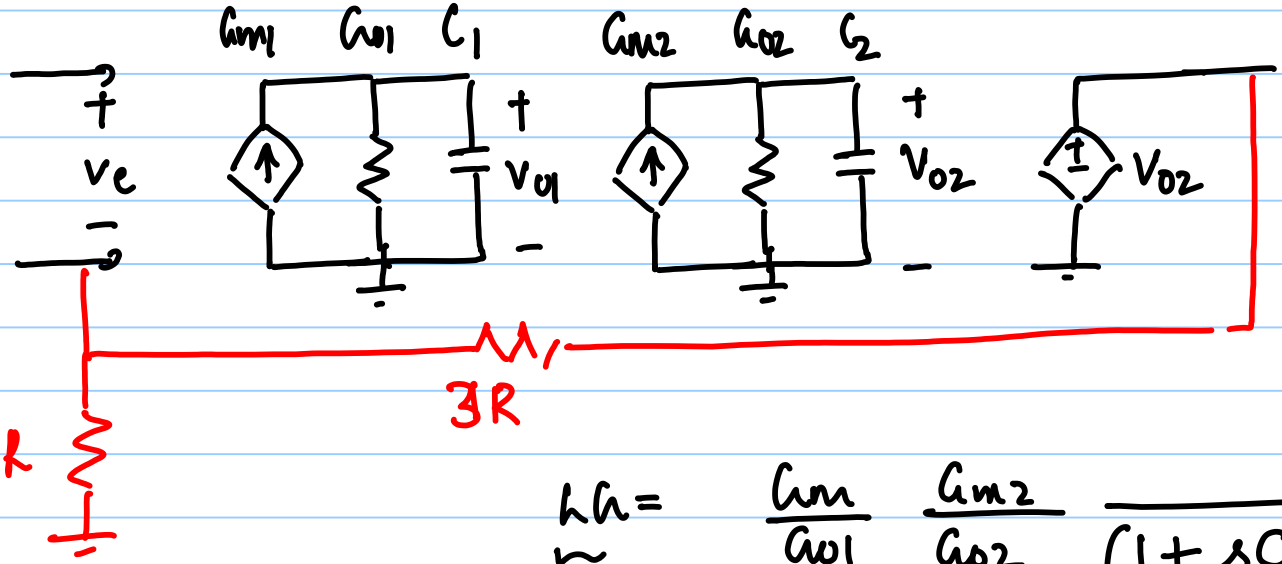
Note Title   23-02-2022

Lecture # 17

- Nyquist Stability Criterian.
- Loop Gain & Phase Margin.

Ex:



$$\underset{\sim}{LG} = \frac{G_m}{G_{o1}} \frac{G_{m2}}{G_{o2}} \frac{1}{\left(1+\frac{sC_1}{G_{o1}}\right)\left(1+\frac{sC_2}{G_{o2}}\right)} \times \frac{1}{4}$$

