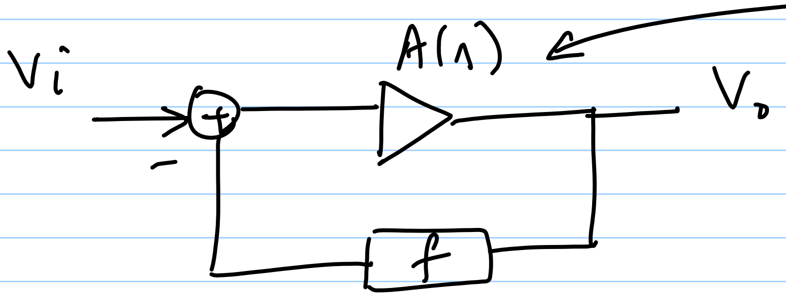
7-11-12

Lec 42



1st order

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

Unconditionally stable

2nd order

$$A(s) = \frac{A_o}{(1+s/\omega_p)^2}$$

→ technically stable, but high Q (ringing)

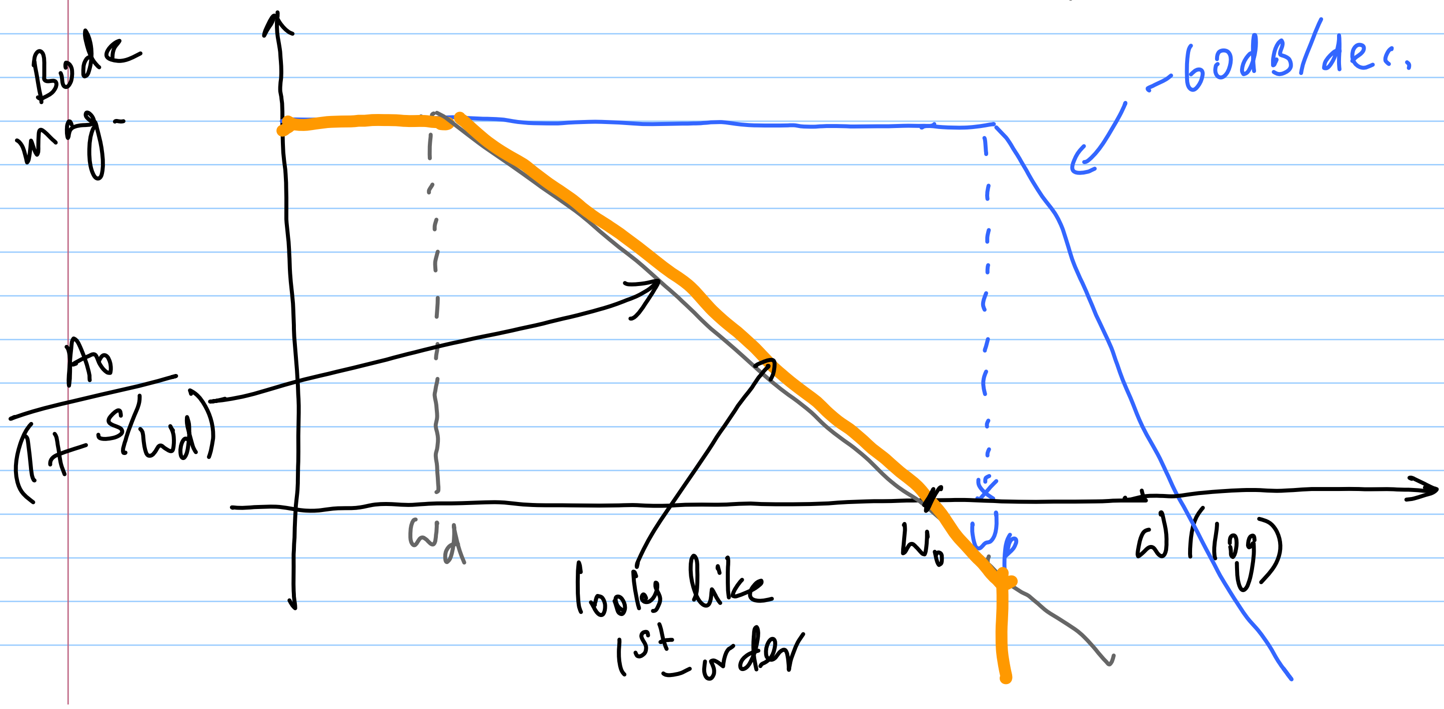
3rd order

$$A(s) = \frac{A_o}{(1+s/\omega_p)^3}$$

← unstable for $A_o f > 8$

Dominant pole

$$A(s) = \frac{A_o}{(1+s/\omega_d)\,(1+s/\omega_p)^3} \quad ; \omega_d \ll \omega_p$$



$A_o f < 1$ (f.b. is dying out)

$\hookrightarrow$ no gain from the fwd. amp.

