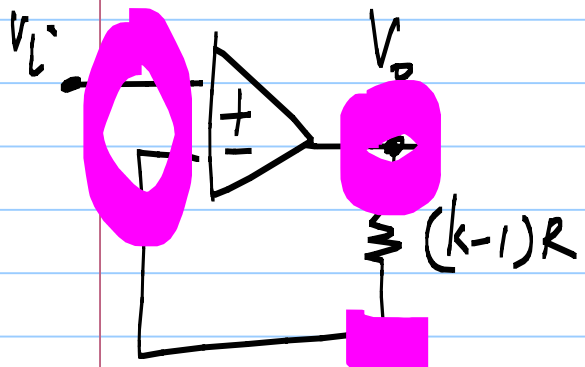
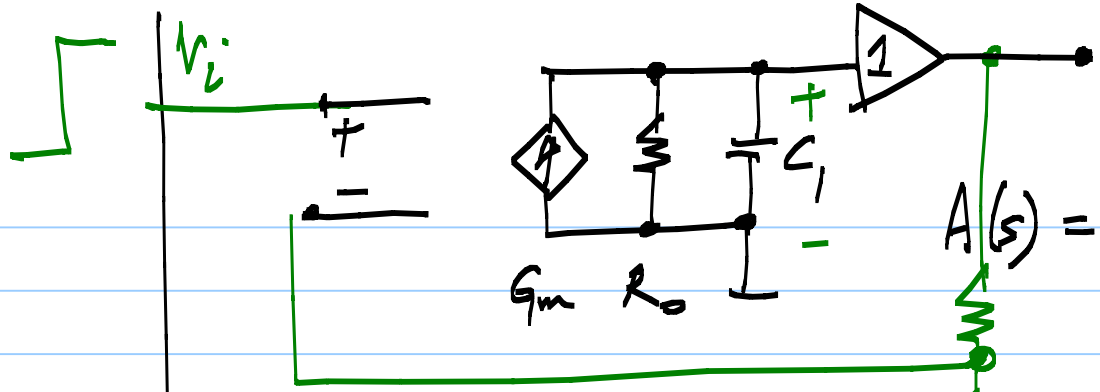
Lecture 8





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

$G_m R_o$

$\frac{1}{C_1 R_o}$

$$\frac{V_o}{V_i} = \frac{k}{1 + \frac{k}{A(s)}} = \frac{k}{1 + \frac{k}{A_o}(1 + s/p_1)}$$

$$A_1 = \frac{\left[k \Big/ 1 + \frac{k}{A_o}\right]}{1 + \frac{s}{p_a}}$$

Pole @ $-p_a$

$$= \left\{ \frac{k}{\left(1 + \frac{k}{A_o}\right) + \frac{s}{\left(\frac{A_o}{k} \cdot p_1\right)}} \right\}$$

$$p_a \simeq +\frac{A_o}{k} p_1$$

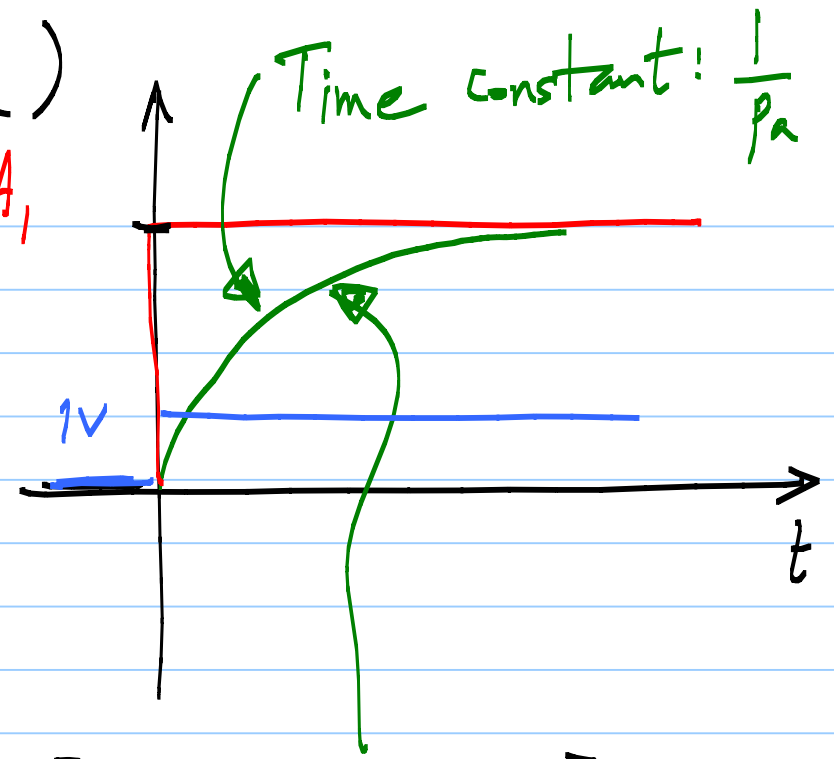
$$= +\frac{A_o}{k} p_1 \left(1 + \frac{k}{A_o}\right)$$

