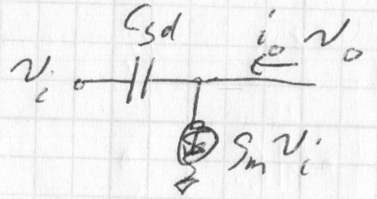
Midterm friday in class + 30 min 1:10 - 2:30
1 page, 2 sides notes

Extra OH today after class
tues 4:30-5:30

RHP zero

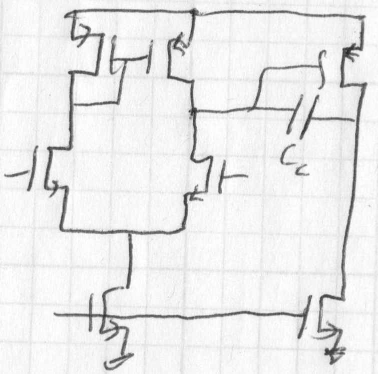
Biasing

RHP zero



G_m: $i_o = g_m v_i + sC_{gd}(\overset{0}{\cancel{v_o}} - v_i)$
$= g_m\left(1 - \frac{sC_{gd}}{g_m}\right) v_i$

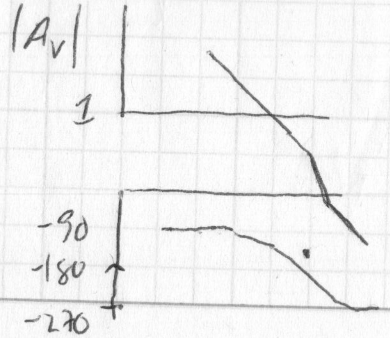
$G_m = g_m\left(1 + \frac{s}{\omega_z}\right)$ $\omega_z = \frac{-g_m}{C_{gd}}$



$\omega_z = -\frac{G_{m2}}{C_c}$

$\omega_u = \frac{G_{m1}}{C_c}$

$\omega_{p2} \approx \frac{G_{m2}}{C_1 + C_2 + \frac{C_1 C_2}{C_c}}$



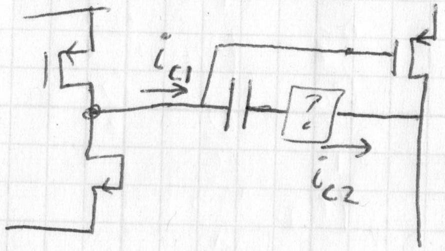
RHP zero complicates design

make $G_{m2} >> G_{m1}$ costs power

make $C_c >> C_2$ costs BW

→ need C_c to split poles, compensate op-amp.

→ Want to get rid of feedforward current that causes RHP zero.



$i_{c1} = sC_c(v_{o1} - v_{o2}) = sC_c(1 - A_{v2})v_{o1}$ "good current"

i_{c2} fights g_{m4} "bad current" (feedforward)

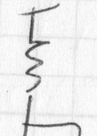
Simplest: $R_z = \frac{1}{g_{m4}}$ and $|i_{c2}|$ is always $< g_{m2} v_i$ in G_m calc.

140

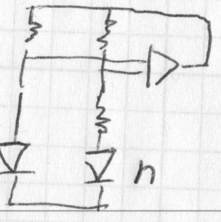
165D

W10L1

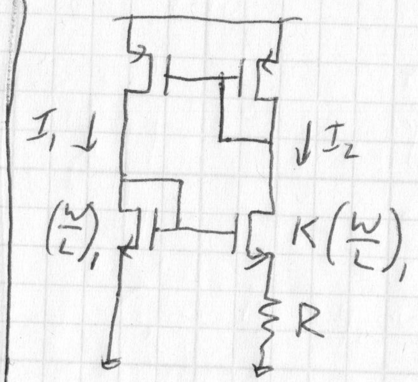
Supply-independent
Biasing

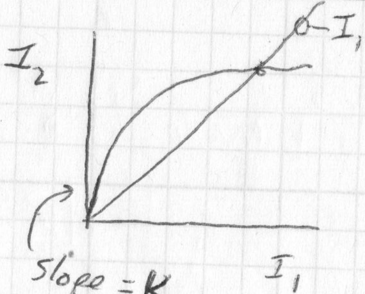


Simple
Varies a lot w/ PVT



Bandgap voltage ~constant
few mV over Temp
What biases the bandgap?





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

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

If $I_1 = I_2$ then $V_{ov1}^2 = K(V_{ov1} - I_2 R)^2$

~~$I_2 R = (\sqrt{K} - 1) V_{ov1}$~~

e.g. $K = 4$ $I_2 R = V_{ov1}$

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

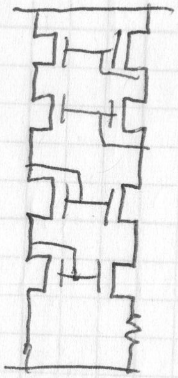
$$\left(1 - \frac{1}{\sqrt{K}}\right) V_{ov1} = I_2 R$$

e.g. $K = 4$ $I_2 R = \frac{1}{2} V_{ov1}$

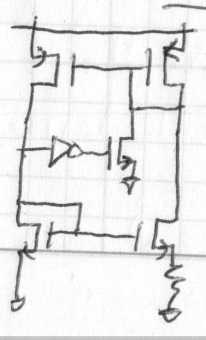
$$V_{ov2} = \frac{1}{2} V_{ov1}$$

$$g_{m1} = \frac{2 I_1}{V_{ov1}} = \frac{2 I_2}{2 I_2 R} = \frac{1}{R}$$ nice!

often cascoded to get better mirror performance (supply rejection)



startup issues: $I_1 = I_2 = 0$ is an equilibrium. Should be unstable b/c



necessary?
cost?