Lab 3

HW 6

2 stage
source/sink current (part 1: later we'll see how C_c plays)

poles move under feedback

How big to make $M4$?

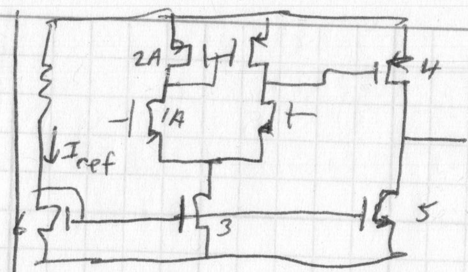
<u>Bias point</u>: $V_{G4} = V_{G2A} = V_{DD} - |V_{tp}| - |V_{ov2}|$

Choose $V_{ov4} = V_{ov2}$

$|I_{D2A}| = \frac{1}{2} I_{tail}$

$|I_{D4}| = |I_{D5}| = |I_{tail}| \frac{(W/L)_5}{(W/L)_3} = \frac{(W/L)_5}{(W/L)_3} 2 I_{D2A}$

<u>so</u> $\left(\frac{W}{L}\right)_4 = 2 \left(\frac{W}{L}\right)_{2A} \frac{(W/L)_5}{(W/L)_3}$



Last time: input cm range, output swing
Specs on these translate to V_{ov} constraints

Output current

Sink: $\frac{\left(\frac{W}{L}\right)_5}{\left(\frac{W}{L}\right)_6} I_{ref}$

Max source current?

$|I_{d4}| - I_{D5}$

I_{D5}: constant

$|I_{d4}|$: depends on output of 1st stage (swing)

140

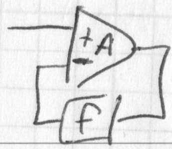
16 SP

W8 L1

Feedback

- improves linearity, gain accuracy, output resistance, input impedance, ...

but can cause instability



$$V_o = A(V_+ - V_-) = A(V_i - fV_o)$$

$$(1+Af)V_o = AV_i$$

$$\frac{V_o}{V_i} = \frac{A}{1+Af} \approx \frac{1}{f} \text{ if } Af >> 1$$

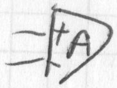
Poles move under feedback:

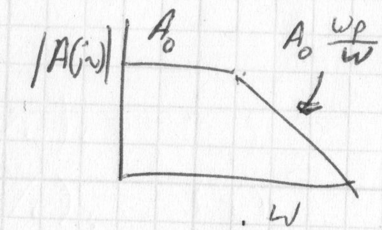
can be good (e.g. increased bandwidth)

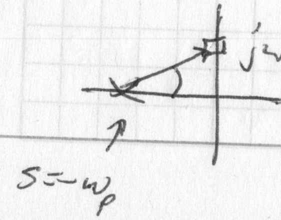
or bad (instability)

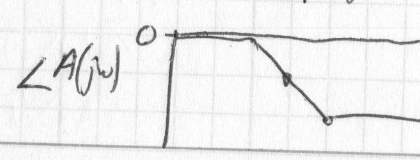
Ex: single pole amplifier

$$A = \frac{A_o}{1+s/\omega_p}$$

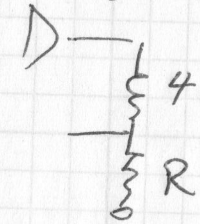








$\underline{f}$ usually comes from a ratio of passives, which can be quite accurate



"R" might vary w/ temperature, process

but $\frac{R}{R+4R} = \frac{1}{5}$ is quite accurate ~0.1% error

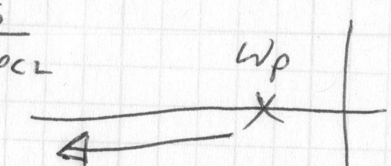
in feedback

$$A_{CL} = \frac{A}{1+Af} = \frac{\frac{A_o\omega_p}{s+\omega_p}}{1+\frac{A_of\omega_p}{s+\omega_p}} = \frac{A_o\omega_p}{s+\omega_p+A_of\omega_p}$$

$$= \frac{A_o\omega_p}{(A_of\omega_p+\omega_p)\left(1+\frac{s}{\omega_{pCL}}\right)} = \frac{A_o\omega_p}{s+\omega_p(1+A_of)}$$

$$\omega_{pCL} = (1+A_of)\omega_p$$

$$= \frac{A_o}{1+A_of} \frac{1}{1+\frac{s}{\omega_{pCL}}}$$



$$A_{CL}(j\omega) = \begin{cases} \dfrac{A_0}{1+A_0 f} \approx \dfrac{1}{f} & \omega << \omega_{pCL} \\ \dfrac{1}{f}\,\dfrac{1}{1+j} & \omega = \omega_{pCL} \\ \dfrac{A_0 \omega_p}{j\omega} & \omega >> \omega_{pCL} \end{cases}$$

same as open-loop above ω_p!