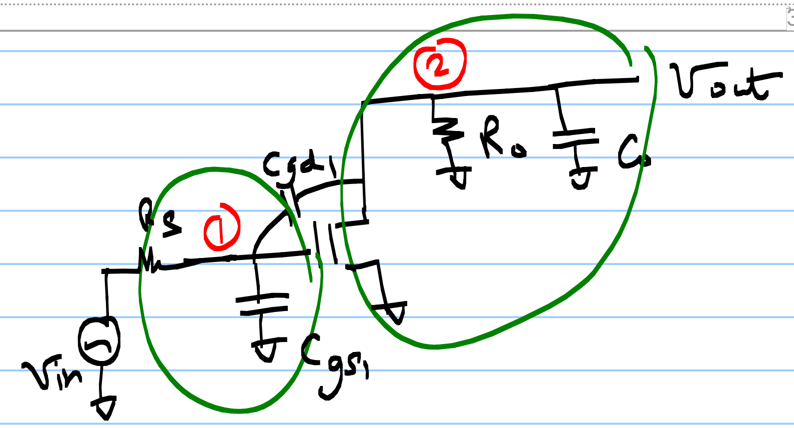
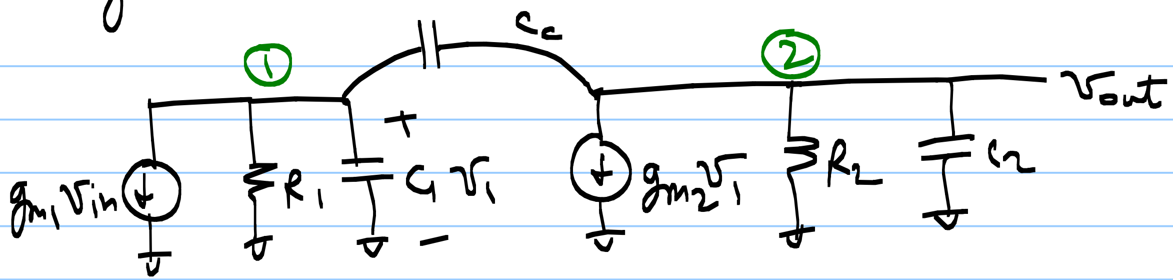
Note Title 3/23/2011

ECE 5411 - Lecture 17



Generic Model for CS $\rightarrow$ 2nd order



Example

21.6 – 21.10

$$A_v = + g_{m1} R_1 g_{m2} R_2 \leftarrow \text{DC gain}$$

$$\omega_{p1} = \frac{1}{R_2(C_2 + C_c) + R_1(C_1 + C_c(1 + g_{m2} R_2))}$$

$$\simeq \frac{1}{g_{m2} R_2 R_1 C_c}$$

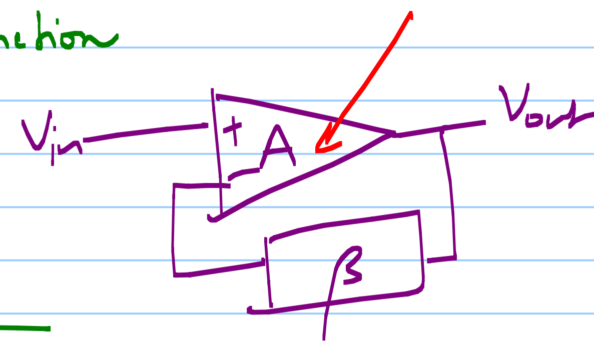
Ex 21.6

$$\omega_{p2} \simeq \frac{g_{m2} C_c}{C_c C_1 + C_1 C_2 + C_c C_2} \propto \frac{g_{m2}}{C_2} \quad \text{if} \quad C_2 \simeq C_c \gg C_1$$

$$\omega_z = \frac{g_{m2}}{C_c}$$

$$A_v(s) = \frac{A_{v0}\left(1 + s/\omega_z\right)}{\left(1 + s/\omega_{p1}\right)\left(1 + s/\omega_{p2}\right)}$$

