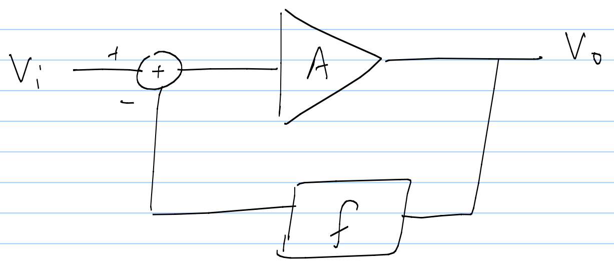
19/8/14

lec 11



behavior

$\Rightarrow LG = Af$

$A = A(s)$

CLG $\quad \frac{V_o}{V_i}(s) = \frac{1}{f} \cdot \frac{LG(s)}{1 + LG(s)}$

1) $A(s) = \frac{A_o}{(1 + s/\omega_p)}$ $\quad 1^{st}$ order system

$\Rightarrow$ Unconditionally stable

If $|LG| \geq 1$ @ $\angle LG = -180°$ } Instability can result

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

$\Rightarrow$ technically stable

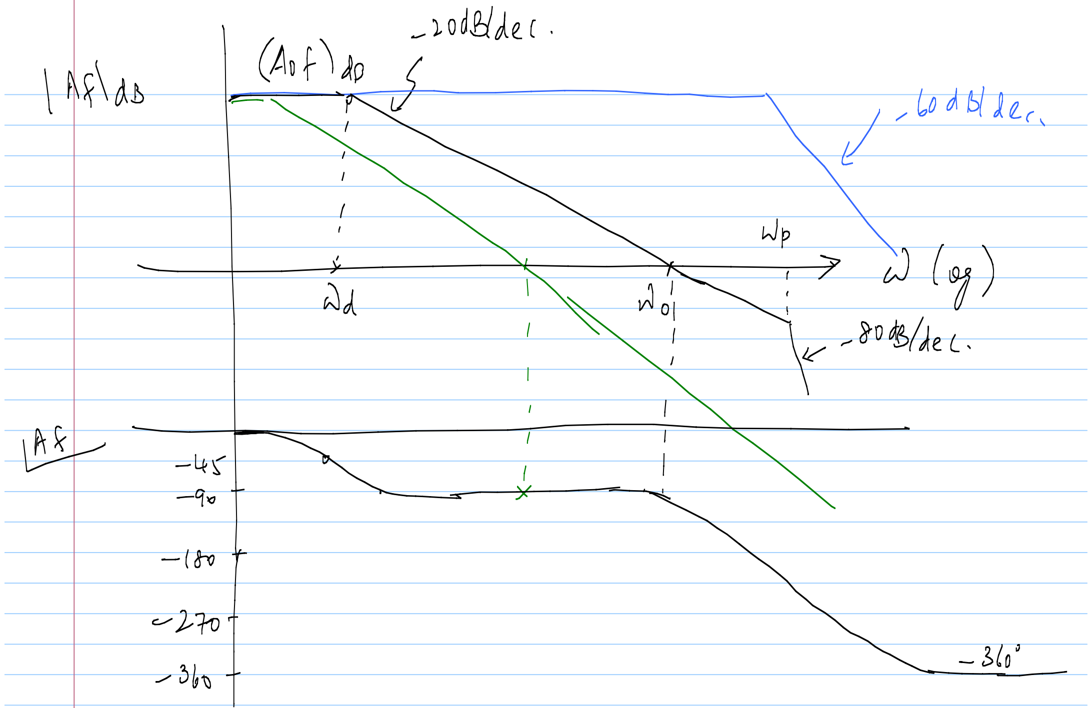
high Q, ringing

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

Unstable if $A_f > 8$

4) $A(s) = \frac{A_o}{(1 + s/\omega_d)(1 + s/\omega_p)^3}$ $\quad 4^{th}$ order system

$\omega_d \ll \omega_p$



$|L_G|$ value @ $\angle L_G = -180°$

(or) $\angle L_G$ value @ $|L_G| = 1$

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

$$L_G(s) = \frac{A_o f}{(1 + s/\omega_p)^3 \left(1 + \frac{1000 s}{\omega_p}\right)}$$

roots of $1 + L_G(s) = 0 \Rightarrow \boxed{L_G(s) = -1}$

mag $|L_G(j\omega_o)| = 1$

phase $\measuredangle L_G(j\omega_o) = \pi$

$$0 - 3\tan^{-1}\left(\frac{\omega_o}{\omega_p}\right) - \tan^{-1}\left(\frac{1000\omega_o}{\omega_p}\right) = \pi$$

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

@ ω_o, phase from $\omega_d \simeq -90°$ (as long as $A_o f$ is large)

$\Rightarrow$ 3 poles @ ω_p should contribute remaining $-90°$ phase shift

$\Rightarrow$ each ω_p should contribute $-30°$

$$\frac{\omega_o}{\omega_p} = \frac{1}{\sqrt{3}}$$

apply $|L_G(j\omega_o)| = 1$

$$\left|\frac{A_o f}{(1 + j/\sqrt{3})^3 \left(1 + j\frac{1000}{\sqrt{3}}\right)}\right| = 1$$

$$\frac{A_o f}{\left(\sqrt{1 + 1/3}\right)^3 \left(\frac{1000}{\sqrt{3}}\right)} = 1$$

$\Rightarrow A_o f = 866$ — much better from simple 3rd order system where limit was $A_o f = 8$

If you want larger $A_o f \Rightarrow$ higher order system $\Rightarrow$ smaller ω_d

$\Rightarrow$ smaller ω_o

closed loop BW is smaller

ω_d = "dominant pole"

" frequency compensation"

This technique is called "dominant pole compensation"

$$\frac{A_o f}{(1+S/\omega_p)^3} \times \frac{(1+s/\omega_p)^2}{(1+S/\omega_{p_1})^2}$$

$\omega_{p_1} \gg \omega_p$

$$\frac{A_o f}{(1+S/\omega_p)(1+S/\omega_{p_1})^2}$$

better than

$$\frac{A_o f}{(1+S/\omega_d)(1+S/\omega_p)^3}$$

"pole-zero compensation"