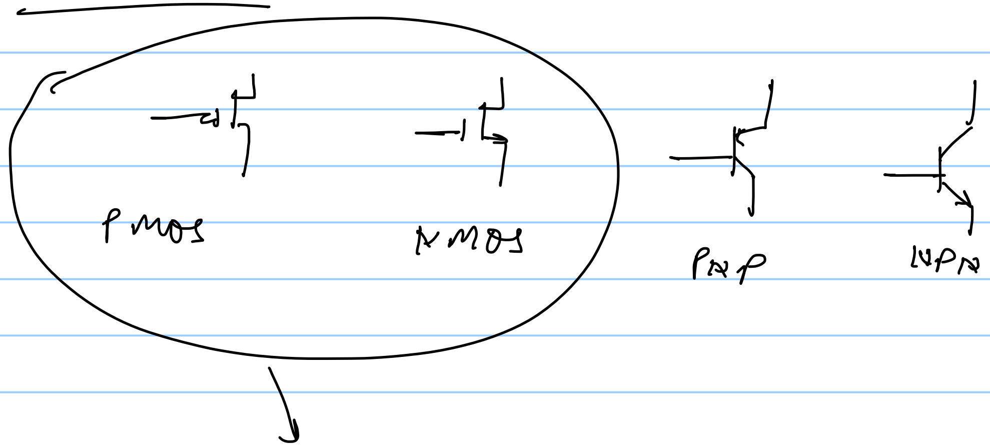
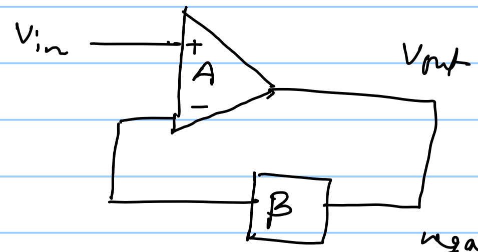
Pass Elements



CMOS Process Technology

AC Analysis of LDO or Linear Regulator

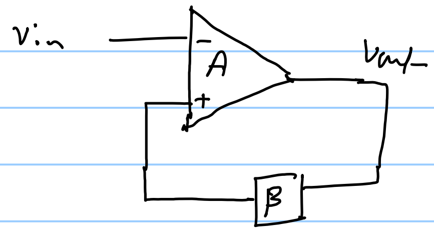
Negative Feedback



negative Feedback

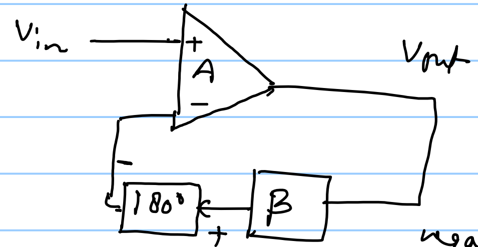
$$\frac{V_{out}}{V_{in}} = \frac{A}{1 + A\beta}$$

$A\beta \rightarrow$ Loop Gain (open loop)



$$\frac{V_{out}}{V_{in}} = \frac{A}{1 - A\beta}$$

$A\beta = 1 \Rightarrow V_{out} \to \infty$ (unstable)



negative Feedback

$$\frac{V_{out}}{V_{in}} = \frac{A}{1 + A\beta}$$

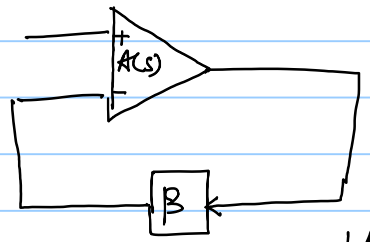
$A\beta \rightarrow$ Loop Gain (open loop)