$$= +p_1 \left(\frac{A_o}{k} + 1\right)$$

Closed loop amplifier

$p_a = p_1(\quad)$

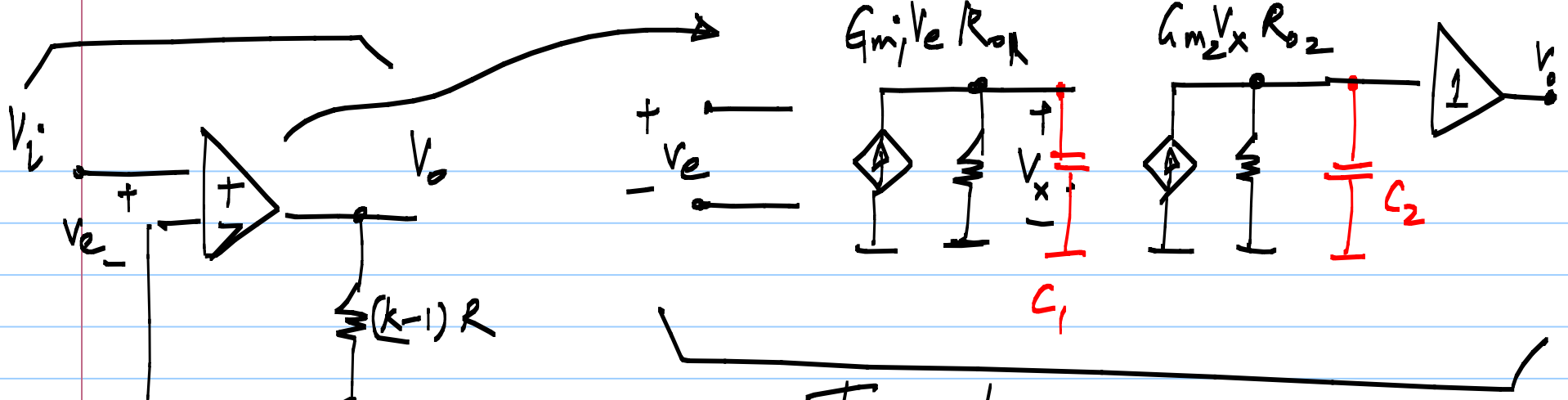
* Guaranteed to be stable.



$$\frac{1}{s} \cdot \frac{A_1}{1 + s/p_a}$$

$$A_1 \left[\frac{1}{s} - \frac{1/p_a}{1 + s/p_a} \right]$$

$$A_1 \left[1 - \exp(-p_a t) \right] u(t)$$



Two stage opamp:

$$\frac{V_o}{V_e} = \frac{G_{m_1} G_{m_2} R_{o_1} R_{o_2}}{(1+sC_1R_{o_1})(1+sC_2R_{o_2})}$$

$$= \frac{A_1}{\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)}$$

$$\frac{V_o}{V_i} = \frac{k}{1 + \frac{k}{A(s)}} \approx \frac{k}{1 + \frac{k(1+s/p_1)(1+s/p_2)}{A_0}}$$