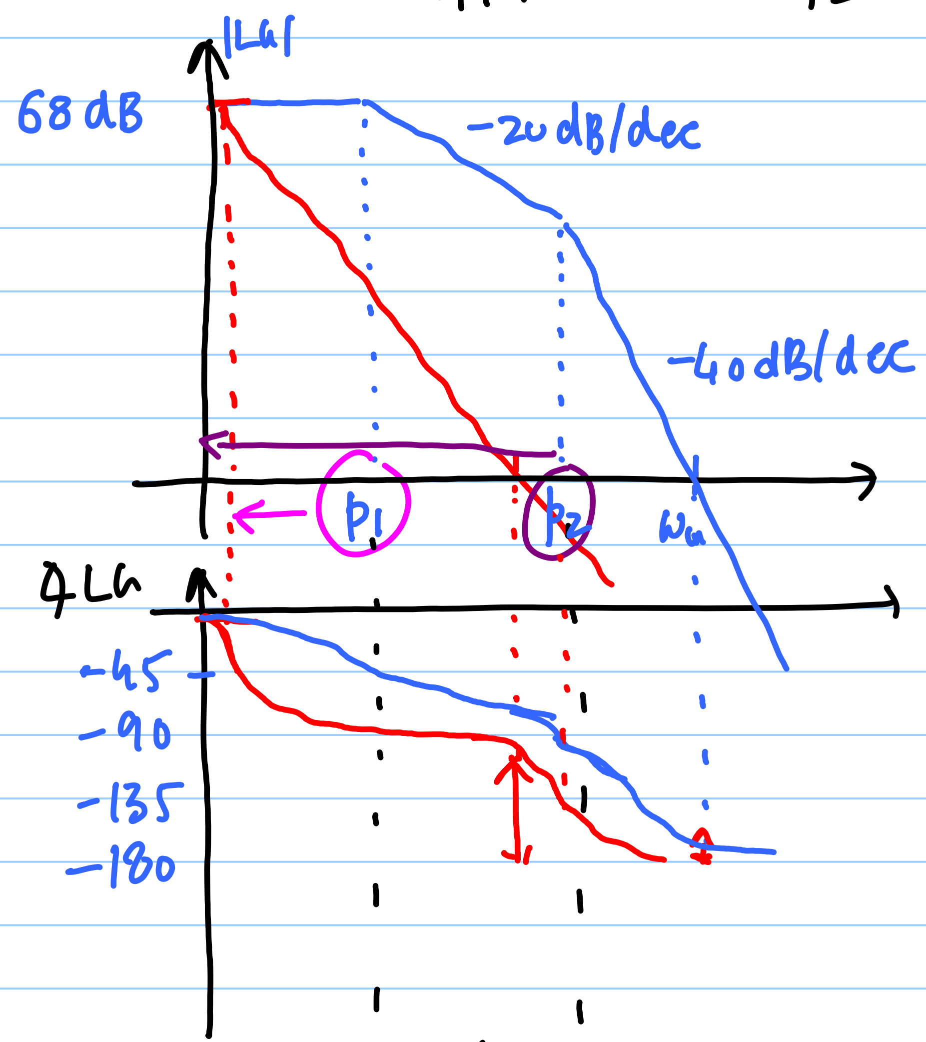
G_{m1} : 10 mS
G_{o1} : 0.1 mS
G_{m2} : 1 mS
G_{o2} : 0.01 mS
C_1 : 1nF
C_2 : 20 pF

$$A_{DC} = \frac{1}{4} \times 100 \times 100$$

$$p_1 = \frac{G_{o1}}{C_1} = \frac{0.1 \times 10^{-3}}{1 \times 10^{-9}} = 10^5 \text{ rad/s}$$

$$p_2 = \frac{G_{o2}}{C_2} = \frac{0.01 \times 10^{-3}}{20 \times 10^{-12}} = \frac{10^7}{20} = 5 \times 10^5 \text{ rad/s}$$

$$\measuredangle L_G = -\tan^{-1}\left(\frac{\omega}{p_1}\right) - \tan^{-1}\left(\frac{\omega}{p_2}\right)$$



$$\phi_m = 180^\circ - \tan^{-1}\left(\frac{\omega_u}{p_1}\right) - \tan^{-1}\left(\frac{\omega_u}{p_2}\right)$$

$$= 180^\circ - \tan^{-1}\left(\frac{111}{1}\right) - \tan^{-1}\left(\frac{111}{5}\right)$$

$$20\log\left(\frac{10^4}{4}\right) = 80 - 12 = \underline{68\text{ dB}}$$

$\omega_u > p_2, p_1$

$$|L_G(j\omega_u)| = 1$$

$$\frac{A_{DC}}{\sqrt{1+\frac{\omega_u^2}{p_1^2}}\sqrt{1+\frac{\omega_u^2}{p_2^2}}} = 1$$

