20/10/2020

Lecture 41

Summary:

1st order → low gain
→ unconditionally stable

2nd order → larger gain
→ technically stable, but ringing in step response

3rd order → very large gain
→ unstable even for small LG_{dc}

4th order → very very large gain
→ highly unstable (guess)

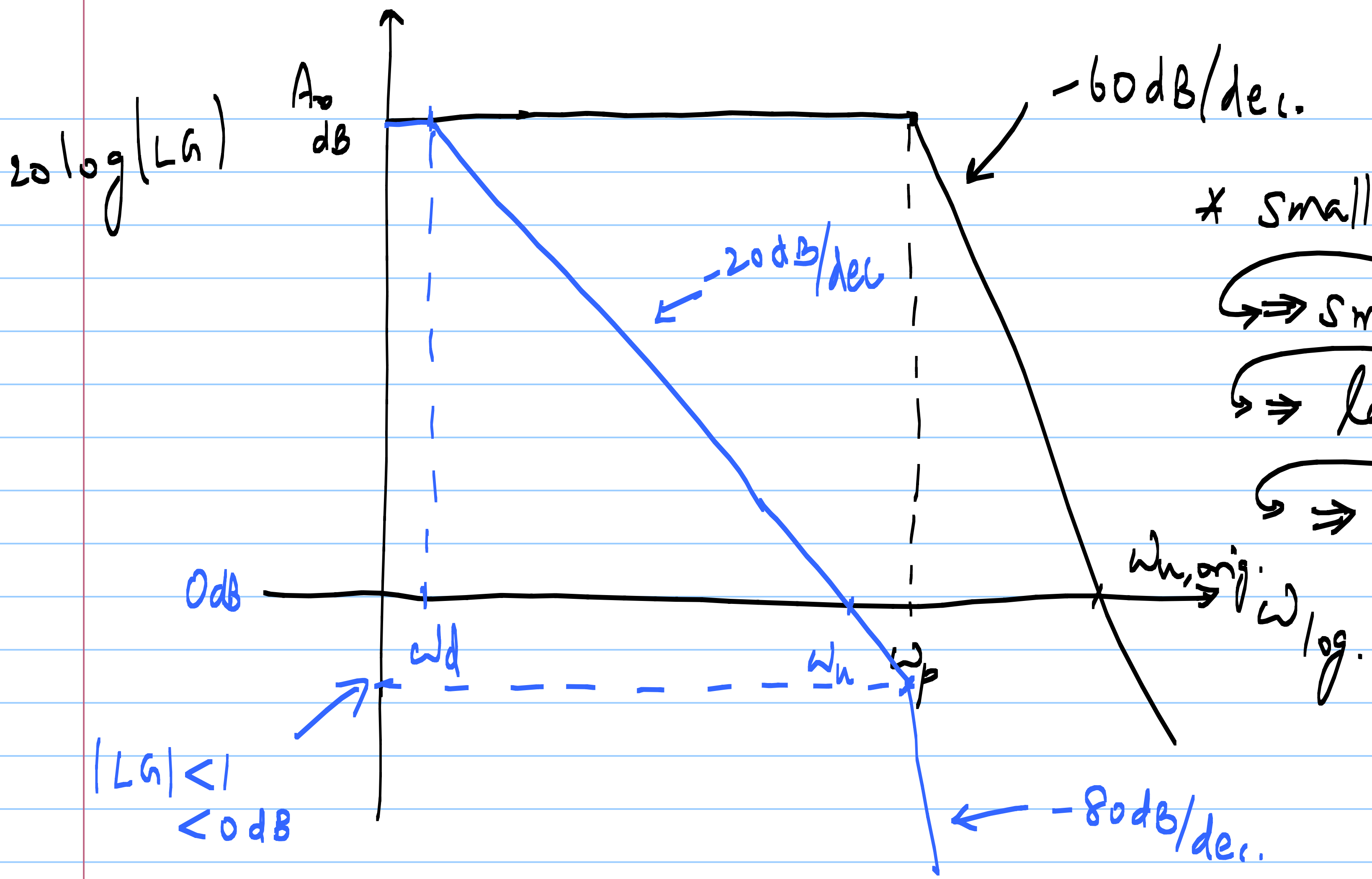
Solution : Make a higher order system look like a 1st order system from the point of view of stability.

Take 3rd order system as an example

$$\frac{A_0}{(1+s/\omega_p)^3} \xrightarrow[\text{pole @ } \omega_d]{\text{add a}} \frac{A_0}{\left(1+\frac{s}{\omega_d}\right)\left(1+\frac{s}{\omega_p}\right)^3}$$

* In reality, you may choose to move one ω_p pole to ω_d.

* $\omega_d \ll \omega_p$ $\qquad$ ω_d = "dominant" pole



* smaller ω_d ⇒ smaller ω_u ⇒ larger $(\omega_p - \omega_u)$ ⇒ system stability improves

Improving stability = "Frequency Compensation"

This technique = "Dominant-pole compensation"

* $LG = -1$

$|LG| = 1$ & $\angle LG = -180^\circ$

* Avoid $\angle LG > 1$ when $\angle LG = -180^\circ$

* Measures of Stability :

1) Gain Margin $= 0\,dB - |LG(j\omega)| \Big|_{\angle LG(j\omega) = -180^\circ}$

2) Phase Margin $= \angle LG(j\omega) \Big|_{|LG| = 0\,dB} - (-180^\circ)$

$= 180^\circ + \angle LG(j\omega) \Big|_{|LG| = 0\,dB}$

* We normally want high GM & PM