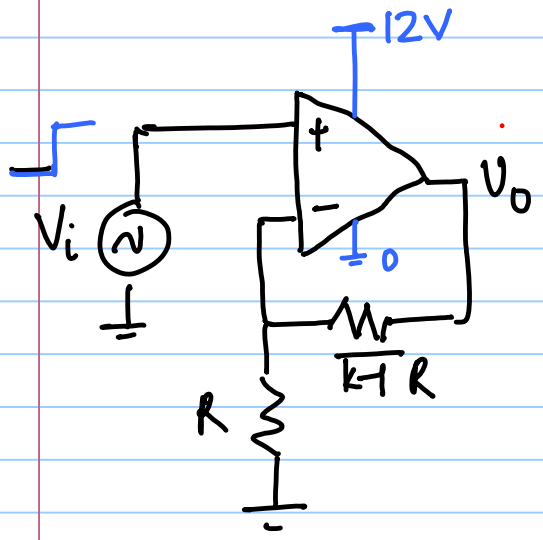
Lecture #15

Note Title 12-02-2020



$$\frac{V_o}{V_i} = K$$

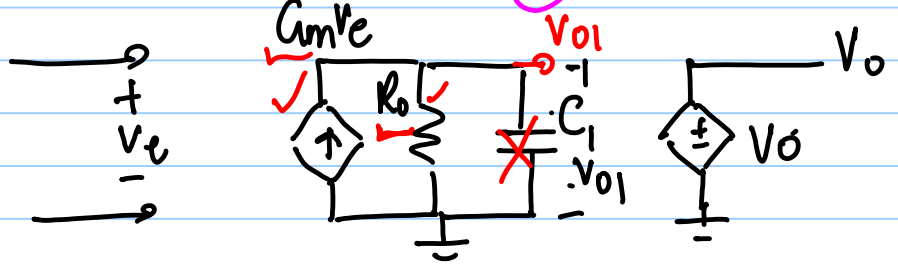
$$V_o = V_e \times G_m\left(R_o \,\|\, \frac{1}{sC_1}\right)$$