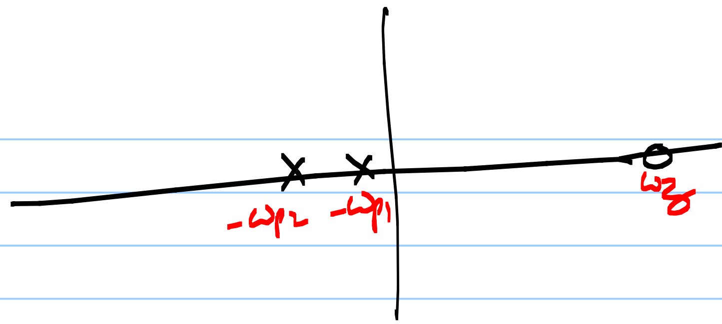
open-loop small-signal transfer function



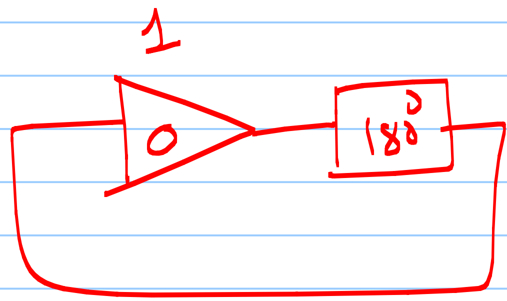
RHP zero $\rightarrow \tan^{-1}\left(\frac{-\omega/\omega_z}{1}\right) = -\tan^{-1}\left(\frac{\omega}{\omega_z}\right)$

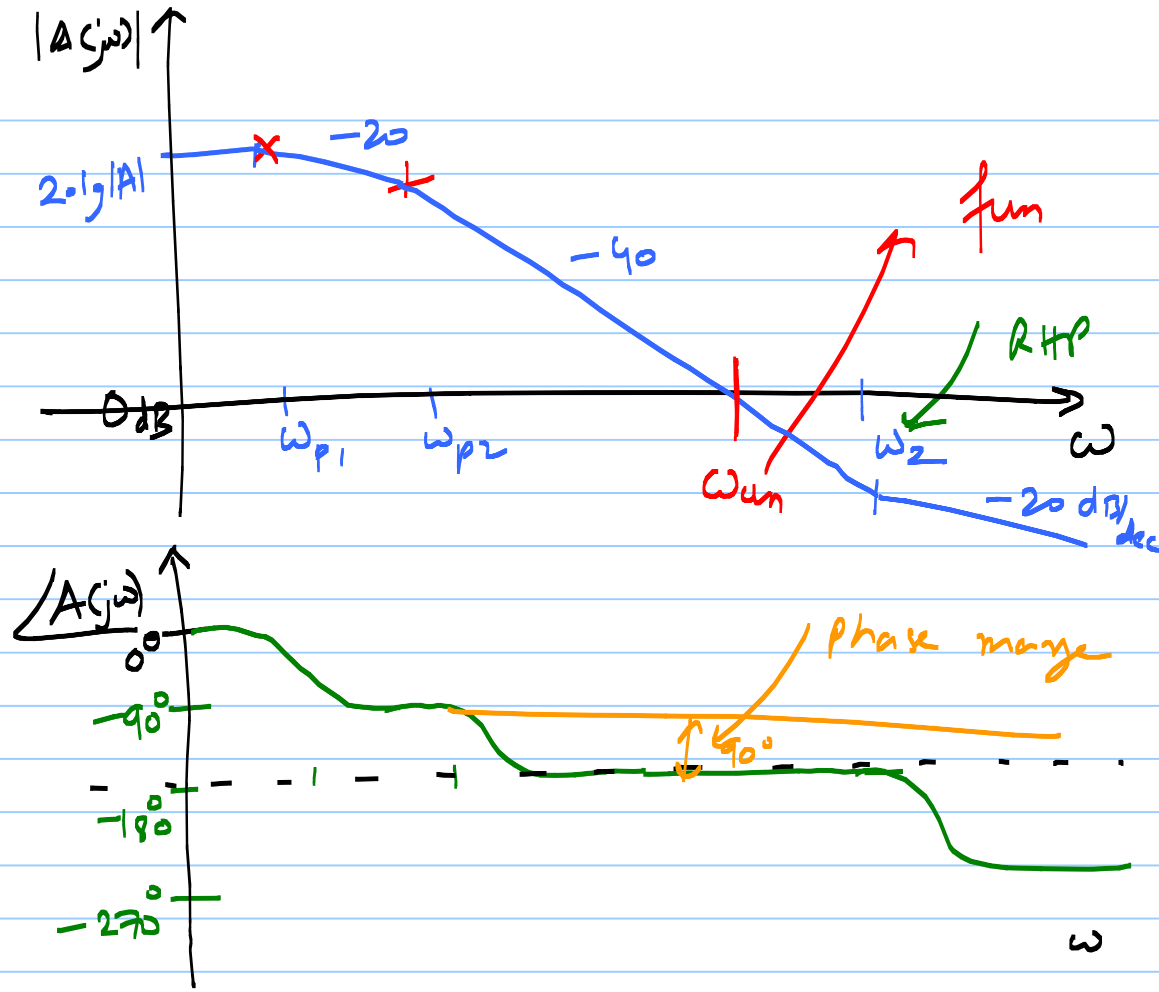
LHP zero $\rightarrow \tan^{-1}\left(\frac{+\omega/\omega_z}{1}\right) = +90^\circ$

