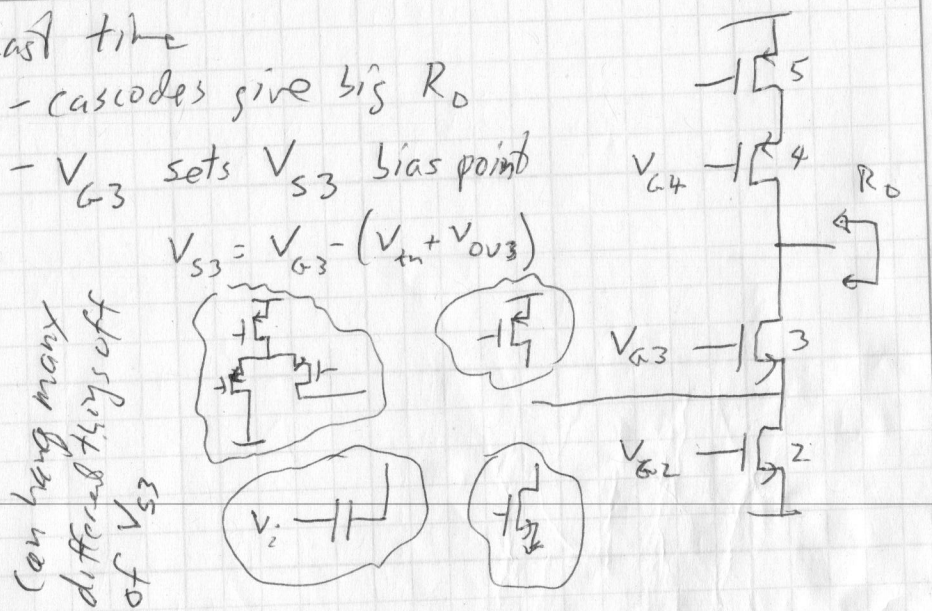
Lab 5
HW 9

Folded Cascode
- currents, sizes, gain
- freq response
- biasing

Last time
- cascodes give big R_o
- V_{G3} sets V_{S3} bias point

$$V_{S3} = V_{G3} - (V_{tn} + V_{OV3})$$



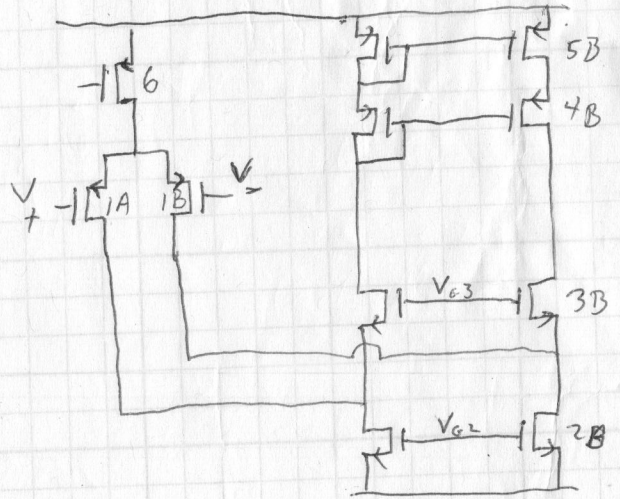
With PMOS diff pair
- common-mode input extends below 0

(if $|V_{tp}| >$ ~~0V~~ $V_{S3} = V_{D2}$)

- roughly single-pole response

$$\text{dominant pole} = \frac{1}{R_o C_L} = \frac{2}{g_m r_o^2 C_L}$$

- bias for M4, M5, M3?
- recover other half of g_{m1}?