$$= V_e \cdot \frac{G_m R_o}{1 + s R_o C_1}$$

$G_m R_o \rightarrow A_0$

$R_o C_1 \rightarrow \frac{1}{p_1}$

Real amp.: $\dfrac{A_0}{1 + s/p_1} = \dfrac{V_o}{V_e}$ ✓ ✓ → p_1



Ideal amp: $C_1 \rightarrow 0$

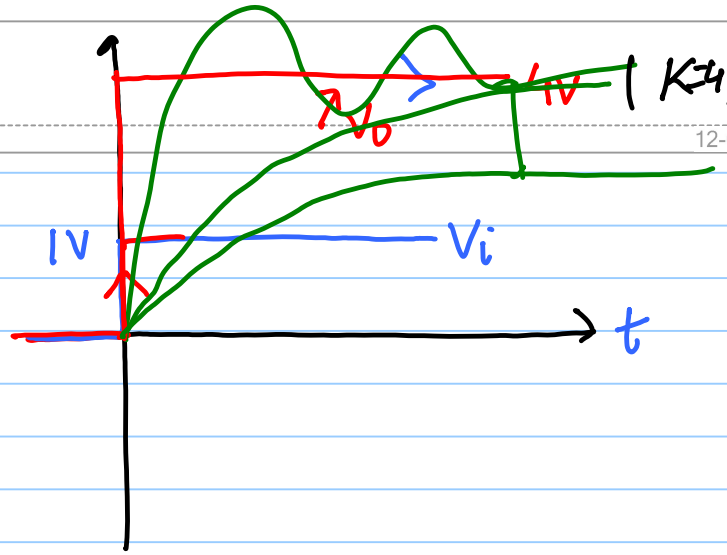
Real amp. $C_1 \neq 0$

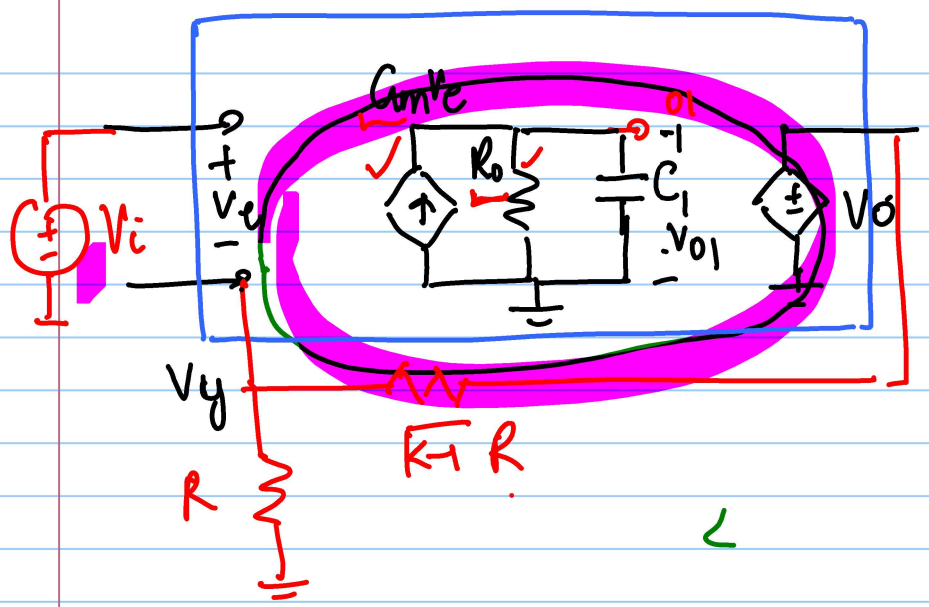
Ideal amp. $A_0 = G_m R_o \rightarrow \infty$

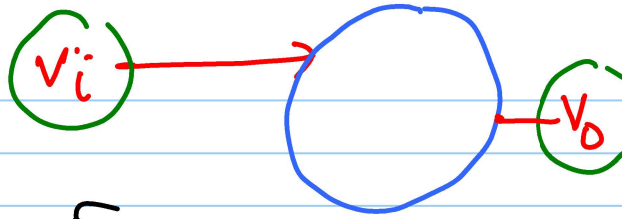
$G_m R_o$ as large as possible

C_1 as low as possible

⇒ finite dc gain and finite value for p_1







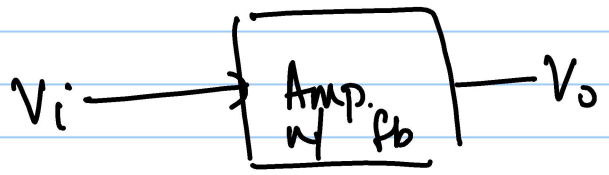
$$\frac{V_o}{V_i} = \frac{K}{1 + \frac{K}{A(s)}}$$

$$V_o = (V_i - V_y)\, A(s)$$

$$= \left(V_i - \frac{V_o}{K}\right) A(s)$$

$$V_o\left(\frac{1}{A(s)} + \frac{1}{K}\right) = V_i$$

$$H(s) = \frac{V_o(s)}{V_i(s)} = K \frac{1}{1 + \frac{K(1 + s/p_1)}{A_0}} = K \frac{1}{\left(1 + \frac{K}{A_0}\right) + \frac{K}{A_0 p_1} s}$$



