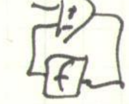
2 stage wrap up

Supply indep. biasing

2 stage review

uncompensated + $C_c$



$\omega_{p1} = \frac{1}{R_1 C_1}$ $\omega_{p1c} = \frac{1}{R_1 G_{m2} R_2 C_c}$ $A_{CL} = \frac{1}{f}$

$\omega_{p2} = \frac{1}{R_2 C_2}$ $\omega_{p2c} = \frac{G_{m2}}{C_1 + C_2 + \frac{C_1 C_2}{C_c}}$ error: $\frac{-1}{Af}$

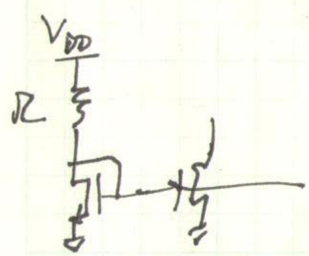
$\omega_{pm} = \frac{g_{m2}}{2 C_{gs}}$ $\omega_{uc} = \frac{g_{m1}}{C_c}$ $\omega_{p_{fB}} = f\,\omega_{uc}$

$\omega_{zm} = 2\,\omega_{pm}$ $\omega_{zc} = \frac{G_{m2}}{C_c}$ $\omega_{u,fb} = \frac{\omega_{uc}}{A_{CL}}$

 oscillates!

 stable

Need a reference current/voltage



$$I_{ref} = \frac{V_{DD} - (V_{tn} + V_{OV})}{R}$$

Would like $I_{ref}$ to be independent of

Process $\mu_n C_{ox}$, $V_{tn}$, $\lambda$

Voltage Batteries $n \times \{1.6 \rightarrow 0.8V\}$

Temperature $V_{tn}$ typ $-2mV/K$

consumer 0-70C

industrial -40 - +85C

auto/mil -55 - +125C

Like to also have a reference voltage

what is 1V?

How much charge left in battery?

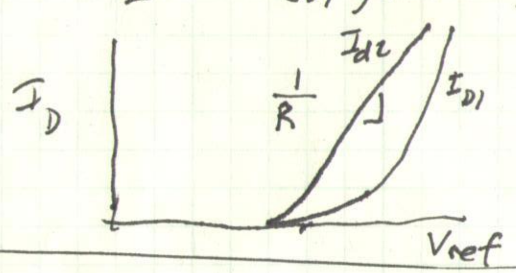
Like to have a temperature sensor

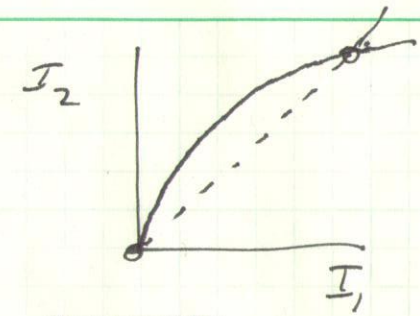
Const $g_m$ bias circuit


$$I_1 = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)_1 (V_{ov1})^2$$

$$I_2 = \frac{\mu_n C_{ox}}{2} K \left(\frac{W}{L}\right)_1 (V_{ov1} - I_2 R)^2$$

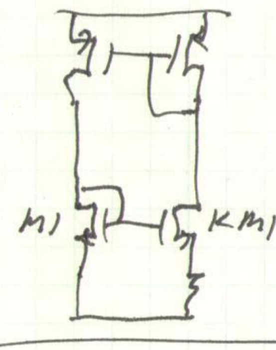
If $I_2 R << V_{ov1}$, then $I_{D2} \simeq K I_{D1}$




$I_{d1} = I_{d2}$ at 2 bias points

so enforce




$$V_{ov1}^2 = K(V_{ov1} - I_2 R)^2$$

$$V_{ov1} = \sqrt{K}(V_{ov1} - I_2 R)$$

$\cancel{I_2 R =}$

$$\frac{V_{ov1}}{\sqrt{K}} + I_2 R = V_{ov1}$$

$$I_2 R = \left(1 - \frac{1}{\sqrt{K}}\right) V_{ov1}$$

pick $K = 4 \Rightarrow I_2 R = \frac{1}{2} V_{ov1}$

$$V_{ov2} = V_{ov1} - I_2 R = \frac{1}{2} V_{ov1}$$

and $g_{m1} = \frac{2 I_{D1}}{V_{ov1}} = \frac{2 I_{D2}}{2 I_{D2} R} = \frac{1}{R}$

"constant $g_m$" biasing indep $\mu_n C_{ox}$, $V_t$, $V_{DD}$

- use long-channel devices
- often cascode to improve supply rejection.
  (we ignored $(1 + \lambda V_{DS})$ )