Note Title 11-08-2020

lecture # 32

$$LG = \frac{A_a A_o}{(1 + s/\omega_{p1})(1 + s/\omega_{p2})}$$

$$\frac{V_o}{V_{ctrl}} = \frac{LG}{1+LG} = \frac{1}{1 + \frac{1}{LG}}$$

$$= \frac{1}{1 + \frac{(1+s/\omega_{p1})(1+s/\omega_{p2})}{A_a A_o}}$$

$$= \frac{A_a A_o}{A_a A_o + 1 + s\left(\frac{1}{\omega_{p1}} + \frac{1}{\omega_{p2}}\right) + \frac{s^2}{\omega_{p1}\omega_{p2}}}$$

$$= \frac{A_a A_o}{\frac{s^2}{\omega_{p1}\omega_{p2}} + s\left(\frac{1}{\omega_{p1}} + \frac{1}{\omega_{p2}}\right) + (1 + A_a A_o)}$$

$$= \frac{(A_o A_a)'}{\frac{s^2}{p_1 p_2} + s\left(\frac{1}{p_1} + \frac{1}{p_2}\right) + 1}.$$

$$\boxed{\omega_{p1} \ll \omega_{p2}}$$

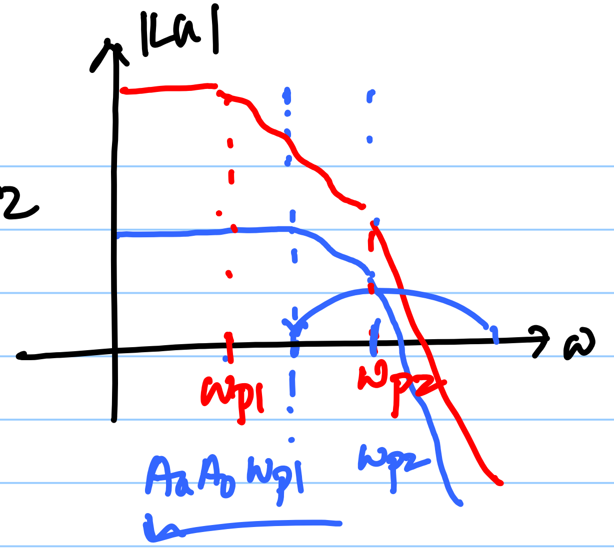
$$ax^2 + bx + c = 0$$

$$x_1 + x_2 = \frac{-b}{a}$$

$$x_1 x_2 = c/a$$

$$\frac{1}{p_1} + \frac{1}{p_2} = \frac{\frac{1}{\omega_{p1}} + \frac{1}{\omega_{p2}}}{1/\omega_{p1}\omega_{p2}}$$

$$\frac{V_{dd,vco}}{V_{ctrl}} : \frac{A_a A_o}{s^2 + s(\omega_{p1}+\omega_{p2}) + (1+A_aA_o)\omega_{p1}\omega_{p2}}$$



$\omega_{p1} \gg \omega_{p2}$

$p_1 \approx -\omega_{p1}$

$p_2 = -A_aA_o\omega_{p2}$

$p_1 \gg p_2$

$\omega_{p1} \ll \omega_{p2}$

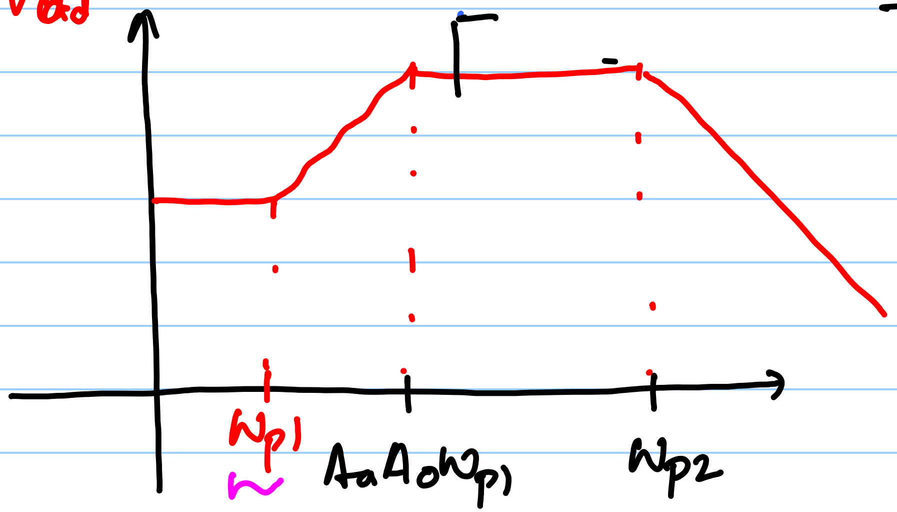
$$p_1 + p_2 \approx -(\omega_{p1}+\omega_{p2})$$