$\frac{\omega_z}{10} < \omega < 10\,\omega_z$


$-\omega_{p2}$
$-\omega_{p1}$
ω_z

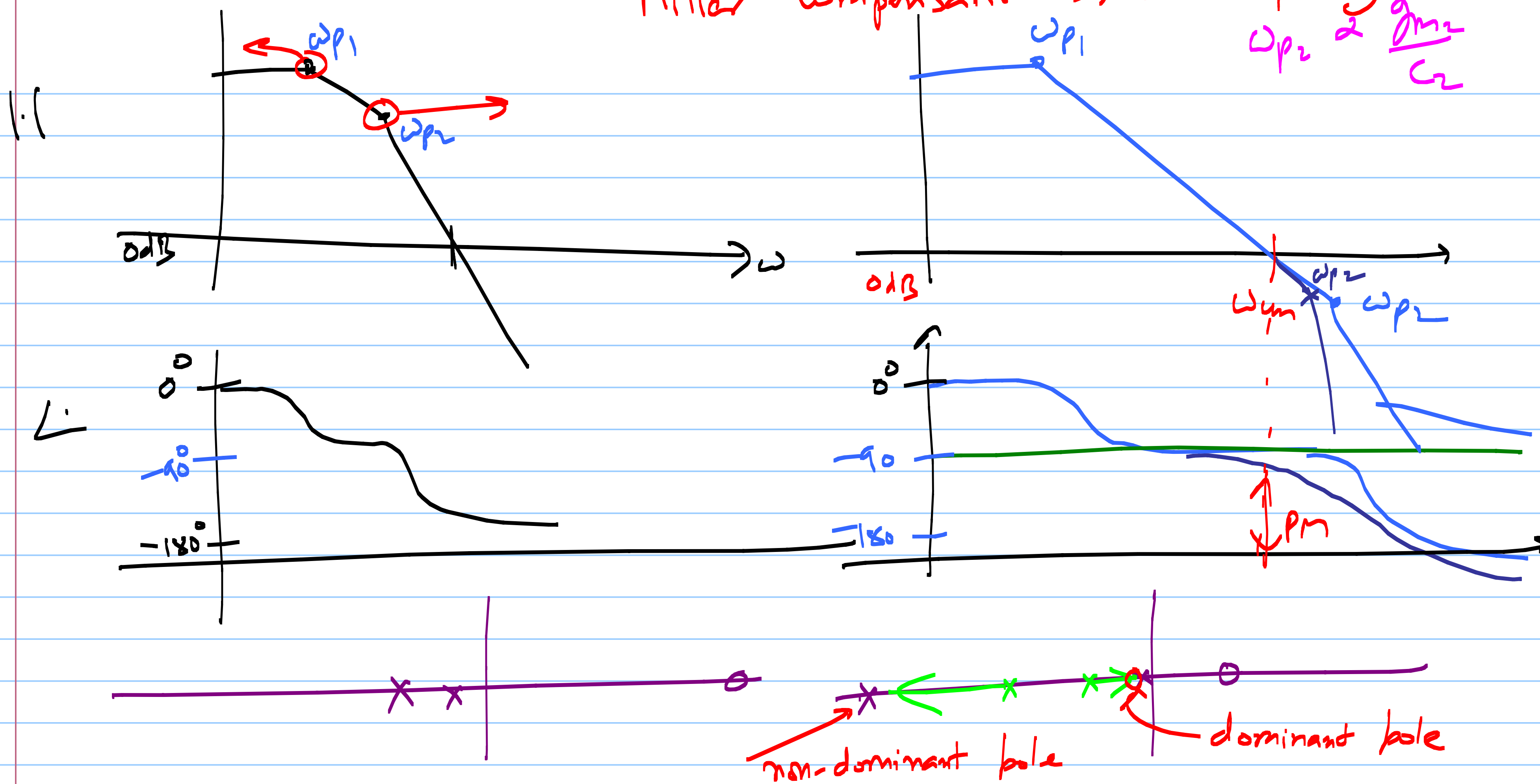
$C_c = C_{gd1}$

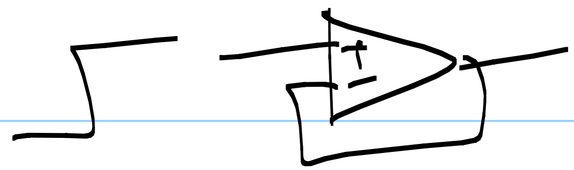

1
0
180^0

