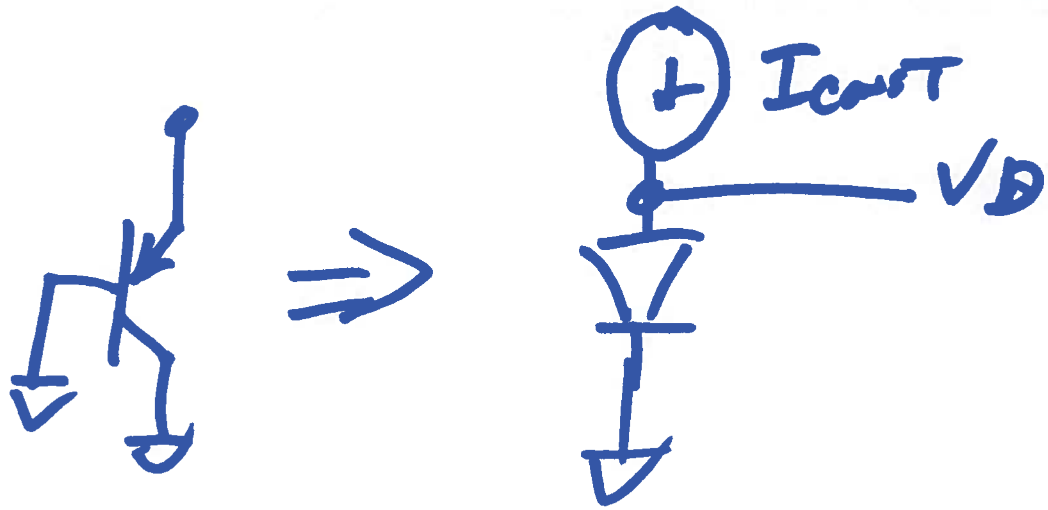
$$\frac{V}{10^{-6}s} = \frac{V}{s}10^6$$

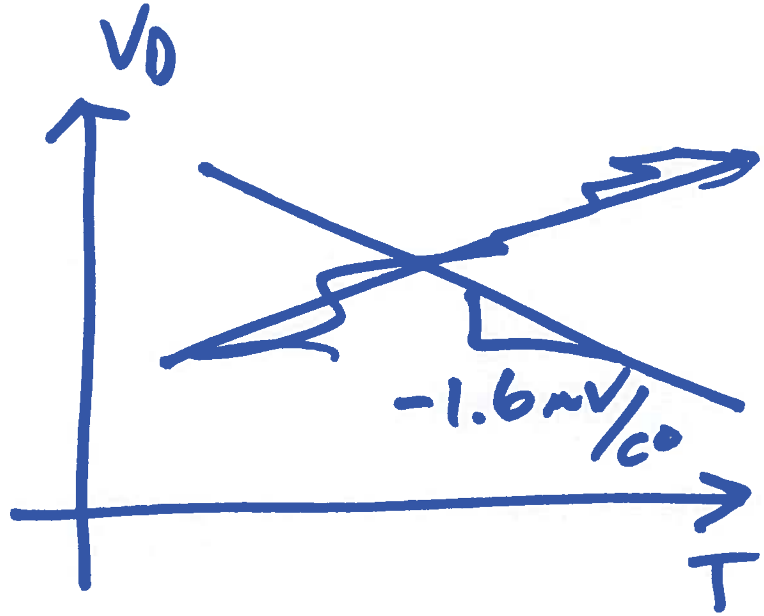
$$\frac{60\mu A}{10pF} \quad 6 \cdot \frac{10^{-6}}{10^{-12}} \quad \frac{6V}{\mu s}$$

$$\frac{6V}{\mu s}$$

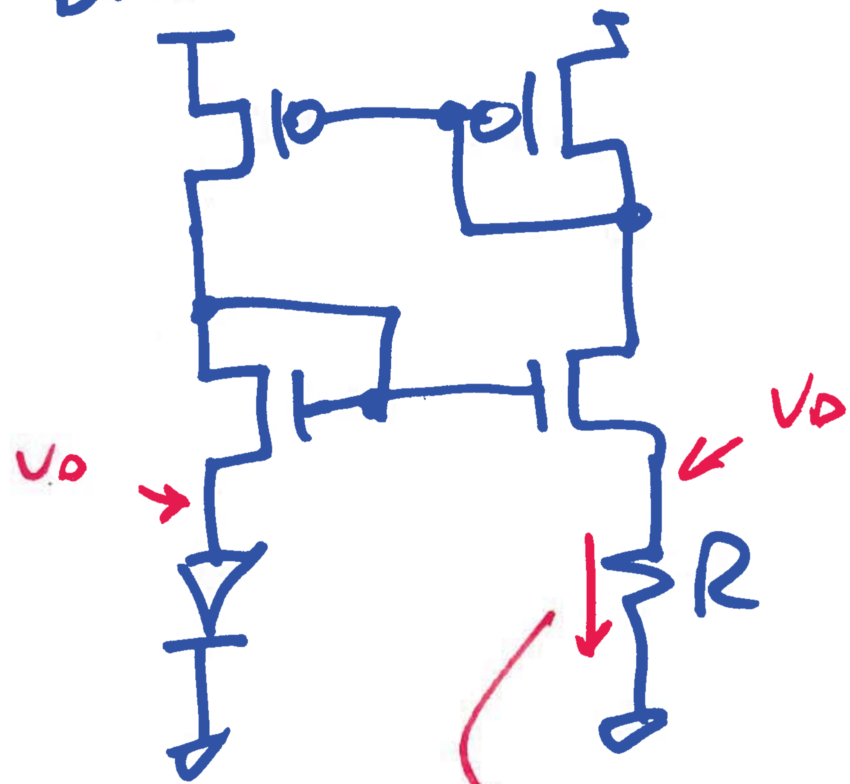
Parasitic PNP




ICONST
VD


VD
-1.6mV/C°
T

Diode Referencing



$\frac{V_D}{R}$

$$I_{REF} = \frac{V_D}{R}$$

$$\frac{\delta I_{REF}}{\delta T} = \frac{\delta}{\delta T} V_D R^{-1}$$

$$= V_D \cdot \frac{(-1)}{R^2} \cdot \frac{\delta R}{\delta T}$$

$$+ \frac{1}{R} \frac{\delta V_D}{\delta T}$$

$$= I_{REF} \cdot \frac{-1}{R} \frac{\delta R}{\delta T} + \frac{1}{R} \frac{\delta V_D}{\delta T}$$

$$\frac{1}{R} \frac{\delta R}{\delta T} = \text{Temp. coef. of Resistor}$$

$$2{,}000 \ \frac{PPM}{C^\circ} = 0.0002$$