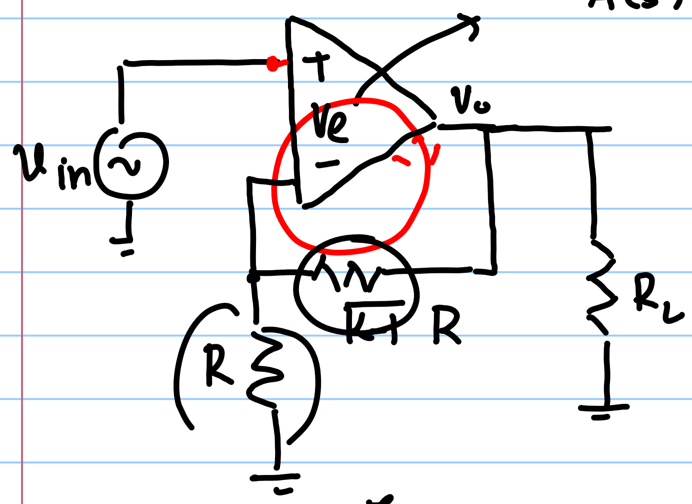
Note Title

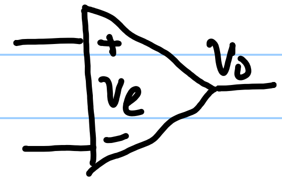
# Lecture # 15

26-02-2021

$A(s)$



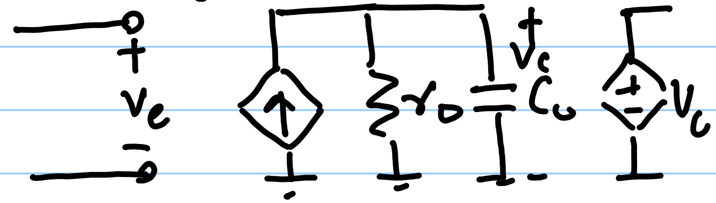

"standalone Amp"




$$A(s) = \frac{V_o}{V_e} = \frac{A_0}{1+s/p_1}$$

L.H.P

$g_m V_e$




$$\longrightarrow \quad A_0 = g_m r_o$$

$$p_1 = \frac{1}{r_o C_o}$$

$$\frac{V_o}{V_e} = g_m \left(r_o \,||\, \frac{1}{sC_o}\right) = \frac{g_m r_o}{1+sC_o r_o}$$

$$v_{in}(t) \xrightarrow{\mathcal{L}} V_{in}(s)$$

$$v_o(t) \xrightarrow{\mathcal{L}} V_o(s)$$

$$\left[ V_{in}(s) - \frac{V_o(s)}{K} \right] A(s) = V_o(s)$$

$$\frac{V_o(s)}{V_{in}(s)} = \frac{K}{1+\frac{K}{A(s)}} = \frac{K}{1+\frac{K}{A_0}\left(1+\frac{s}{p_1}\right)} = \frac{K}{1+\frac{K}{A_0}} \; \frac{1}{1+\frac{sK/A_0}{p_1\left(1+\frac{K}{A_0}\right)}}$$

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

$$= A_{DC} \frac{1}{1+ s/\omega_p}$$

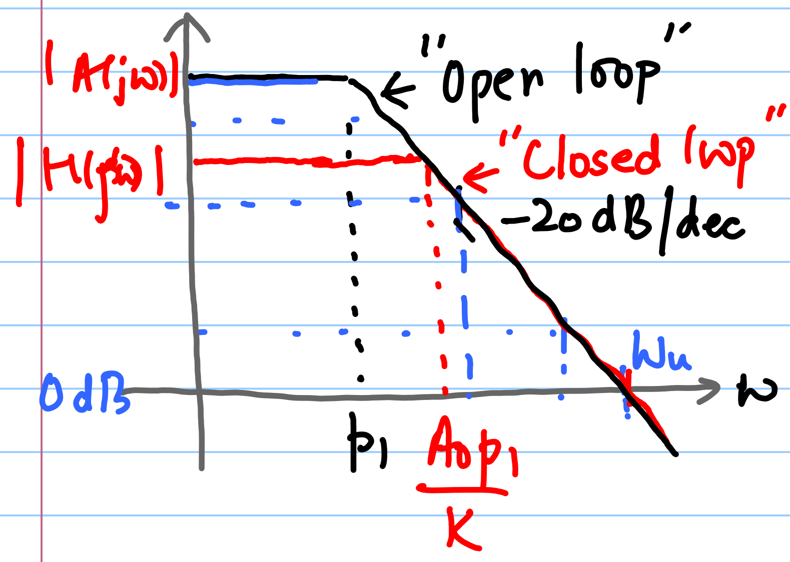
$$|H(j0)| = \frac{K}{1+\frac{K}{A_0}} \approx K$$

$$\omega_u = A_{DC} \cdot \omega_p$$

$$= K \cdot \frac{A_0 p_1}{K} = A_0 p_1$$

Where $A_{DC} = \frac{K}{1+K/A_0}$ , $\omega_p = p_1\left(1+\frac{A_0}{K}\right) \approx \frac{A_0 p_1}{K}$

$s_1 = -\omega_p$ (L.H.P)




$$A(s) = \frac{A_0}{1+s/p_1} \xrightarrow{\omega_u} \omega_u \approx A_0 p_1$$

$20\log_{10}|A(j\omega)|$ : @ $\omega=0$ $20\log_{10}|A_0|$

@ $s = jp_1 \Rightarrow 20\log_{10}\left(\left|\frac{A_0}{1+j}\right|\right)$

Gain x bandwidth = Constant.