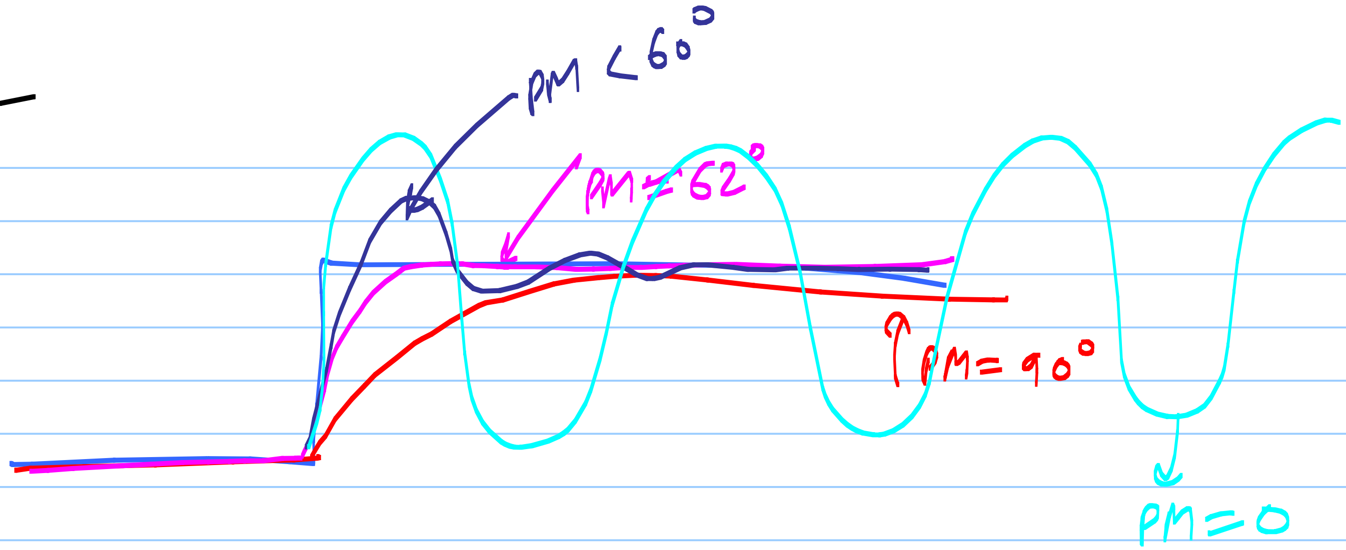

$|A(j\omega)|$
$20 \lg |A|$
-20
-40
$0\,dB$
ω_{p1}
ω_{p2}
ω_{un}
f_{un}
RHP
ω_z
$-20\, dB/dec$
ω
$\angle A(j\omega)$
0^0
-90^0
-180^0
-270^0
phase margin
90^0
ω

