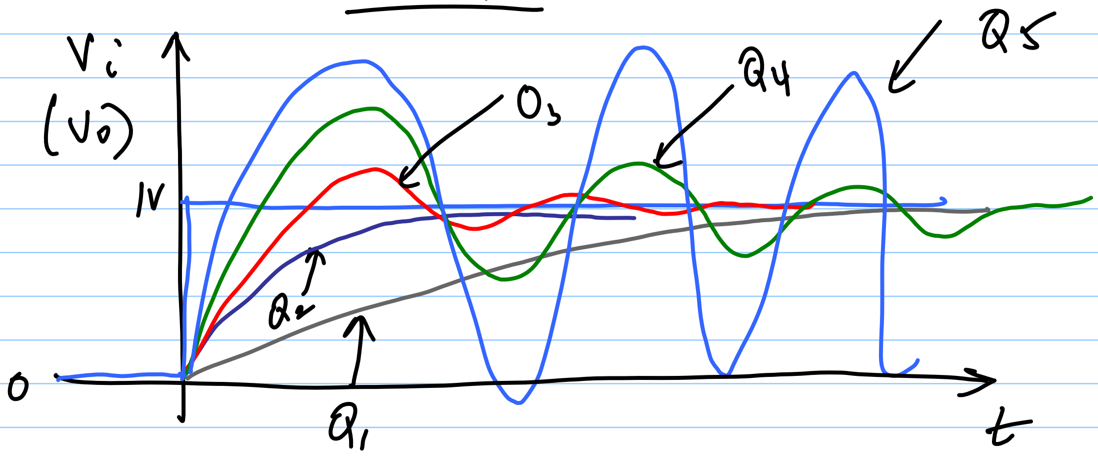
1-11-12

Lec 40



$Q_1 < Q_2 < Q_3 < Q_4 < Q_5$

$Q_2 = 1/2$, $Q_5 = \infty$

sinusoid that does not die out

$$\underbrace{1 + \frac{s}{\omega_0 Q} + \frac{s^2}{\omega_0^2}}_{\text{gen. 2nd order}} \longleftrightarrow \underbrace{1 + \frac{2s}{A_{of}\,\omega_p} + \frac{s^2}{\omega_p^2 A_{of}}}_{\text{2-pole fwd. amp.}}$$

$$\omega_0 = \omega_p \sqrt{A_{of}}$$

$$Q = \frac{\sqrt{A_{of}}}{2}$$

trying to realise large $A_{of} \Rightarrow$ <u>Q is very large</u>

<u>Not good enough</u>

3rd-order system

$$A(s) = \frac{A_0}{\left(1+\frac{s}{\omega_p}\right)^3}$$

$$= \frac{A_0}{1+\frac{3s}{\omega_p}+\frac{3s^2}{\omega_p^2}+\frac{s^3}{\omega_p^3}}$$

$$CLG(s) = \frac{1}{f}\cdot\frac{A_0 f}{1+A_0 f}\cdot\frac{1}{\underbrace{1+\left[\frac{3s}{\omega_p}+\frac{3s^2}{\omega_p^2}+\frac{s^3}{\omega_p^3}\right]\cdot\frac{1}{1+A_0 f}}_{D(s)}}$$

$$Dr.\ D(s) = 1+\frac{3s}{\omega_p(1+A_0 f)}+\frac{3s^2}{\omega_p^2(1+A_0 f)}$$
$$+\frac{s^3}{\omega_p^3(1+A_0 f)}$$

$$D\left(\frac{s}{\omega_p}\right) = 1+\frac{3s}{1+A_0 f}+\frac{3s^2}{1+A_0 f}+\frac{s^3}{1+A_0 f}$$

Roots of $(1+A_0 f)+3s+3s^2+s^3$

$$(1+s)^3 = -A_0 f$$

$$s = -1 + (-A_0 f)^{1/3}$$

Example $\quad A_0 f = 8$

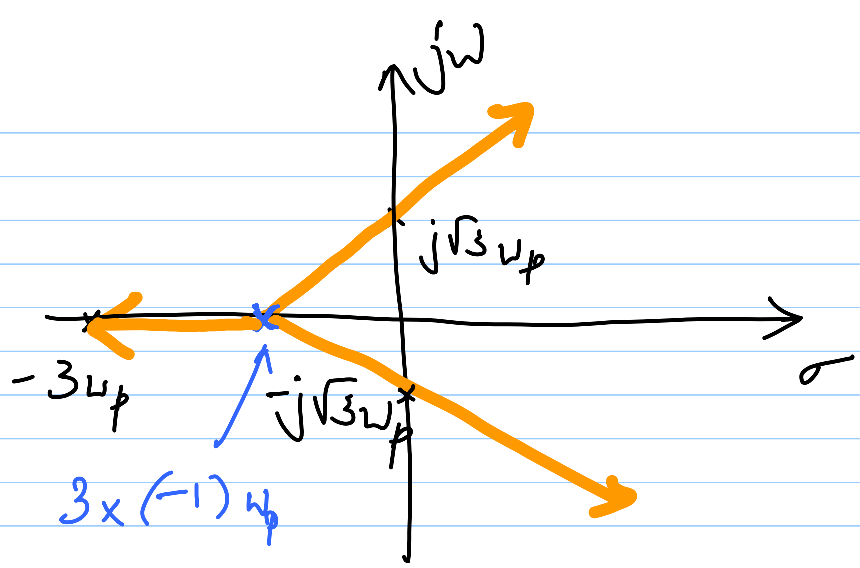
$$s_1 = -1 - 2 = -3$$

$$s_2 = -1 - 2e^{-j2\pi/3}$$

$$s_3 = -1 - 2e^{+j2\pi/3}$$

$$s = -3\,,\ \pm j\sqrt{3}$$

poles are @ $-3\omega_p\,,\ \pm j\sqrt{3}\,\omega_p$



$A_0 f = 0 \Rightarrow$ all 3 roots lie @ (-1)

sum of roots $= -3(\omega_p)$

Huge problem $\quad A_0 f > 8 \Rightarrow$ complex conjugate roots move into RHP

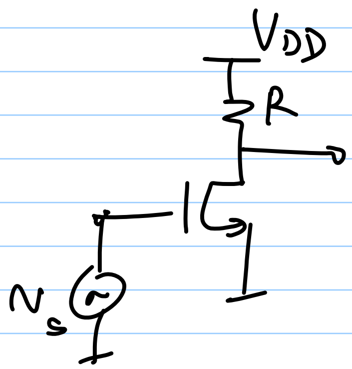
4th order $\Rightarrow$ will be worse

solution 1

$$\left(\frac{A_0}{\left(1+\frac{s}{\omega_{p_1}}\right)^{3}}\right)^{0} \quad \frac{\cancel{\left(1+s/\omega_{p_1}\right)^{2}}}{\left(1+s/\omega_{p_2}\right)^{2}}$$

$$\frac{1+s/\omega_z}{1+s/\omega_p}$$

$\omega_z \approx \omega_p$



1-pole system

Solution 2:

1st order → low gain
→ unconditionally stable

2nd order → larger gain
→ technically stable

3rd order → v. large gain
→ unstable

make a higher order system look like a 1st order system

$$\frac{A_0}{(1+s/w_p)^3} \longrightarrow \frac{A_0}{(1+s/w_d)(1+s/w_p)^3}$$

$w_d << w_p$

1) $\dfrac{A_0}{1+s/w_d}$

2) $\dfrac{A_0}{(1+s/w_p)^3}$

3) $\dfrac{A_0}{(1+s/w_d)(1+s/w_p)^3}$