EE2019 Analog Systems & Lab

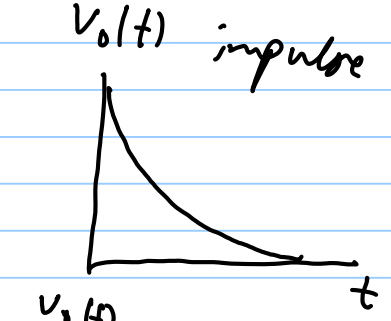
Note Title 2/25/2020

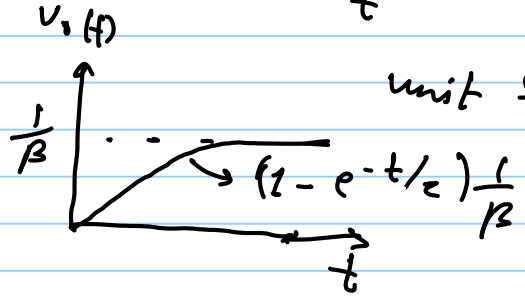
Stability

Stability of First order system.

→ First order system is inherently stable for $\beta > 0$

→ min. phase margin is 90^0

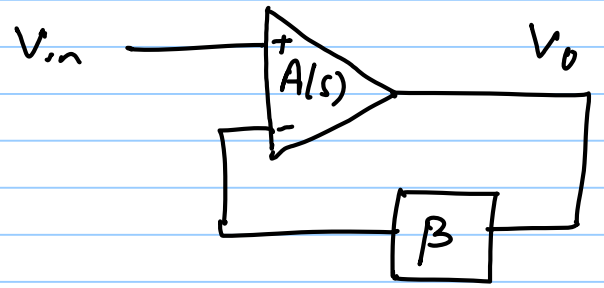




$\tau = \frac{1}{\omega_{ugb}}$

$\omega_{ugb} = \beta A_0 \omega_p$

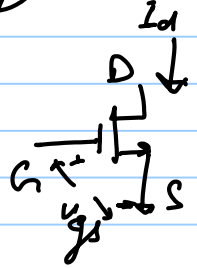
stability of a second order system



$$A(s) = \frac{A_0}{(1 + s/\omega_{p_1})(1 + s/\omega_{p_2})}$$

2-stage op-amp

Need of 2-stage op-amp



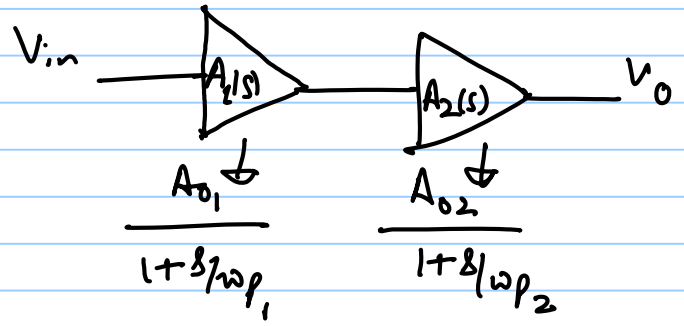
$I_d = g_m \cdot V_{gs}$

$Gain = g_m \cdot r_o$

→ Gain of single stage op-amp is limited by the transistor.

→ Usually this gain is limited to <100 (40 dB).

→ In order to achieve higher gain, we need to cascade multiple single stages.



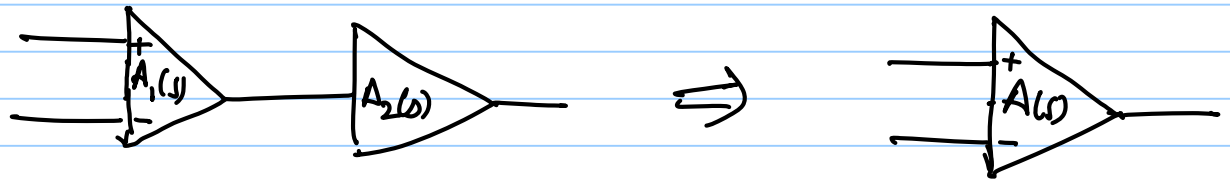
$$\frac{V_o}{V_{in}} = A_1(s) \cdot A_2(s)$$

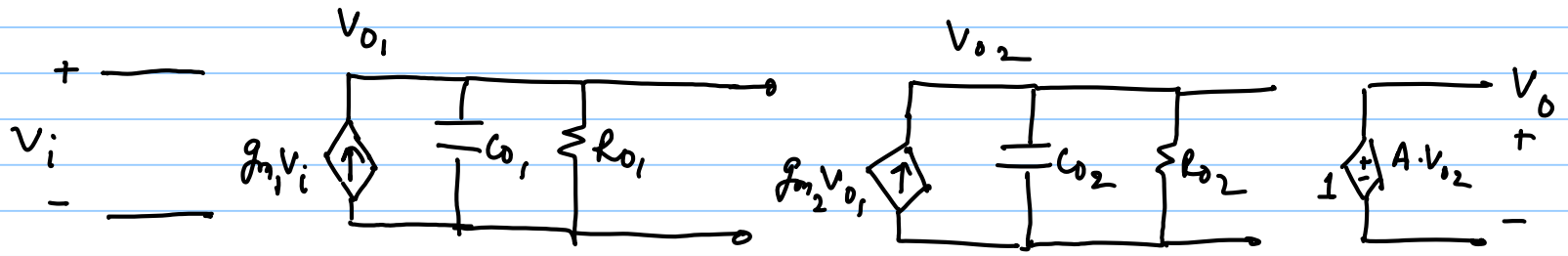
$$= \frac{A_{01}}{1+s/\omega_{p_1}} \cdot \frac{A_{02}}{1+s/\omega_{p_2}}$$

$$= \frac{A_0}{(1+s/\omega_{p_1})(1+s/\omega_{p_2})} \qquad A_0 = A_{0_1} \cdot A_{0_2}$$