Miller Compensation ⇒ Pole splitting

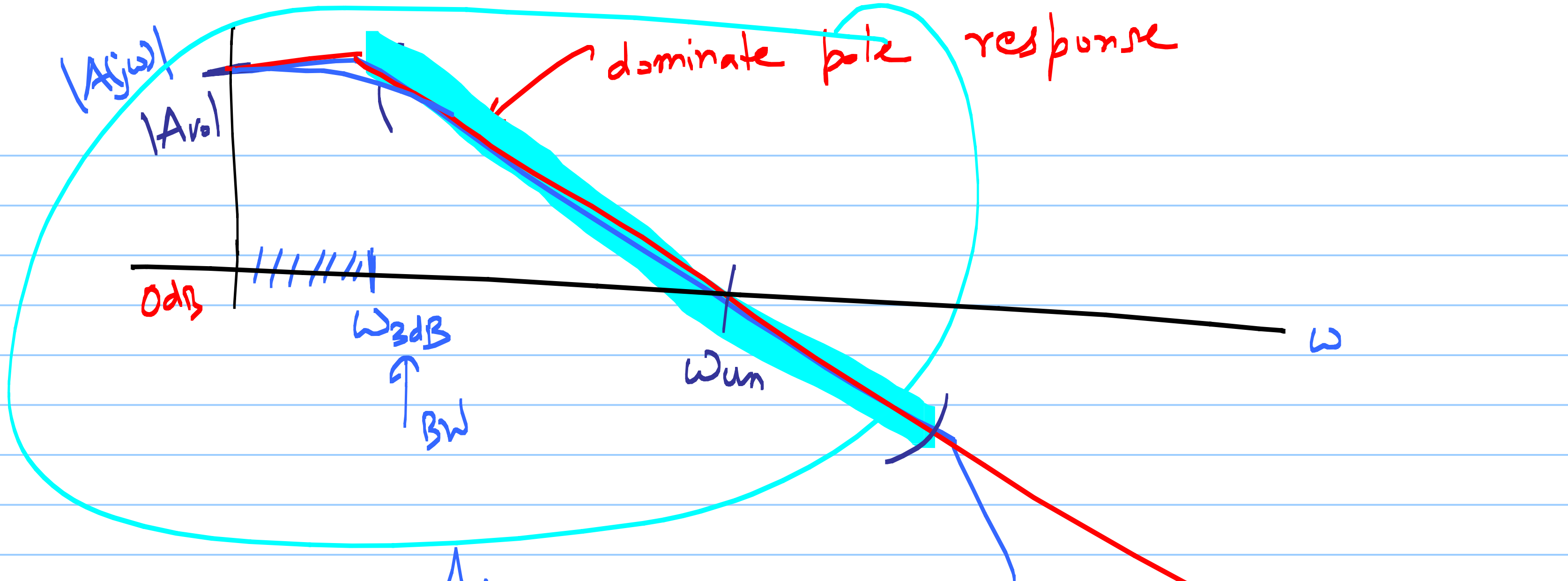
$\omega_{p_2} \propto \dfrac{g_{m_2}}{C_2}$







PM < 60°
PM = 62°
PM = 90°
PM = 0



$$A(s) = \frac{A_{v0}}{\left(1 + s/\omega_{3dB}\right)}$$

$$A(j\omega) = \frac{A_{v0}}{1 + j\frac{\omega}{\omega_{3dB}}}$$

$$\omega \gg \omega_{3dB}$$

$$|A(j\omega)| \simeq \frac{A_{v0}}{\omega/\omega_{3dB}} = \frac{A_{v0}\cdot\omega_{3dB}}{\omega} =$$

