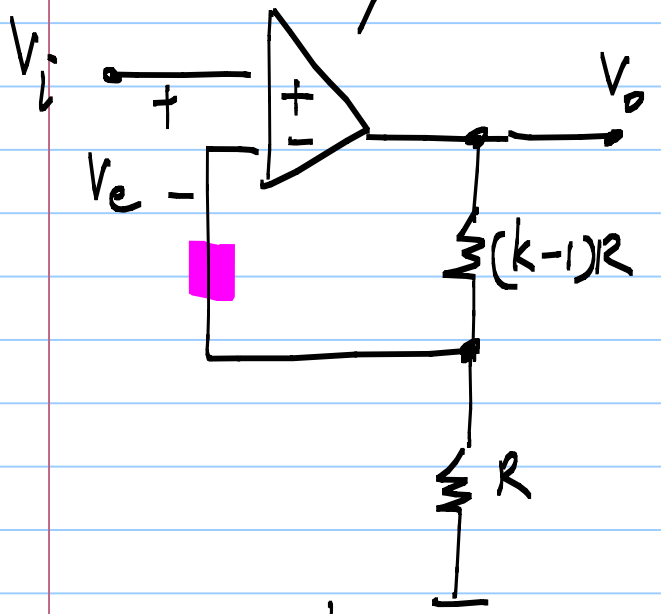
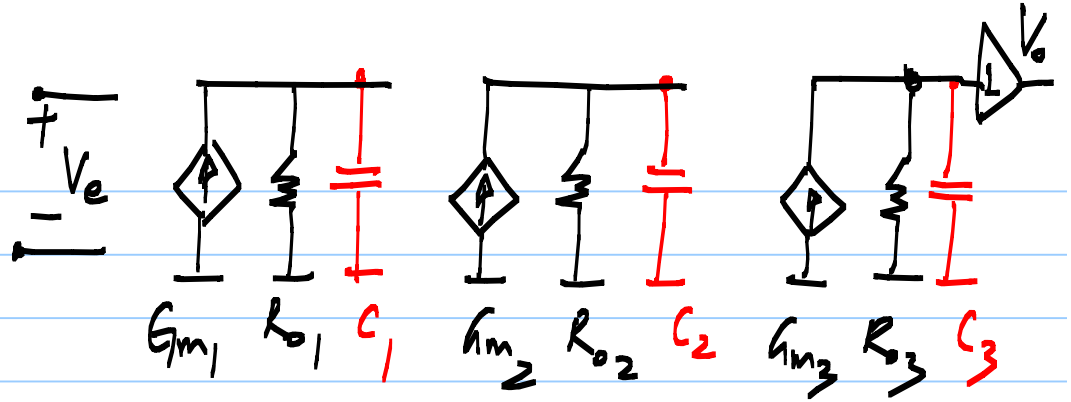
Lecture 9





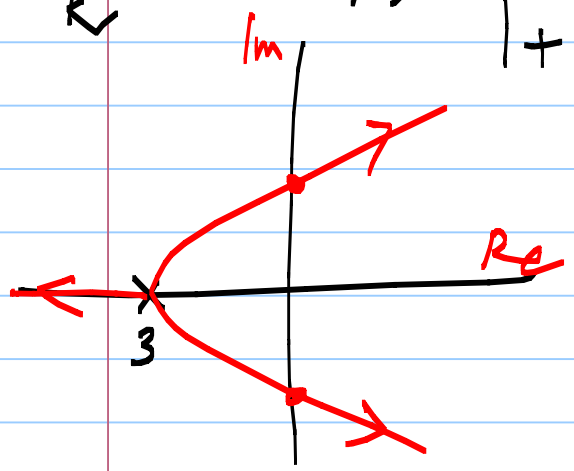
$$A(s) = \frac{A_o}{\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)\left(1+\frac{s}{p_3}\right)}$$

$$\frac{V_o}{V_i} = \frac{k}{1+\frac{k}{A(s)}} \rightarrow \frac{k}{1+\frac{k}{\frac{A_o}{\left(1+\frac{s}{p_1}\right)^3}}} \rightarrow \frac{k}{1+\frac{k}{A_o}\left(1+\frac{s}{p_1}\right)^3}$$

Find out if $D(j\omega)$ can be $= 0$

$$\frac{V_o}{V_i} = \frac{k}{1 + \frac{k}{A_o}\left(1 + \frac{s}{p_1}\right)^3} = \frac{k}{1 + \frac{k}{A_o} + \frac{k}{A_o} \cdot 3\frac{s}{p_1} + \frac{k}{A_o} \cdot 3\left(\frac{s}{p_1}\right)^2 + \frac{k}{A_o}\left(\frac{s}{p_1}\right)^3}$$

$$\frac{A_o}{k} + \left(1 + \frac{s}{p_1}\right)^3$$



$$1 + \frac{k}{A_o} + \frac{k}{A_o} \cdot 3\,(-3) = 0$$

$$\frac{k}{A_o} \cdot 3 \cdot \frac{j\omega}{p_1} - \frac{k}{A_o} \cdot \frac{j\omega^3}{p_1^3} = 0$$

$$\Rightarrow \frac{A_o}{k} = 8$$

$$\omega = \sqrt{3}\, p_1$$

First order:

