Some examples

- Co-located poles, gain of 1000
  - \( \omega_n = \sqrt{1000} \omega_p \)
  - \( \angle A(j\omega_n) = -135 \)
  - \( pm = 45 \) OK!

- Co-located, gain of 10
  - \( \omega_n = 10 \)
  - \( \omega_p = \omega_n \)
  - \( \angle A(j\omega_n) = -180 \)
  - \( pm = 0 \) BAD!

Big gain

- 2 well-separated poles
  - \( \omega_n \) single pole
  - \( \omega_p = -1 \)

- 2nd pole adds kink
  - \( \omega_p = -2 \)
  - \( \angle A(j\omega_p) \) effect of low freq pole

- \( \omega_p = 3 \omega_n \)

Always want at least 45° pm, so must choose \( \omega_p \geq \omega_n \)

Compensation

- Changing the freq response of the open loop amplifier (typically by adding capacitance) so that the closed loop amplifier is stable
- Has desired settling properties (phase margin)

- \( \angle A(j\omega_n) = -135 \)
- \( \angle A(j\omega_p) = 90 - 22.5 \)
- \( pm = 45 \) OK
- \( pm \geq 67 \) good!
How to compensate single stage: Close up read it (only 1 pole, P=2)

2 stages:

3 natural points: output of 1st stage
2 stages of compensation
across 2 stages
miller compensation

movers will lose of smaller cap

$C_{miller} = \frac{1}{(1 - A_{v2}) C_c}$

$C_{miller} = \frac{1}{1 + \frac{1}{(1 - A_{v2})}} C_c$

where $A_{v2} = 1 + \frac{1}{(1 - A_{v2})}$

$C_{miller} = \frac{1}{1 + \frac{1}{(1 - A_{v2})}} C_c$

$C_{miller} = \frac{1}{1 + \frac{1}{(1 - A_{v2})}} C_c$

$C_{miller} = \frac{1}{1 + \frac{1}{(1 - A_{v2})}} C_c$

$C_{miller} = \frac{1}{1 + \frac{1}{(1 - A_{v2})}} C_c$
$Z_{\text{Miller}}$ low freq $s=j\omega \ \omega < \omega_{p20}$

$Z_{\text{Miller}} = \frac{1}{s(1+Av_{20})C_L} = \frac{1}{j\omega C_{\text{Miller}}}$

mid freq $\omega_{p20} < \omega < \omega_{u20}$

$Z_{\text{Miller}} = \frac{A}{s} \frac{3}{\omega_{p20}} = \frac{1}{s} \frac{A}{\omega_{20} C_{\text{Miller}}}$

constant real! Resistive

capacitance $\frac{1}{\omega A v} \ \ \ \ A v = \frac{1}{\omega}$

high freq $\omega_{u20} < \omega$

$Z_{\text{Miller}} = \frac{\omega_{u20}}{s(1+Av_{20})C_L} \left( \frac{s}{1+Av_{30}^2} \right)$

$= \frac{1}{s C_L}$