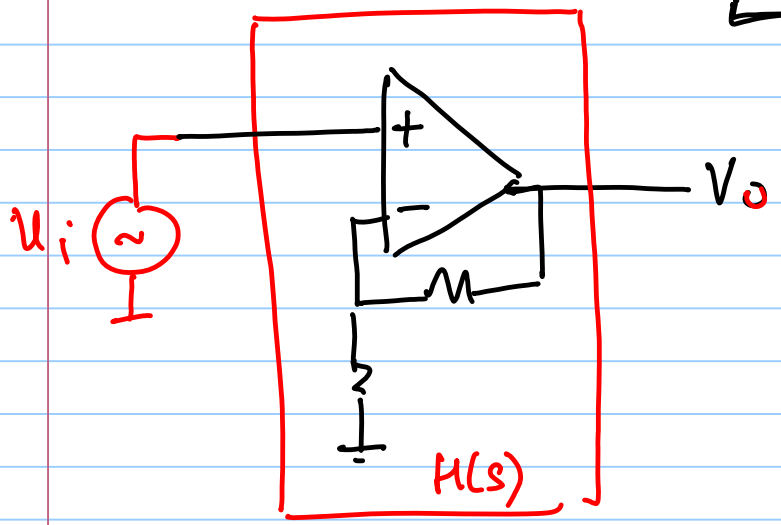
→ poles in L.H.P

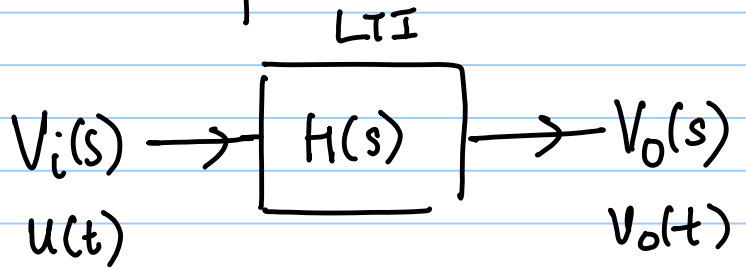
$$H(s) = \frac{V_o(s)}{V_i(s)} = \frac{K}{\left(1+\frac{K}{A_0}\right)} \cdot \frac{1}{1+\frac{K}{A_0 p_1\left(1+\frac{K}{A_0}\right)}s} = \frac{K}{\left(1+\frac{K}{A_0}\right)} \cdot \frac{1}{1+\frac{s}{p_1\left(\frac{A_0}{K}+1\right)}}$$

$$= \frac{A_{DC}}{1+\frac{s}{p_1'}} \quad \checkmark \qquad p_1'$$

$$A_{DC} = \frac{K}{1+\frac{K}{A_0}}$$

1st pole $s = -p_1' = -p_1\left(1+\frac{A_0}{K}\right)$ ✓





$$v_o(t) = v_i(t) * h(t),$$

$$V_o(s) = V_i(s)\, H(s)$$

$$v_o(t) = \mathcal{L}^{-1}\left(V_o(s)\right)$$

$v_i(t) = u(t)$

$V_i(s) = \frac{1}{s}$

$$V_0(s) = \frac{1}{s} \cdot \frac{A_{DC}}{1 + s/p_1'} = \frac{A_{DC} p_1'}{(s + p_1')\, s}$$