$A_0 \times p_1 = A_0 p_1$ / open loop

$$|A(j\omega_u)| = 1 : \left|\frac{A_0}{1+j\frac{\omega_u}{p_1}}\right| \approx \left|\frac{A_0}{j\frac{\omega_u}{p_1}}\right|$$

$\Rightarrow \omega_u = A_0 p_1$

$K \times \frac{A_0 p_1}{K} = A_0 p_1$ closed loop

$$H(s) = \frac{A_0}{1 + s/p_1} \checkmark$$

$-3$ dB bandwidth (BW) is frequency at which $|H(j\omega)| = \frac{1}{\sqrt{2}} |H(0)|$

$$\omega_{-3dB} = p_1$$

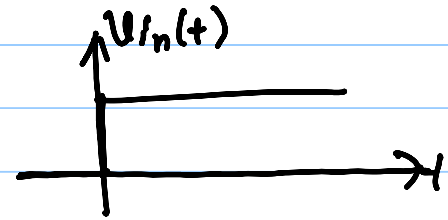
$$V_{in}(s) \longrightarrow \boxed{H(s)} \longrightarrow V_o(s)$$

$$V_o(s) = V_{in}(s)\, H(s)$$

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

$$= \mathcal{L}^{-1}\{V_{in}(s)\, H(s)\}$$

$$v_{in}(t) = \underline{v_{in}(0)\, u(t)}$$




$$V_{in}(s) = \frac{v_{in}(0)}{s}$$

$$V_o(s) = \frac{v_{in}(0)}{s} \times \frac{A_{DC}}{1 + s/\omega_p}$$

$$v_o(t) = \mathcal{L}^{-1}\{ \downarrow \}$$

$$\frac{v_{in}(0)}{s} \times \frac{A_{DC}}{1 + s/\omega_p} = \frac{P}{s} + \frac{Q}{s + \omega_p}$$

$$v_o(t) = \mathcal{L}^{-1}\left\{ \frac{A_{DC}}{\underset{\sim}{s}} + \frac{-A_{DC}}{s+\omega_{p1}} \right\}$$

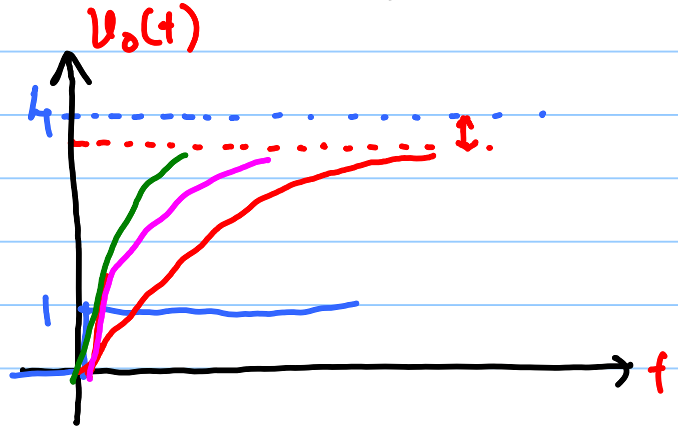
$$= \left[ A_{DC}\, u(t) - A_{DC}\, e^{-\omega_p t} u(t) \right] v_{in}(0)$$

$$= A_{DC} \left(1 - e^{-\omega_p t}\right) v_{in}(0)\ u(t)$$

$$\approx \frac{K}{1+\frac{K}{A_o}} v_{in}(0) \left(1 - e^{-\omega_p t}\right) u(t)$$

$$\frac{dv_o}{dt} = \frac{K}{1+\frac{K}{A_o}} v_{in}(0)\, \omega_p e^{-\omega_p t}$$

$$\omega_p = \frac{A_o p_1}{K}$$




$$\epsilon_s = \frac{v_o^{ideal}(t\to\infty) - v_o(t\to\infty)}{v_o^{ideal}(t\to\infty)}$$

$$= \frac{K - K/(1+K/A_o)}{K} = 1 - \frac{1}{1+K/A_o}$$

$$= \frac{(A_o/K)^{-1}}{1+(A_o/K)^{-1}} = \frac{1}{1+A_o/K}\ \checkmark$$