Example

$$A(s) = \frac{A_o}{(1 + s/\omega_p)^3 \cdot \underbrace{\left(1 + \frac{1000 s}{\omega_p}\right)}}$$

$$\omega_d = \frac{\omega_p}{1000}$$

$$3 \tan^{-1}\left(\frac{\omega_o}{\omega_p}\right) = \pi - \tan^{-1}\left(\frac{1000\omega_o}{\omega_p}\right)$$

algebraic solution

take tan on both sides

$$\tan(3x) = \frac{3\tan x - \tan^3 x}{1 - 3\tan^2 x}$$

$$\tan(\pi - x) = -\tan x$$

$$\frac{3\left(\frac{\cancel{\omega_o}}{\cancel{\omega_p}}\right) - \left(\frac{\omega_o}{\omega_p}\right)^{\cancel{3}\,2}}{1 - 3\left(\frac{\omega_o}{\omega_p}\right)^2} = -\frac{1000\cancel{\omega_o}}{\cancel{\omega_p}}$$

$$3 - \left(\frac{W_o}{w_p}\right)^2 = -1000\left[1 - 3\left(\frac{W_o}{W_p}\right)^2\right]$$

$$3001\left(\frac{W_o}{W_p}\right)^2 = 1003$$

$$\Rightarrow \frac{W_o}{W_p} \approx \frac{1}{\sqrt{3}}$$ ← same answer

$W_o \gg W_d$ ← $A_o f \gg 1$ ←

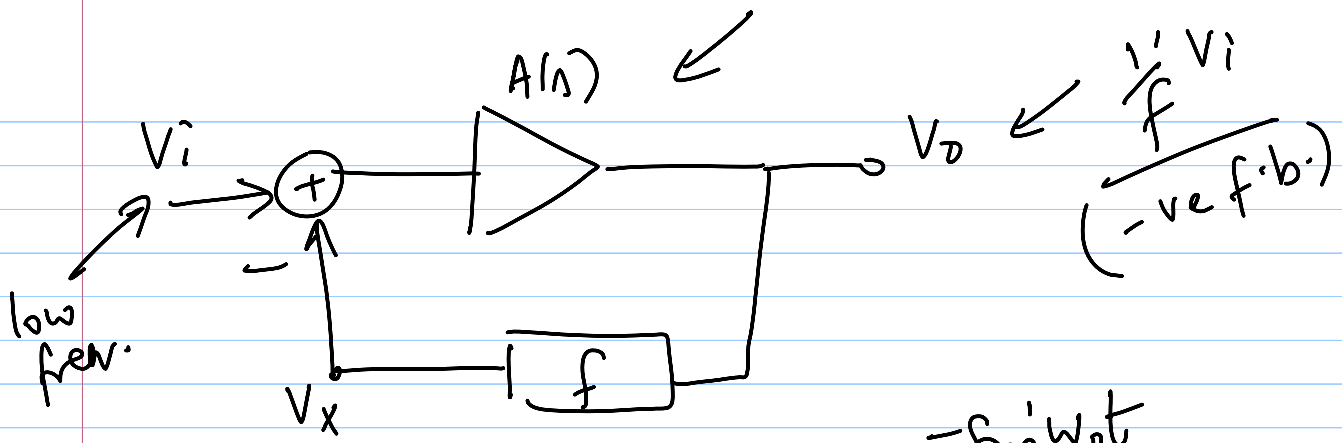
$\underbrace{W_o \gg W_d}_{-90^\circ \text{ from } W_d}$