@ $\omega = \omega_{un}$

$$\frac{A_{v_0} \cdot \omega_{3dB}}{\omega_{un}} = 1 \Rightarrow \omega_{un} = \underbrace{A_{v_0}} \cdot \underbrace{\omega_{3dB}}$$

$$f_{un} = A_{v_0} \cdot f_{3dB}$$

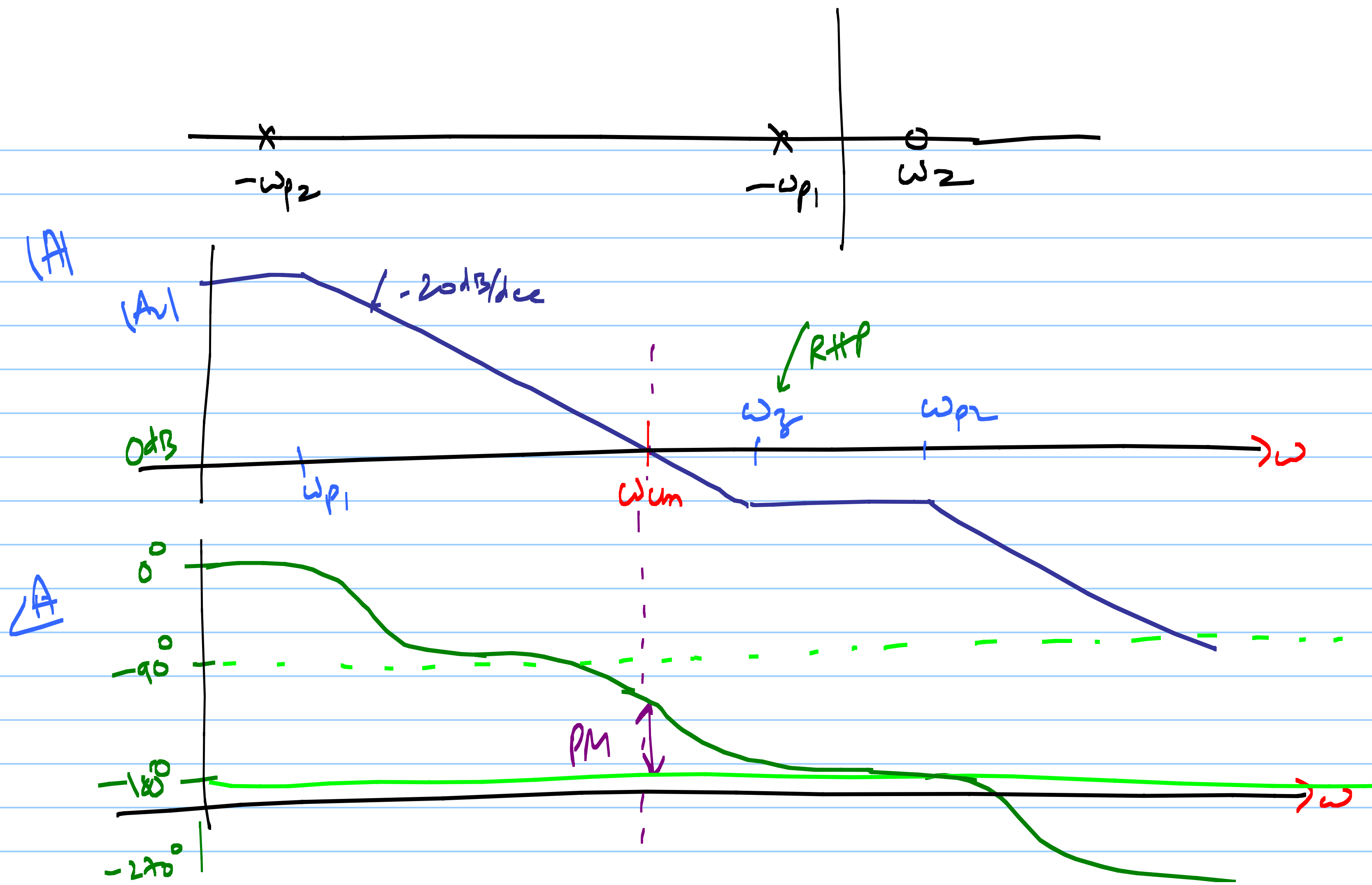
unity gain frequency

$$\omega_{un} \cong A_{v_0} \cdot \omega_{p_1}$$

$$= g_{m_1} \cancel{R_1}\, \cancel{g_{m_2}} \cancel{R_2} \times \frac{1}{\cancel{g_{m_2}} \cancel{R_2} \cancel{R_1} C_c}$$