$$= \frac{A_{DC}}{s} + \frac{-A_{DC}}{s + p_1'}$$

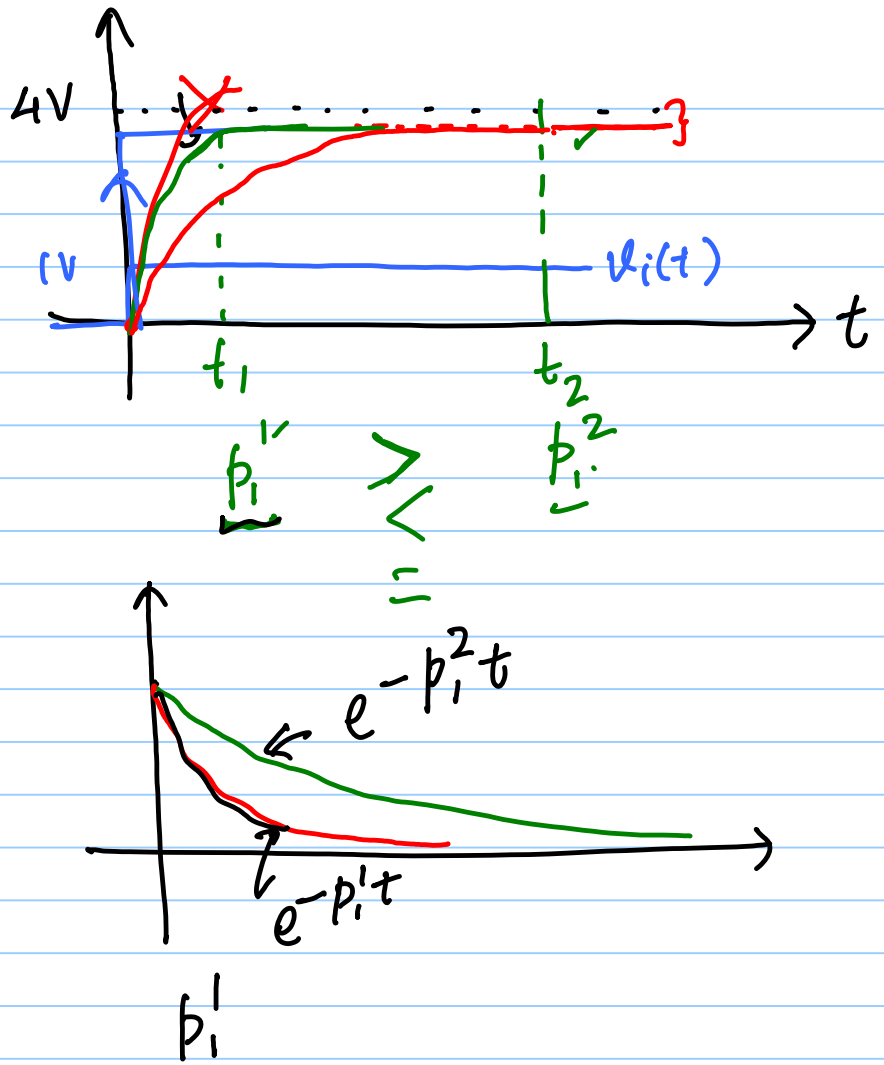
$$= A_{DC} \left[\frac{1}{s} - \frac{1}{s + p_1'} \right]$$

$$v_0(t) = \mathcal{L}^{-1}[V_0(s)]$$

$$= A_{DC} \left[u(t) - e^{-p_1' t} u(t) \right]$$

$$= A_{DC} \left[1 - e^{-p_1' t} \right] u(t)$$

$$= \frac{K}{1 + \frac{K}{A_0}} \left[1 - e^{-p_1 \left(1 + \frac{A_0}{K}\right) t} \right] u(t)$$



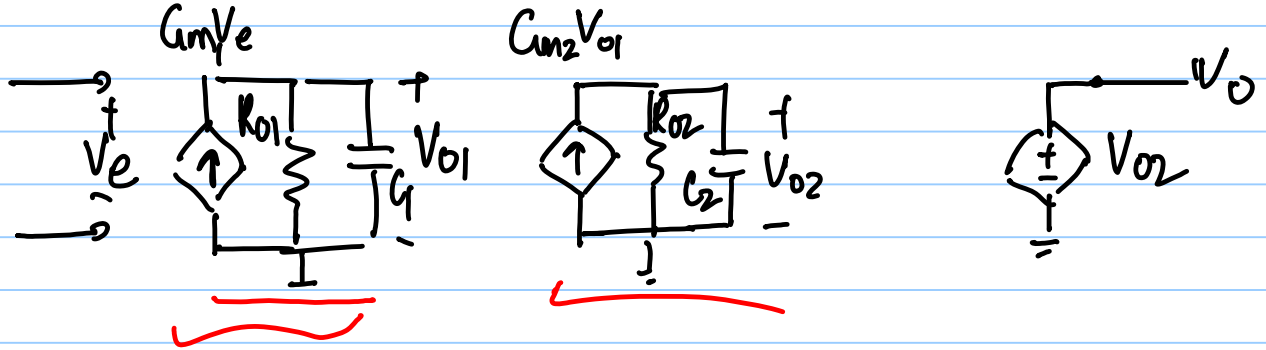
$$\frac{dV_o(t)}{dt} = A_{DC}\, p_1'\, e^{-p_1' t}$$

