21/10/2020

Lecture 42

Example: $\omega_d = \dfrac{\omega_p}{1000}$

original limit for stability: $A_o f = 8$

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

we need to find new limit on $A_o f$

$$LG(s) = \frac{X(s)}{Y(s)}$$

$$CLG(s) = \frac{1}{f} \cdot \frac{LG(s)}{1 + LG(s)} = \frac{1}{f} \frac{X(s)/Y(s)}{1 + X(s)/Y(s)} = \frac{N(s)}{D(s)}$$

roots of $LG(s) = -1$

$|LG(j\omega_o)| = 1$ & $\angle LG(j\omega_o) = -\pi$ ← apply this first

$$-3\tan^{-1}\left(\frac{w_0}{w_p}\right) - \tan^{-1}\left(\frac{1000\,w_0}{w_p}\right) = -\pi$$

@ $w_0 \to$ wd give $-\pi/2$ phase shift

$$\Rightarrow -3\tan^{-1}\left(\frac{w_0}{w_p}\right) = -\pi/2$$

each w_p pole gives $-\pi/6$ (-30°)

$$\frac{w_0}{w_p} \approx \frac{1}{\sqrt{3}}$$

$$\boxed{w_0 = \frac{w_p}{\sqrt{3}}}$$

* Apply magnitude condition: $|LG(jw_0)| = 1$

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

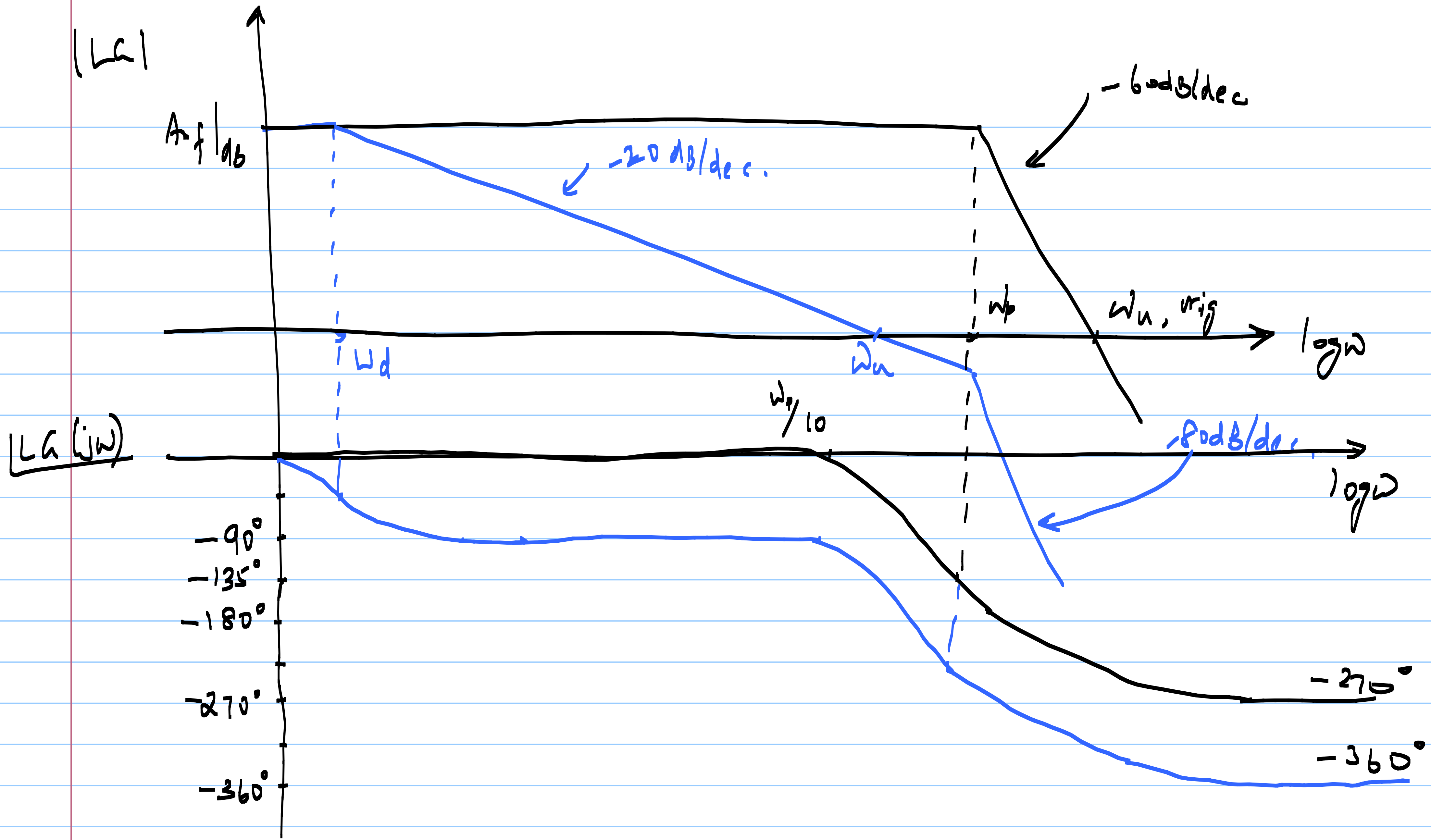
$$\frac{A_o f}{\left(\sqrt{1 + 1/3}\right)^3 \left(\frac{1000}{\sqrt{3}}\right)} = 1 \Rightarrow A_o f \approx 890$$

