Poles move in feedback

$\omega_{pcl} = f\,\omega_u$ for single pole

multiple poles can cause instability

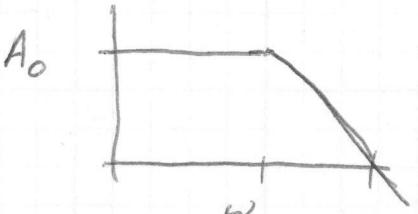
phase margin & step response

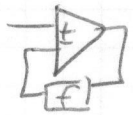
& transfer function

Compensation

Last time

single pole amp

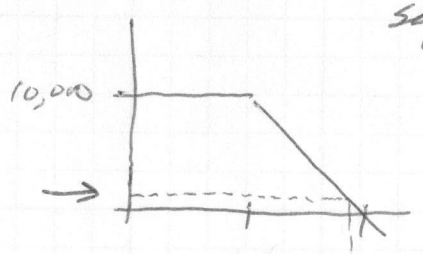




$0 \le f \le 1$

$$A_{cl} = \frac{A_D}{1+A_0 f}\,\frac{1}{1+\frac{s}{\omega_p(1+A_0 f)}} \approx \frac{1}{f}\,\frac{1}{1+\frac{s}{\underbrace{\omega_p A_0 f}_{\omega_u}}}$$

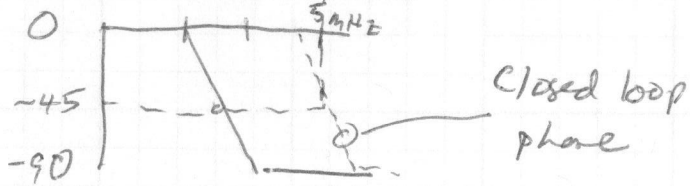
2



say $A_0 = 10{,}000$

$f_p = 1\text{KHz}$

$f = 0.5$



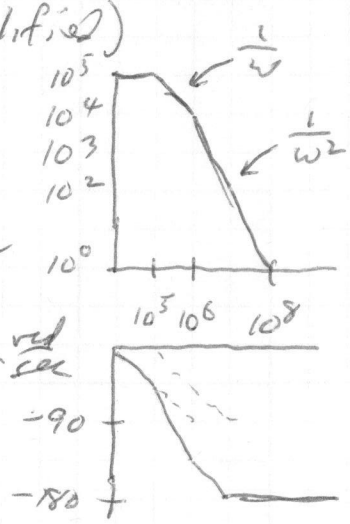
$\omega_{p,cl} \approx \omega_u f$ $\qquad f_{p,cl} = 5\text{MHz}$

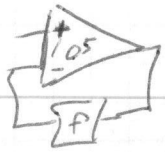
two pole amplifier (simplified)

diff pair $\qquad$ 2nd stage

$A_{v_1} = 1{,}000$ $\qquad A_v = 100$

$\omega_p = 1\text{K}\frac{\text{rad}}{\text{sec}}$ $\qquad \omega_p = 100\text{K}\frac{\text{rad}}{\text{sec}}$

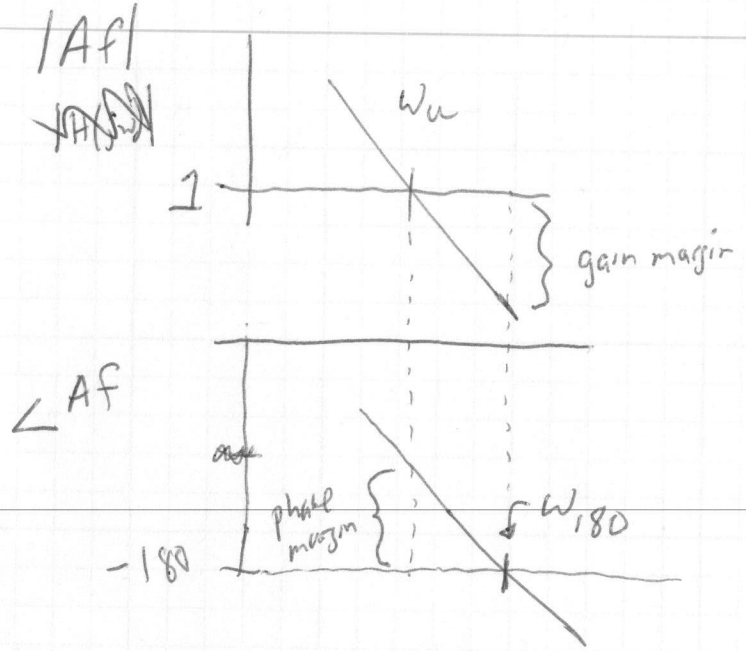




above $10^7 \frac{\text{rad}}{\text{sec}}$, -180 phase $\Rightarrow$ V_+, V_- swap

$\Rightarrow$ unstable for some values of f

Stability



(open loop) (closed loop)

Phase margin is related to time response

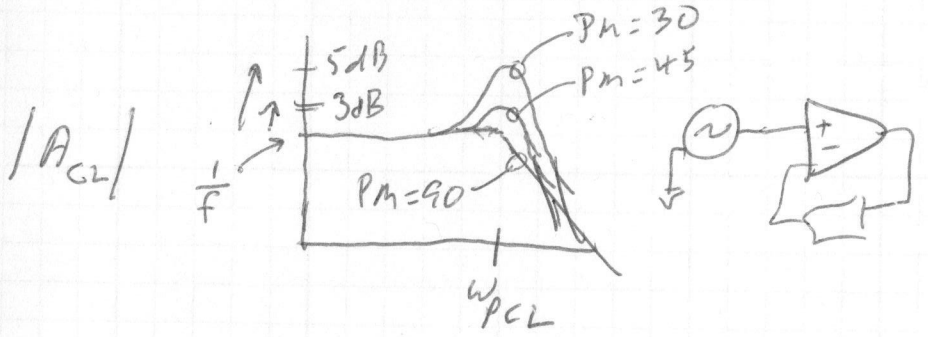
90 degree PM → closed loop looks like single pole response

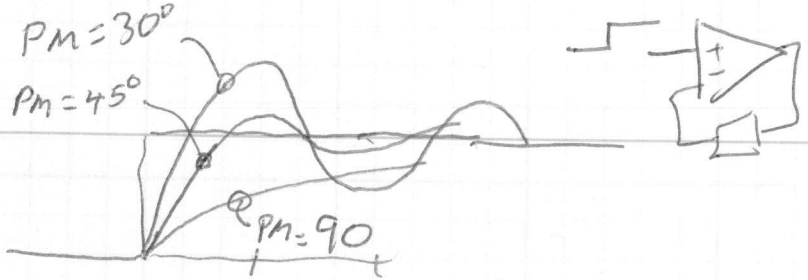
45° PM → 25% overshoot on step response

→ 3dB peaking all pole

30° PM → 40% overshoot on step

5 dB peaking all pole





Is it a problem?

Single pole amplifier - no.

Single stage amplifier - usually not.

two stage amplifier - yes