Two conditions for unstable system

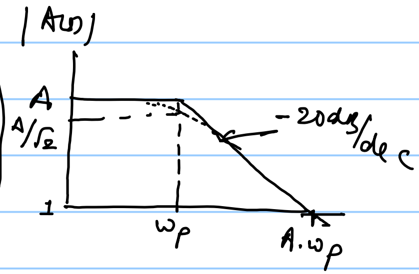
$A\beta \geq 1$

$\angle A\beta = 180°$

Phase shift is introduced by combination of R & C



$$A(s) = \frac{A}{1 + s/\omega_p}$$

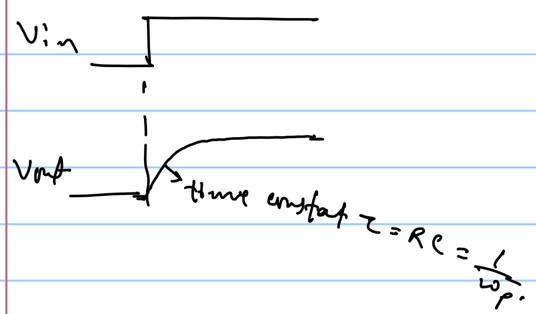


$$|A(s)| = \frac{A}{\sqrt{1 + \left(\frac{\omega}{\omega_p}\right)^2}}$$

$\omega / \omega_p >> 1$

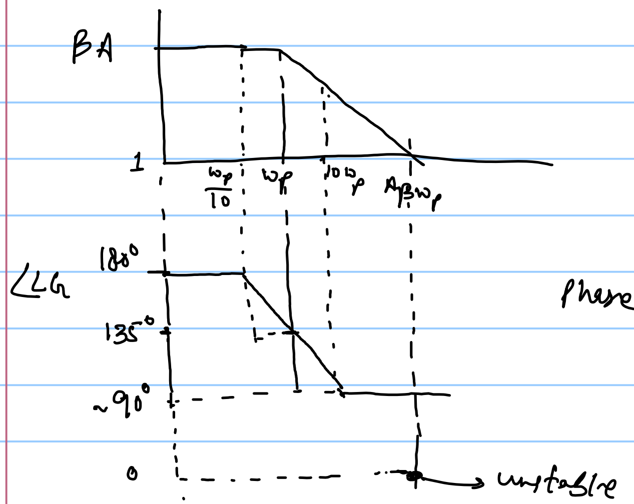
$$|A(s)| = A \cdot \frac{\omega_p}{\omega}$$

$\omega = 10 \cdot \omega_p$



First order system is always stable as long as pole in closed loop remains in L.H.P.

$|\beta A(\omega)| = |LG|$



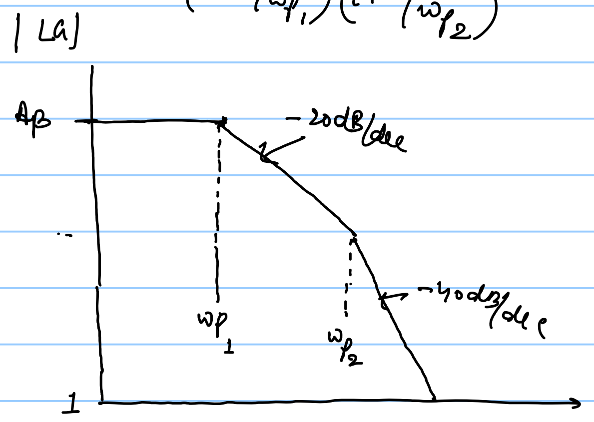
Phase $= \tan^{-1}\frac{\omega}{\omega_p}$

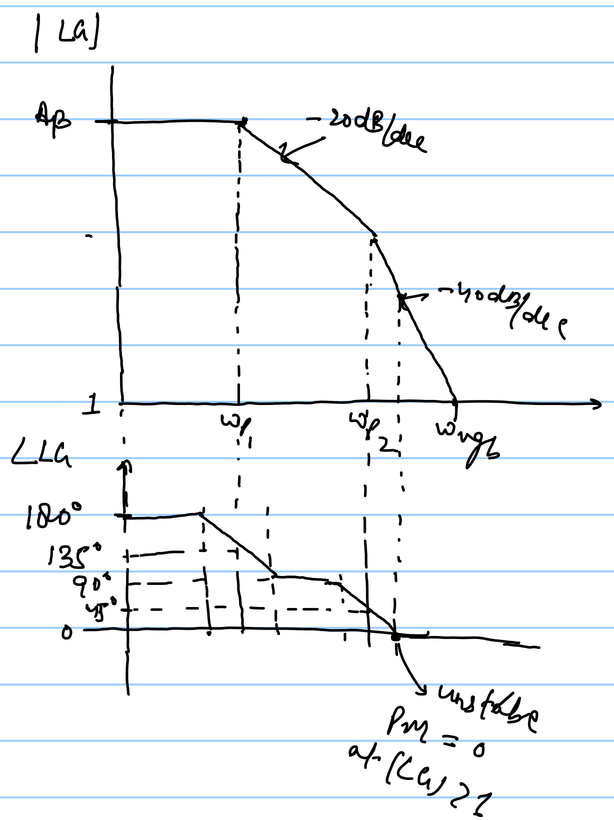
Phase Margin $= 180^\circ - \tan^{-1} \frac{\omega_{ugb}}{\omega_p}$

$\omega_{ugb} = \omega$ at $|LG| = 1$

Second order system

$$A(s) = \frac{A}{(1+s/\omega_{p_1})(1+s/\omega_{p_2})}$$





|LG|
Aβ
-20dB/dec
-40dB/dec
1
ωp1
ωp2
ωugb
∠LG
180°
135°
90°
45°
0
unstable
PM = 0
at |LG| ≥ 1

Assume

$\omega_{p_2} = \omega_{ugb}$

$PM = 45°$

A stable system requires $PM > 60°$

2nd pole should always be outside ω_{ugb}.