Lab 5
HW 9

140/240A 17 SP | WILL

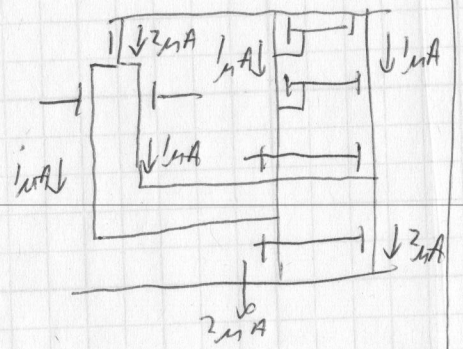
Usually current in 1, 3, 4, 5 are the same (signal path)

if so, then $I_{D2A} = I_{D1A} + I_{D3A} = 2I_{D1} = I_{tail} = I_{D6}$

$\left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_4 = \left(\frac{W}{L}\right)_5$

$\left(\frac{W}{L}\right)_6 = 2\left(\frac{W}{L}\right)_1$

$\left(\frac{W}{L}\right)_2 = 2\left(\frac{W}{L}\right)_3$



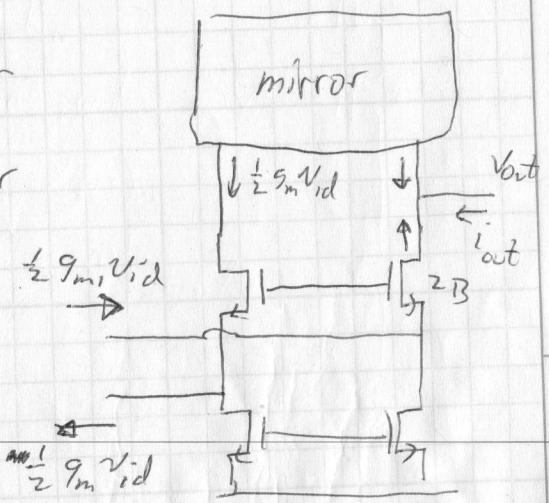
R_o unchanged from yesterday $\approx \frac{1}{4}(g_m r_o) r_o$

$G_m = \frac{-1}{2} g_m + \frac{-1}{2} g_m$

2B, 2A, mirror

$G_m = -g_{m1}$

$A_v = \frac{1}{4}(g_m r_o)^2$



What typical response? Mirrors

Dominant pole $\frac{1}{R_o C_L} \Rightarrow \omega_u = \frac{g_{m1} R_o}{R_o C_L} = \frac{g_{m1}}{C_L}$?

mirrors (2) $\omega_{pm5} = \frac{g_{m5}}{2C_{gs5}}$

$\omega_{zm5} = 2\omega_{pm5}$

2? or sqrt(2)?

simple cascode

$i_i = g_m v_{gs} + \frac{1}{r_o} v_{ds} + sC_{gs}(-v_s)$

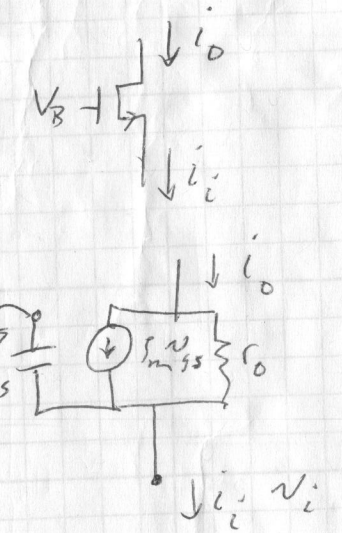
$= \left(g_m + \frac{1}{r_o} + sC_{gs}\right)(-v_s)$