$$\boxed{\omega_{un} \cong \frac{g_{m_1}}{C_c}}$$

$$\omega_z = \frac{g_{m_2}}{C_c}$$

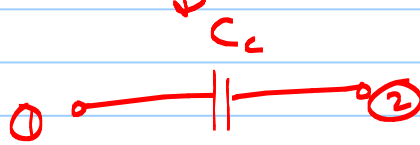


$-\omega_{p2}$
$-\omega_{p1}$
ω_z
$|A|$
$|A_v|$
$-20dB/dec$
RHP
ω_z
ω_{p2}
0dB
ω_{p1}
ω_{um}
ω
$\angle A$
0°
-90°
PM
-180°
-270°
ω

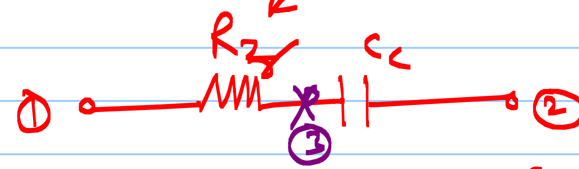
RHP zero is undesired $\longrightarrow$ near ω_{un}

Miller Cap

Compensation Cap



RHP zero nulling resistor

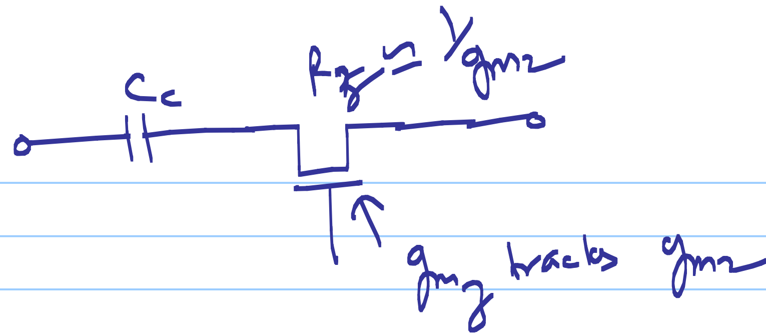


$$\omega_z = \frac{+1}{C_c\left[\frac{1}{g_{m2}} - R_z\right]}$$

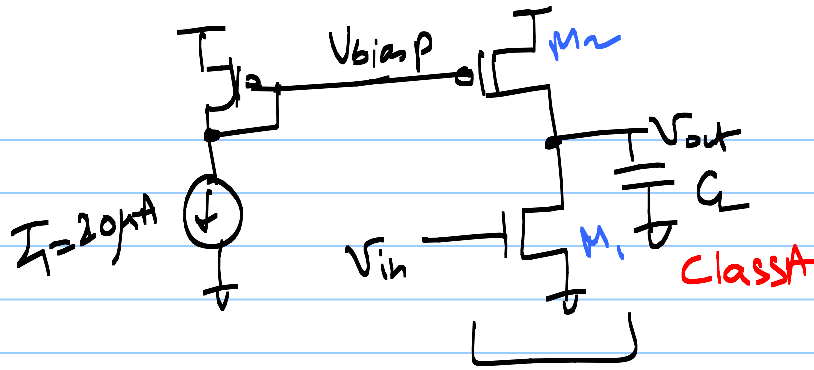
$$+\frac{g_{m2}}{C_c} = \frac{1}{\frac{C_c}{g_{m2}}}$$