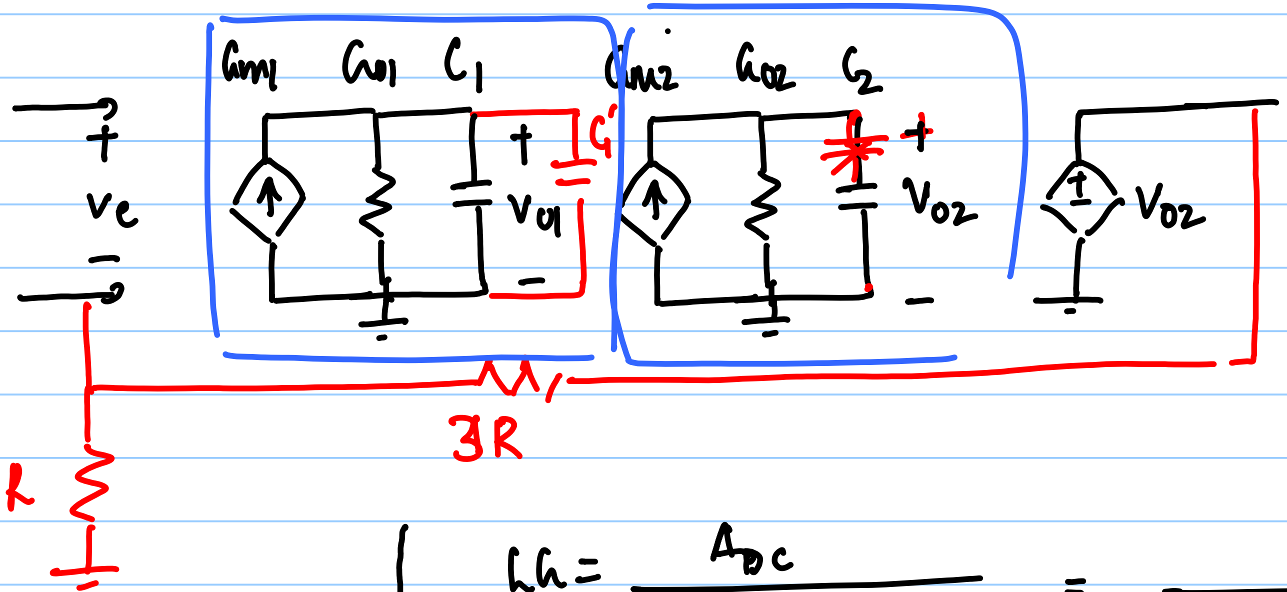
$$\frac{A_{DC}}{\frac{\omega_u^2}{p_1 p_2}} \approx 1 \Rightarrow \omega_u = \sqrt{A_{DC}\cdot p_1 p_2}$$

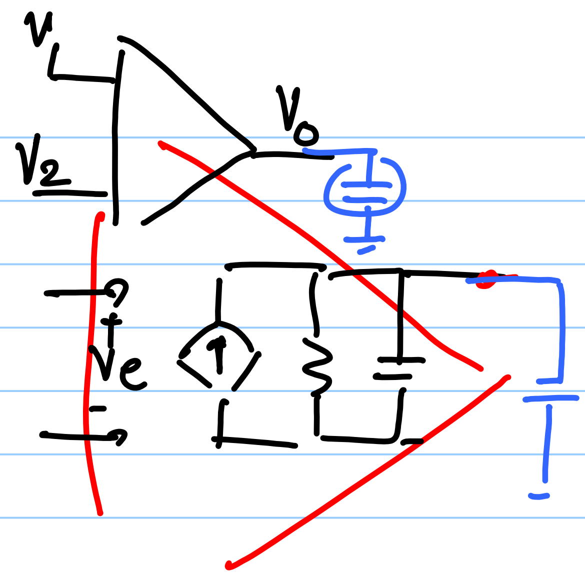
$$\omega_u = \sqrt{2500 \times 10^5 \times 5\times 10^5}$$

$$= \sqrt{125} \times 10^6$$

$$= 11.1 \times 10^6 = 111 \times 10^5 \text{ rad/s}$$

$$\phi_m = 180^\circ - 89.5 - 87.4 = 3.1^\circ$$





$$p_1 = \frac{G_{o1}}{\cancel{C_1}}$$

$$p_2 = \frac{G_{o2}}{\cancel{C_2}}$$

$$LG = \frac{A_{DC}}{\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)} = \frac{K \cdot \omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$\zeta = \frac{1}{2}\left(\sqrt{\frac{p_1}{p_2}} + \sqrt{\frac{p_2}{p_1}}\right)\frac{1}{\sqrt{1+A_0/K}} = 1 \Rightarrow \phi_m = 76^\circ$$

$$\zeta = 1 \Rightarrow \frac{p_1'}{p_2} + \frac{p_2}{p_1'} + 2 = 4\left(1+\frac{A_0}{K}\right)$$

$$p_2 \gg p_1' \Rightarrow \frac{p_2}{p_1'} \approx 4\left(1+\frac{A_0'}{K}\right) - 2 = 2 + 4\frac{A_0}{K}$$

$$\boxed{p_2 = \frac{4A_0 p_1'}{K} = 4\omega_u}$$

$$\phi_m = 76^\circ \Longrightarrow p_2 = \frac{4A_0}{K} p_1' \Longrightarrow p_1' = \frac{p_2}{4A_0/K} = \frac{5\times10^5}{4\times10^4/K_1} = 50\ \text{rad/s}$$

$$p_1 = 10^5\ \text{rad/s} \longrightarrow p_1' = 50\ \text{rad/s.}$$

"Dominant Pole Compensation"