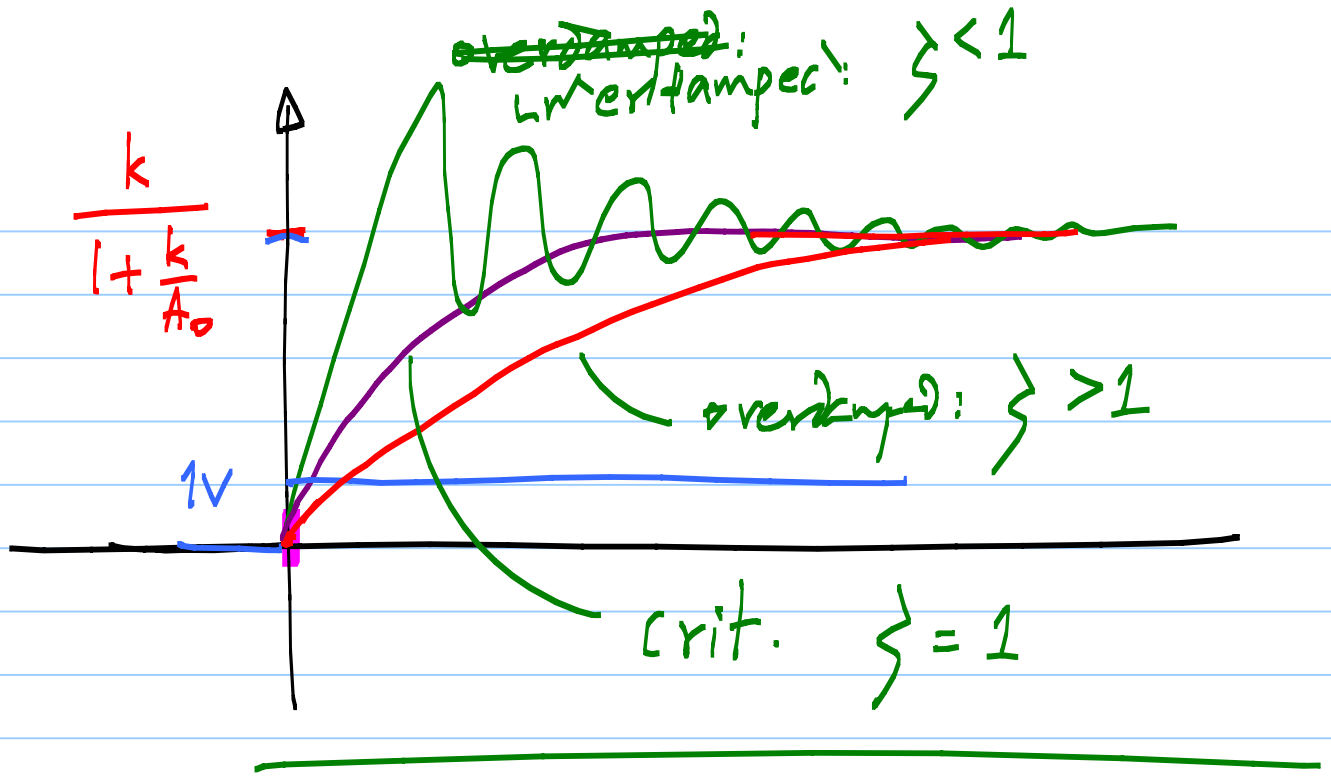
$$= \frac{k}{\left(1 + \frac{k}{A_0}\right) + \frac{k}{A_0}\left(\frac{1}{p_1} + \frac{1}{p_2}\right)\cdot s + \frac{s^2}{p_1 p_2}\cdot\frac{k}{A_0}}$$

$$s^2 + 2\zeta\omega_n s + \omega_n^2 \quad \Big| \quad \frac{s^2}{\omega_n^2} + \frac{s}{Q\omega_n} + 1$$

$$\frac{V_o}{V_i} = \frac{k}{1 + \frac{k}{A_0} + s \cdot \frac{k}{A_0}\left(\frac{1}{p_1} + \frac{1}{p_2}\right) + s^2 \cdot \frac{k}{A_0} \cdot \frac{1}{p_1 p_2}}$$

$$\omega_n = \sqrt{\left(\frac{A_0}{k} + 1\right) p_1 p_2} \qquad \zeta = \frac{p_1 + p_2}{2\sqrt{\left(\frac{A_0}{k} + 1\right) p_1 p_2}}$$

$$Q = \frac{\sqrt{\frac{A_0}{k} + 1}}{\sqrt{\frac{p_1}{p_2}} + \sqrt{\frac{p_2}{p_1}}} \qquad ; \qquad = \frac{1}{2} \cdot \frac{1}{\sqrt{\frac{A_0}{k} + 1}} \cdot \left(\sqrt{\frac{p_1}{p_2}} + \sqrt{\frac{p_2}{p_1}}\right)$$


underdamped: $\zeta < 1$
$\frac{k}{1+\frac{k}{A_0}}$
overdamped: $\zeta > 1$
1V
crit. $\zeta = 1$