Assume $A_{0_1} = A_{0_2} = 100$ (40 dB)

$A_0 = 10^4$ (80 dB)





$$\frac{V_O(s)}{V_i(s)} = \frac{g_{m_1} R_{O_1}}{1 + R_{O_1} C_{O_1} s} \times \frac{g_{m_2} R_{O_2}}{1 + R_{O_2} C_{O_2} s}$$

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

$$A_O = g_{m_1} R_{O_1} \cdot g_{m_2} R_{O_2}$$

$$\omega_{p_1} = \frac{1}{R_{O_1} C_{O_1}} \quad ; \quad \omega_{p_2} = \frac{1}{R_{O_2} C_{O_2}}$$

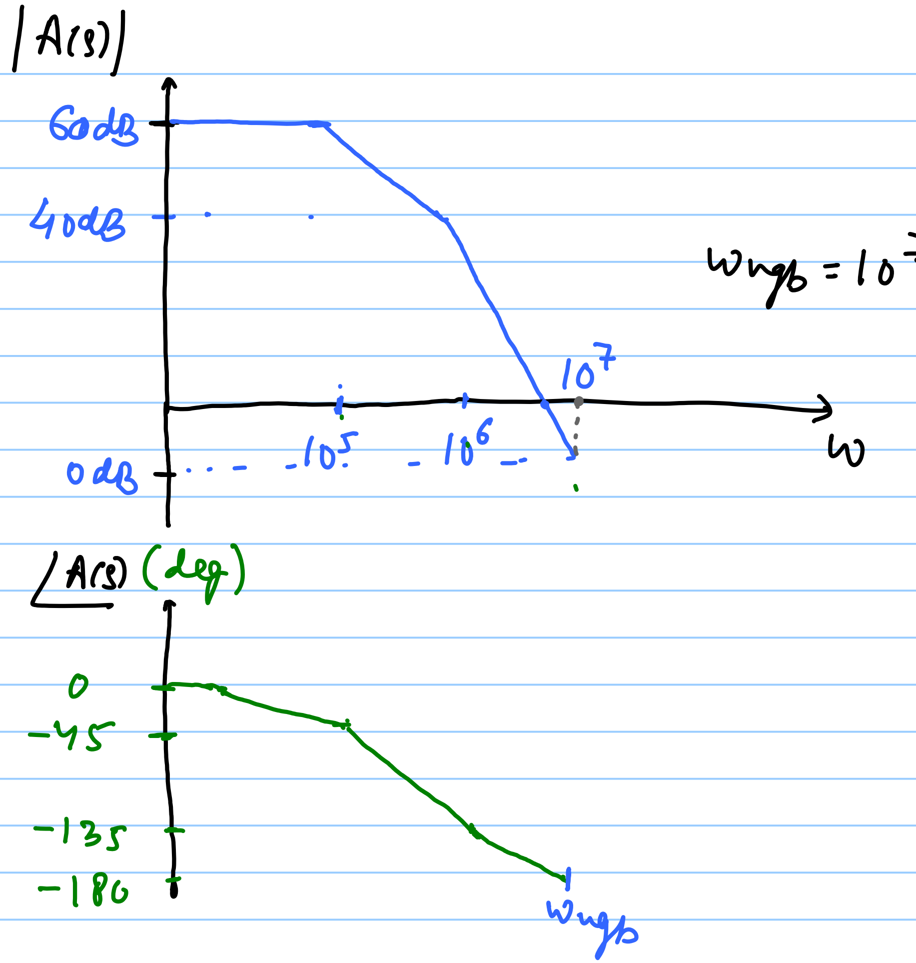
Assume, $A_0 = 1000$; $g_{m_1} = 100\mu A/V$, $R_{o_1} = 1M\Omega$, $g_{m_2} = 100\mu A/V$, $R_{o_2} = 100K\Omega$

$g_{m_1} R_{o_1} = 100$, $g_{m_2} R_{o_1} = 10 \longrightarrow A_0 = 1000$

$C_{o_1} = 10pF$ & $C_{o_2} = 10pF$

$$\omega_{p_1} = \frac{1}{R_{o_1} C_{o_1}} = \frac{1}{10^6 \times 10^{-11}} = 10^5 \text{ rad/sec}$$

$$\omega_{p_2} = \frac{1}{R_{o_2} C_{o_2}} = \frac{1}{10^5 \times 10^{-11}} = 10^6 \text{ rad/sec}$$



$\omega_{ugb} = 10^7$ rad/sec

Phase margin ≈ 0

Total phase shift due to poles $= -180^\circ$

-180° comes from -ve feedback

So if this op-amp is connected in -ve feedback then

total loop phase shift $= -360^\circ \Longrightarrow$ +ve feedback $\rightarrow$ unstable.