Steady state error, $\epsilon_{static} = \lim_{t\to\infty} v_o(t)$ — $\lim_{t\to 0} v_o(t)$

$t\to\infty$, Λ ? is ideal $\qquad t\to 0$

$$= K v_{in} - \frac{K}{1+\frac{K}{A_o}} v_{in}$$

$$= \frac{1}{\frac{A_o}{K}+1}\, v_{in}$$

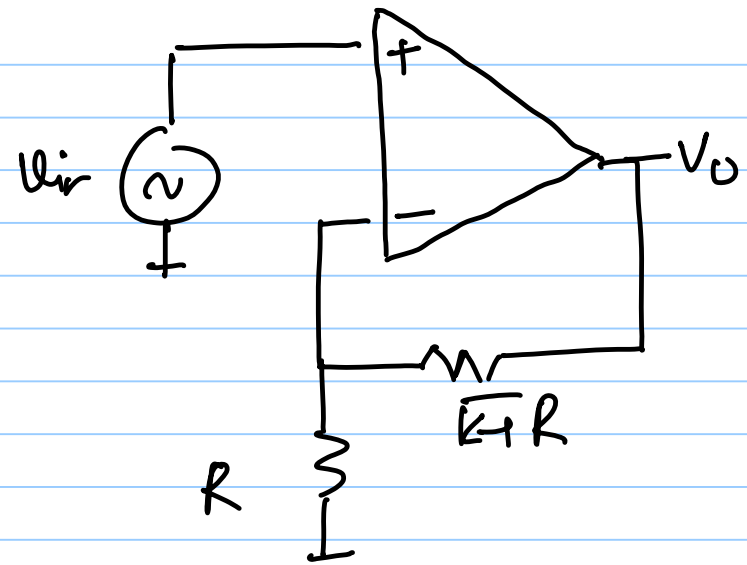


$$A(s) = \frac{V_o}{V_e} = \frac{G_{m1} R_{o1}}{1+sR_{o1}C_1}\,\frac{G_{m2} R_{o2}}{1+sR_{o2}C_2} = \frac{A_o}{(1+s/p_1)(1+s/p_2)}$$

$$A_0 = G_{m1} R_{o1} G_{m2} R_{o2}$$

$$s = -p_1 = -\frac{1}{R_{o1} C_1}$$

$$s = -p_2 = \frac{-1}{R_{o2} C_2}$$



$$\frac{V_O}{V_i} = \frac{K}{1+\frac{K}{A(s)}} = \frac{K}{1+\frac{K}{A_0}\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)}$$

$$= \frac{K}{\frac{K}{A_0}\left[\frac{A_0}{K}+1\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)\right]} = \frac{A_0}{\frac{A_0}{K}+1+s\left(\frac{1}{p_1}+\frac{1}{p_2}\right)+\frac{s^2}{p_1 p_2}}$$

$$= \frac{K}{1+\frac{K}{A_0}}\left[\frac{1}{1+\frac{s}{(1+A_0/K)}\left(\frac{1}{p_1}+\frac{1}{p_2}\right)+\frac{s^2}{p_1 p_2\left(1+\frac{A_0}{K}\right)}}\right]$$

$$= \frac{A_{DC}}{1 + s(\quad) + s^2(\quad)}$$

$$= \frac{1}{\frac{s^2}{\omega_p^2} + \frac{s}{\omega_p Q_p} + 1} = H(s)$$

$$H(s) = \frac{1}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$