for stability

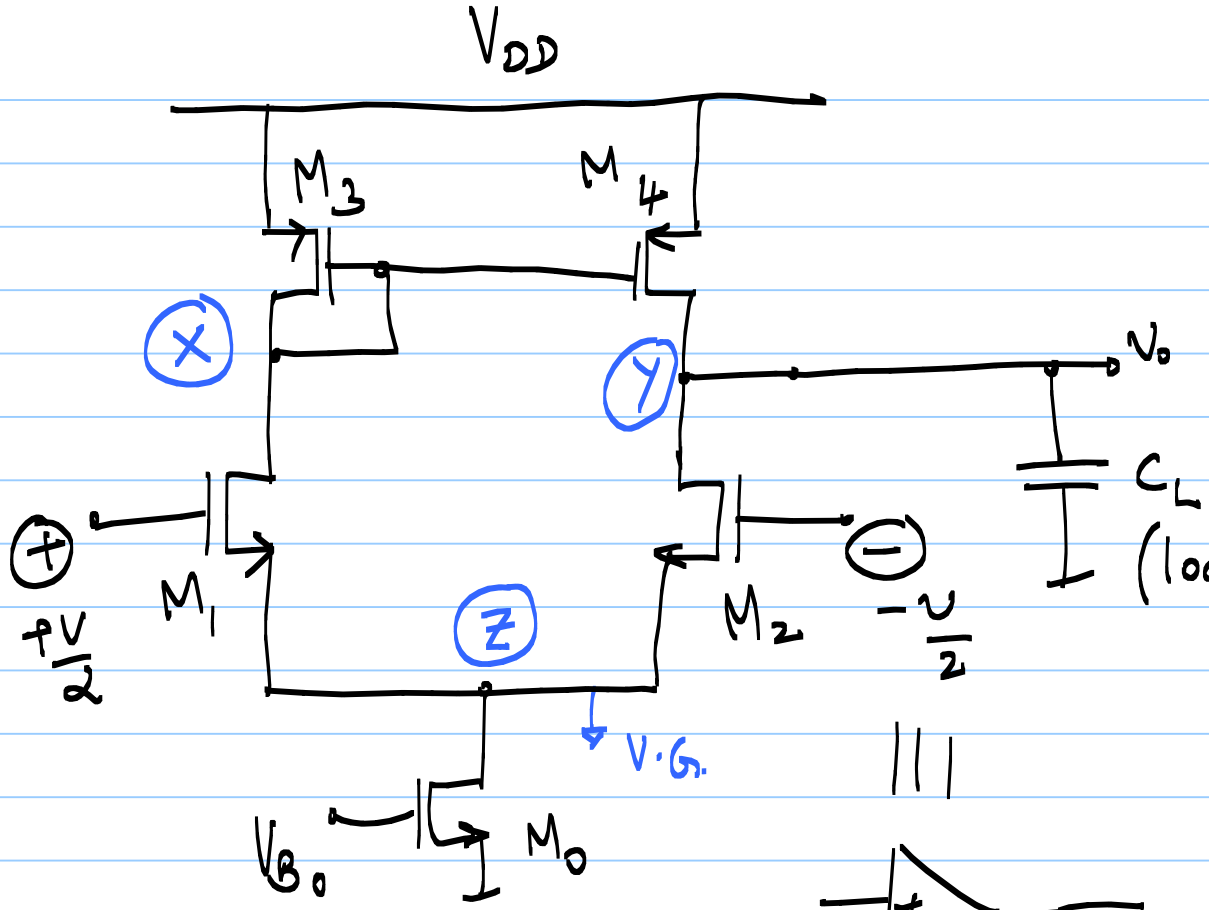
* Worst-case scenario: largest possible $A_o f$