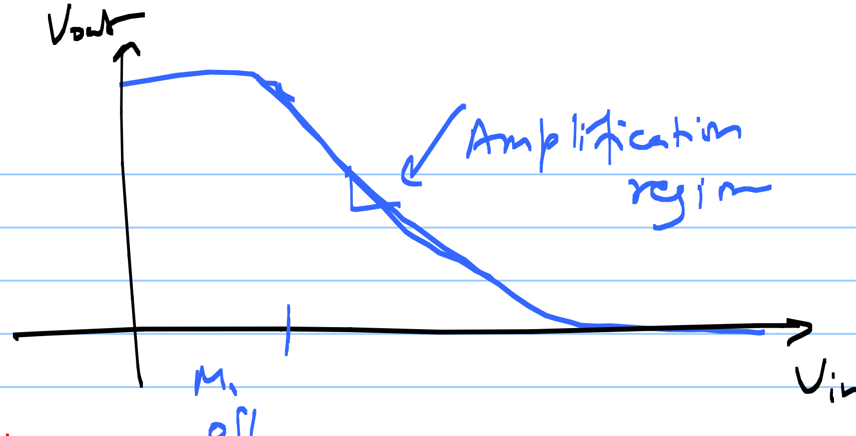
* $R_z = \frac{1}{g_{m2}}$ $\leftarrow$ RHP zero nulling

* $R_z > \frac{1}{g_{m2}}$ $\leftarrow$ LHP zero



$$R_z = \frac{1}{g_{mz}} \simeq \frac{1}{g_{m2}}$$

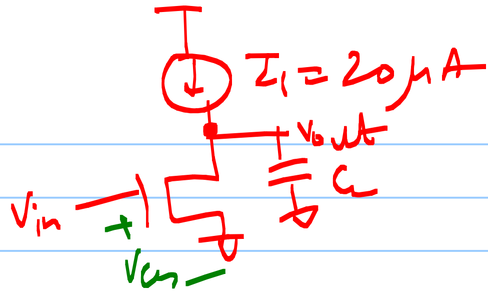


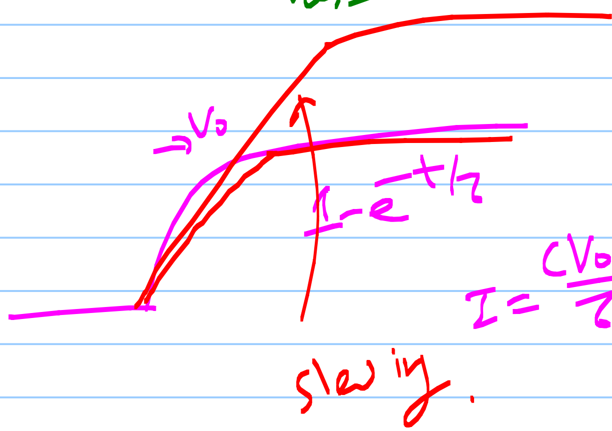


Class A → Both Pull-up / pull-down device are ON

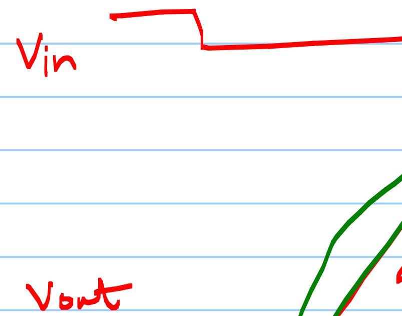
Class B → only one is ON

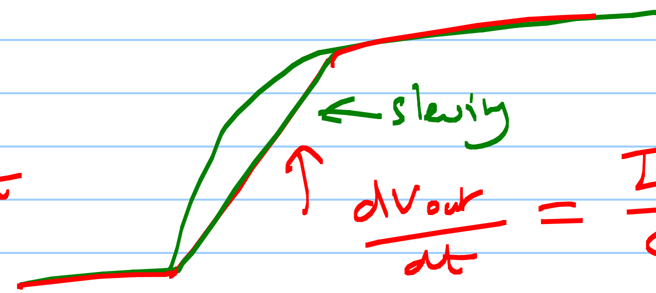
Class AB → both are ON during the transition





$$I = \frac{CV_o}{\tau} e^{-t/\tau}$$





$$\frac{dV_{out}}{dt} = \frac{I_1}{C_L}$$

+ve slew-rate limitation