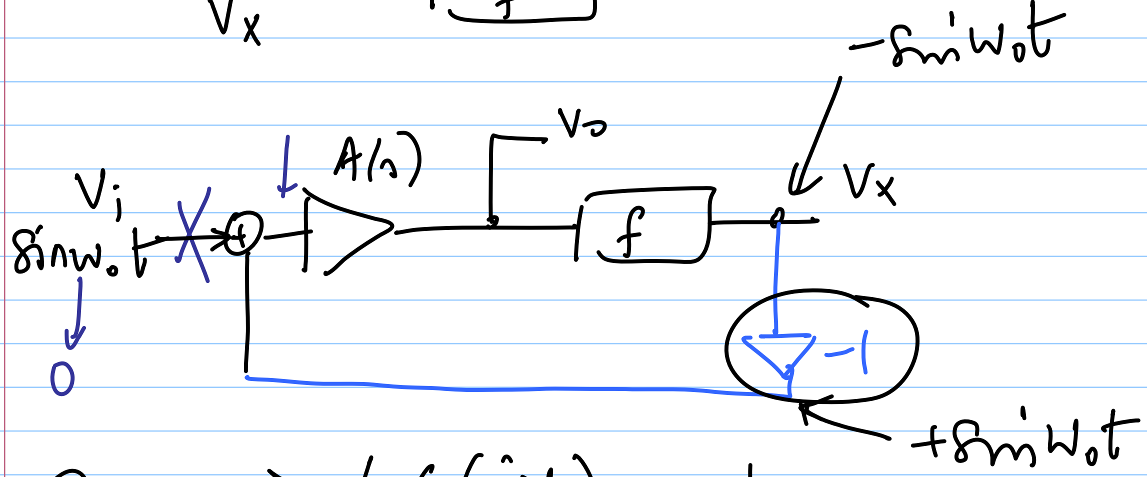
$$\frac{W_o}{W_p} = \frac{1}{\sqrt{3}}$$ ⇒ plug into mag. condition

$|A_o f| \approx 890$ ← limit of stability

$LG(jW_o) = -1$ ←

$$CLG(jw) = \frac{1}{f} \cdot \frac{A_o(jW) \cdot f}{1 + A_o(jw) \cdot f}$$



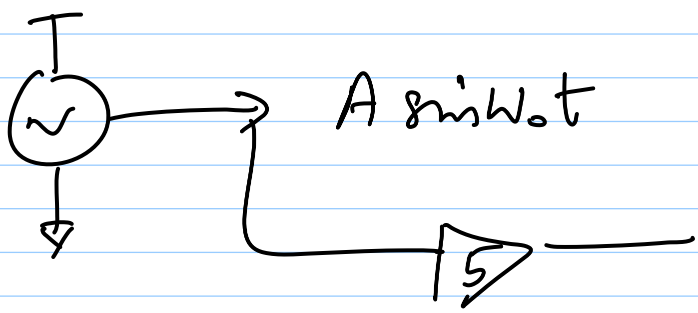


$$@\ \omega_0 \Rightarrow LG(j\omega_0) = -1$$

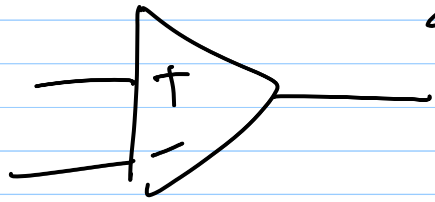
$$V_i = \sin\omega_0 t$$

without any input, output $= \sin\omega_0 t$

(looks like an oscillator)



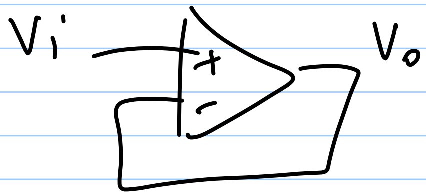
$$CLG = \frac{LG}{1+LG} \cdot \frac{1}{f}$$

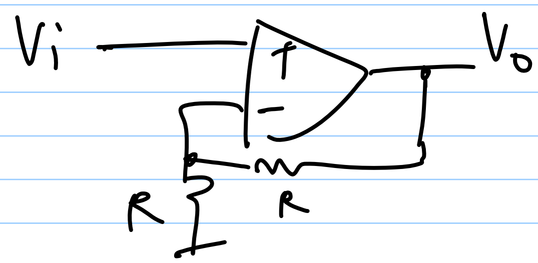


D.P. comp.

$$\omega_d = f(\omega_p, A_{of})$$

* What is the worst-case scenario for stability





f = large $\Rightarrow$ A_{of} is large

$\Downarrow$

more instability

$\boxed{f_{max.} = 1} \rightarrow \boxed{CLG_{min} = 1}$

<u>Commercial opamps</u>

↳ internally compensated for unity gain f.b.