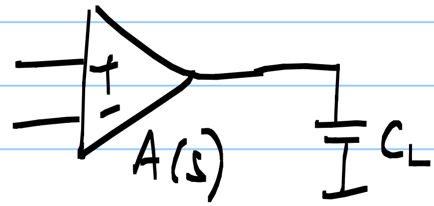
$\Rightarrow$ largest possible f

$\Rightarrow$ $f_{max} = 1$ i.e. unity gain amplifier



|LG|
$A_f|_{dB}$
-20 dB/dec.
-60dB/dec
ω_p
ω_u, orig
log ω
ω_d
ω_u
$\omega_p/10$
∠G(jω)
-80dB/dec
log ω
-90°
-135°
-180°
-270°
-360°
-270°
-360°





$$A_0 = g_{m1}\left(r_{ds2} \,||\, r_{ds4}\right)$$

$$A(s) = g_{m1}\left(r_{ds2} \,||\, r_{ds4} \,||\, \frac{1}{sC_L}\right)$$

$$= A_0 \frac{1}{1 + \frac{s}{\omega_p}}$$

* 1-pole system without parasitics

$$A(s) = \frac{g_{m1}}{g_{ds2} + g_{ds4} + sC_L} = \left[\frac{g_{m1}}{(g_{ds2} + g_{ds4})}\right] \cdot \frac{1}{1 + \frac{sC_L}{g_{ds2} + g_{ds4}}}$$

$$\omega_p = \frac{g_{ds_2} + g_{ds_4}}{C_L} = \frac{1}{(r_{ds_2} \| r_{ds_4}) \cdot C_L}$$

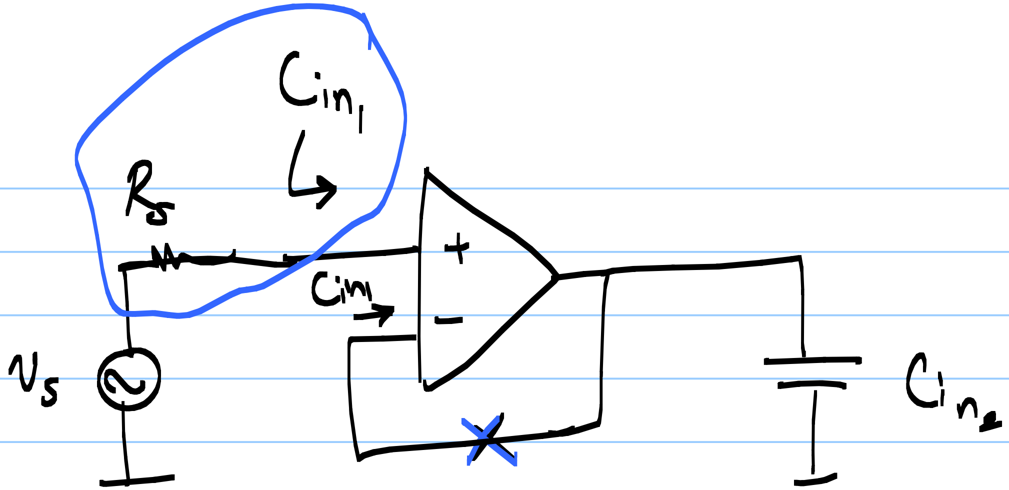
* Ignore C_{gd}

$$C_X = C_{gs_3} + C_{gs_4} + C_{db_3} + C_{db_1} \approx 2C_{gs_3}$$

$$C_Y = C_L + C_{db_2} + C_{db_4} \approx C_L$$

$$C_Z = C_{db_0} + C_{gs_1} + C_{gs_2} + C_{sb_1} + C_{sb_2}$$ ← No DM current through C_Z

* 2-pole system when parasitic caps are taken into account



$C_L = C_{in_1} + C_{in_2}$