* Unconditionally stable
* Well behaved step response

Second order:

* Unconditionally stable
* Step response can be underdamped.
  - well behaved for large $\frac{\omega_0}{K}$ only if $\frac{p_2}{p_1}$ is also large (widely separated poles)

Third order:

* Conditionally stable

First order: Unity gain frequency

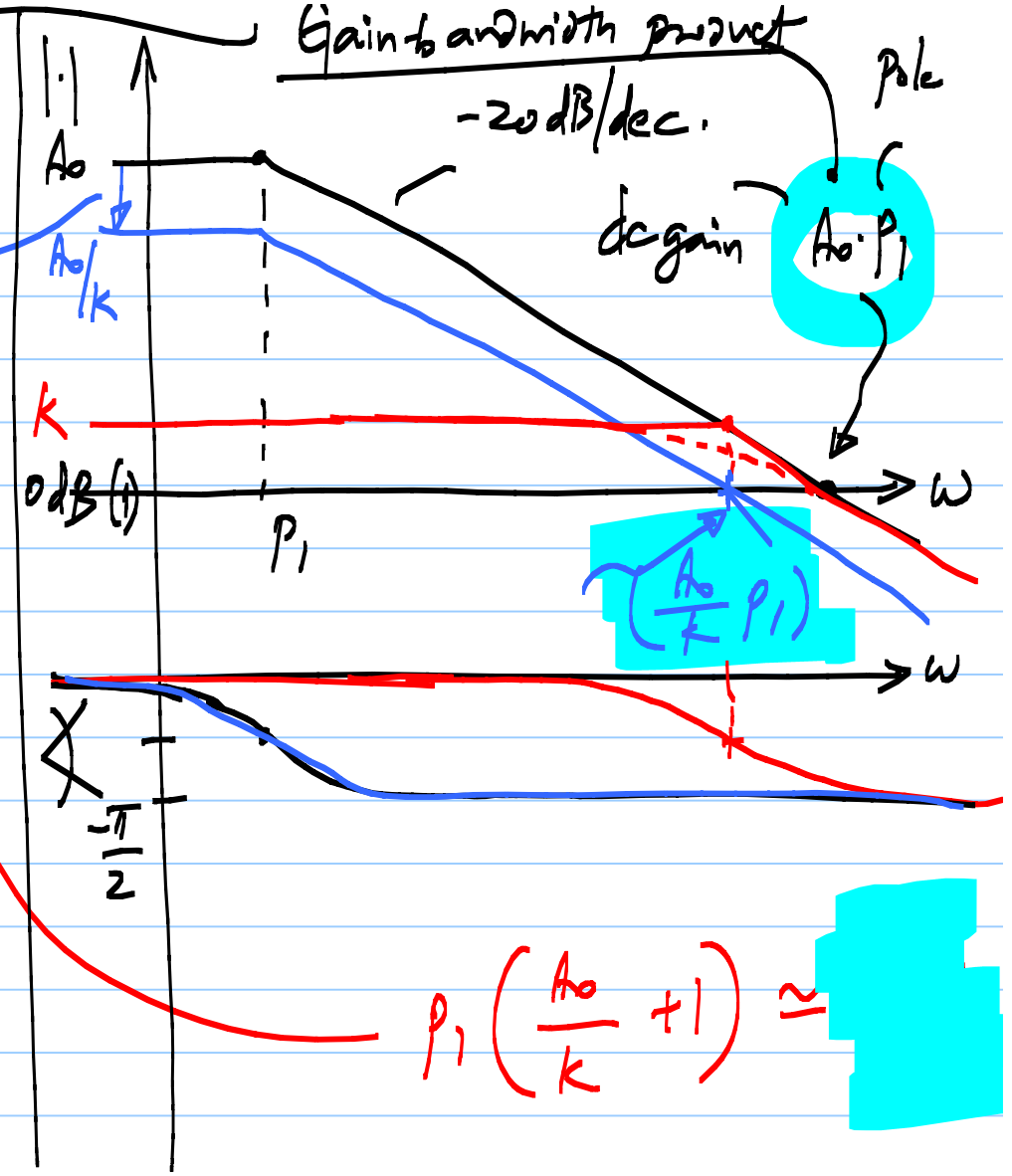
opamp: $A(s) = \frac{A_0}{1 + \frac{s}{p_1}}$

Loop-gain: $L(s) = \frac{A(s)}{k} = \frac{A_0/k}{1 + s/p_1}$

Closed-loop TF: $\frac{V_o}{V_i} = \frac{k}{1 + \frac{k}{A_0} + \frac{s}{p_1 \cdot A_0/k}}$

$\frac{A_0}{\sqrt{1 + \frac{\omega^2}{p_1^2}}} = 1 \quad \sqrt{A_0^2 - 1} \cdot p_1 = \omega$

$\simeq A_0 \cdot p_1$



$p_1 \left(\frac{A_0}{k} + 1\right) \simeq$

$$H(s) = \frac{1000}{1 + \frac{s}{100}}$$

$$\log\left(\frac{\omega}{1\,\text{rad/s}}\right)$$