$v_s = \frac{-i_i}{g_m\left(1 + \frac{1}{g_m r_o} + \frac{sC_{gs}}{g_m}\right)}$

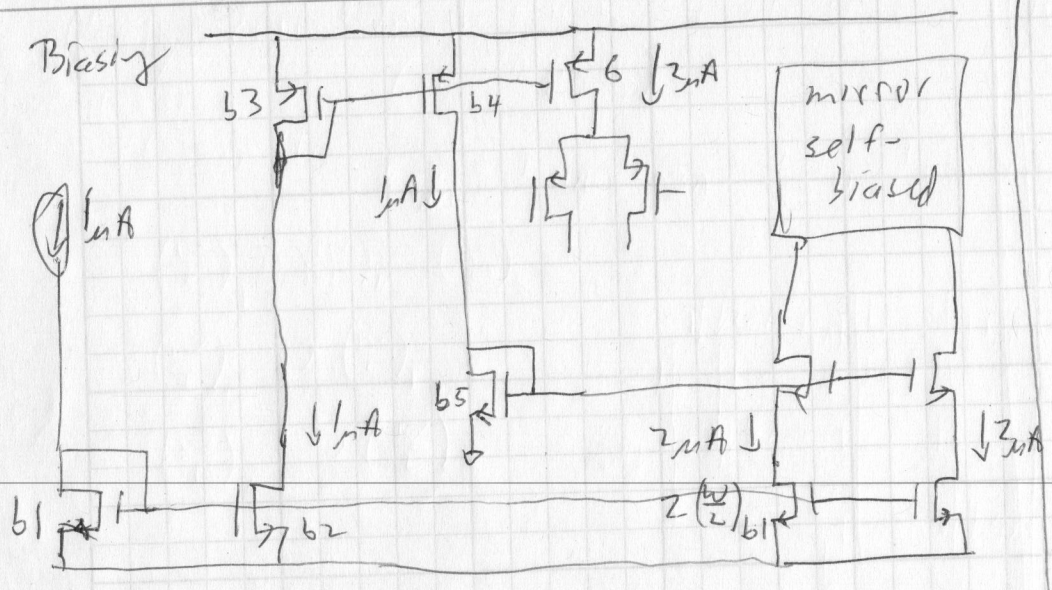
$i_o = g_m v_{gs} = g_m(-v_s)$

$= \frac{+i_i}{1 + \frac{1}{g_m r_o} + s/\omega_{pc}}$

$\omega_{pc} = \frac{g_m}{C_{gs}}$



Biasing



Size b1 to set the right V_{ovn} $n = 2, 3$

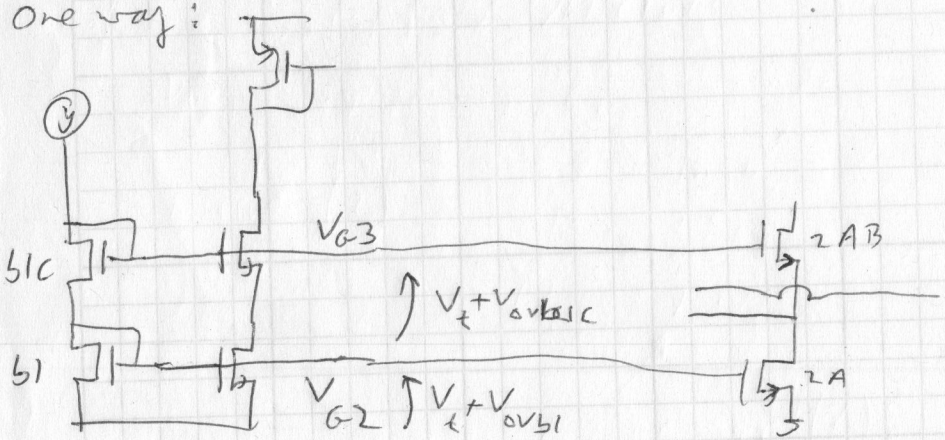
$$\left(\frac{W}{L}\right)_{2A} = 2\left(\frac{W}{L}\right)_{b1}$$

Size 33 to set the right V_{ov6}

$$\left(\frac{W}{L}\right)_6 = 2\left(\frac{W}{L}\right)_{b3}$$

How to size 55 to set desired V_{G3}?

One way:



$$V_{G3} = 2V_t + 2V_{ov} \Rightarrow V_{o,min} = V_t + 2V_{ov}$$

and $V_{in,cm} = V_{33} - |V_{tp}| = V_{th} + V_{ov2} - |V_{tp}| > 0$