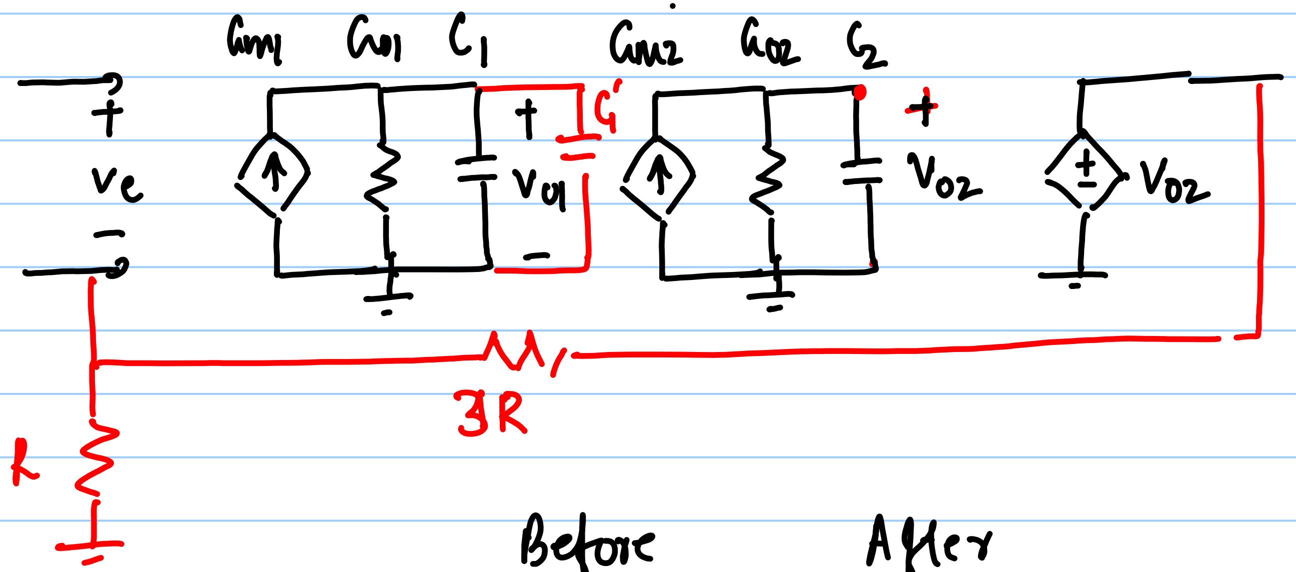
$$p_1' = \frac{G_{01}}{C_1'} = \frac{0.1\times10^{-3}}{C_1'} = 50$$

$$C_1' = \frac{1}{5}10^{-5} = 2\times10^{-6} = 2\mu F$$

$$C_1 = 1nF$$

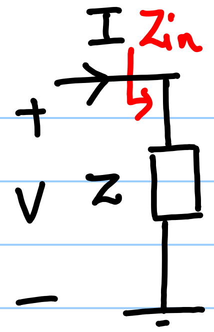
$$\Delta C = C_1' - C_1 = 2\mu F - 1nF = \underline{1.999\,\mu F}$$

$p_1 = 4 . A_0$

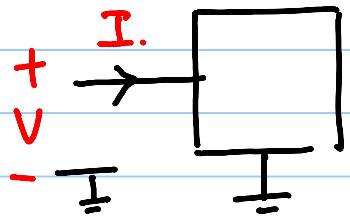


	Before	After
DC gain	2500	2500
p_1	10^5	50
p_2	5×10^5	5×10^5
ω_u	117×10^5	1.25×10^5
ϕ_m	3.4°	76°
C_1	1nF	2µF

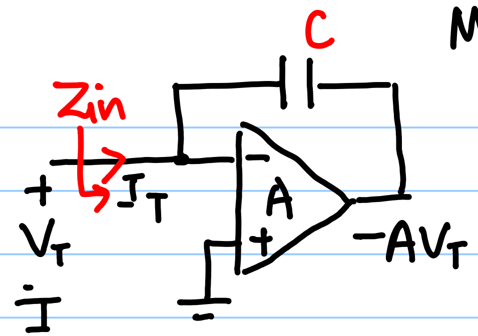
"Miller Multiplication"



$$Z_{in} = \frac{V}{I} = Z$$



$$\frac{V}{I} = Z$$



$$I_T = \frac{V_T - (-AV_T)}{1/sC}$$

$$I_T = (1+A)\,V_T \times sC$$

$$Z_{in} = \frac{V_T}{I_T} = \frac{1}{s\,\underbrace{(1+A)C}} = \frac{1}{sC_x}$$

$$C_x \doteq (1+A)\,C$$