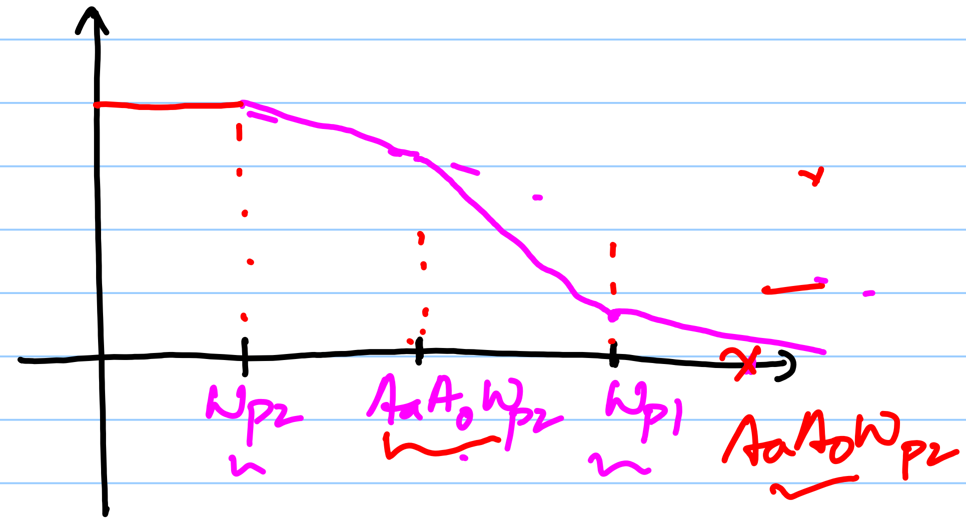
$$\boxed{p_1 \approx -\omega_{p2}}$$

$$p_1 p_2 = \frac{(1+A_aA_o)\,\omega_{p1}\omega_{p2}}{1}$$

$$p_2 \approx \frac{A_aA_o\,\omega_{p1}\omega_{p2}}{-\omega_{p2}} = -A_aA_o\,\omega_{p1}$$

$$\frac{V_{dd,vco}}{V_{dd}}$$





$\omega_{p2} \leq A_oA_a\omega_{p2} \leq \omega_{p1}$

$\omega_{p2} \ll \omega_{p1}$

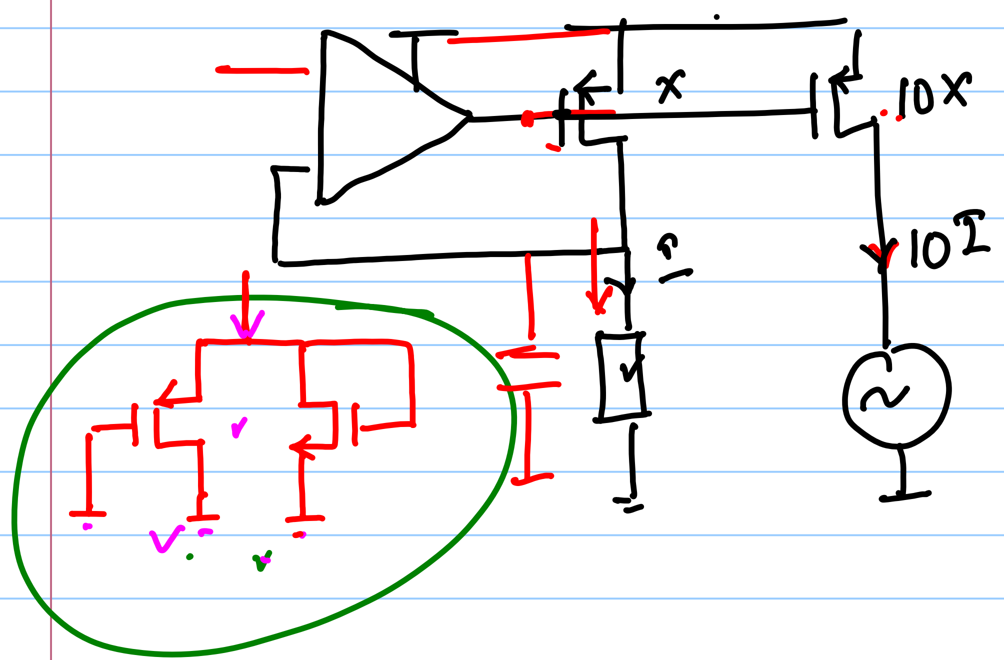
Phase Noise

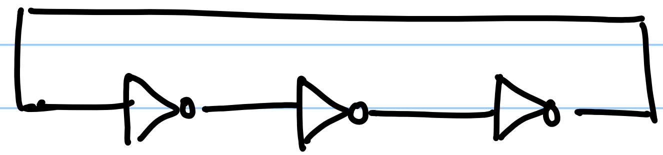
PLL — ϕ_{out} $\quad \overline{\left(\phi_{out}^{total}\right)^2} = \int S_{\phi_{out}}^{total} \cdot df$

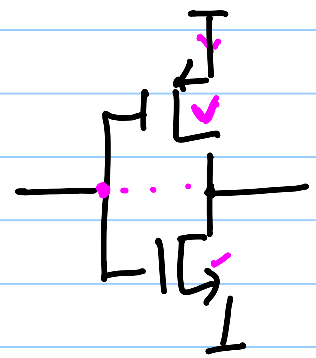
T_{out} $\quad$ frequency spectrum of phase disturbanc

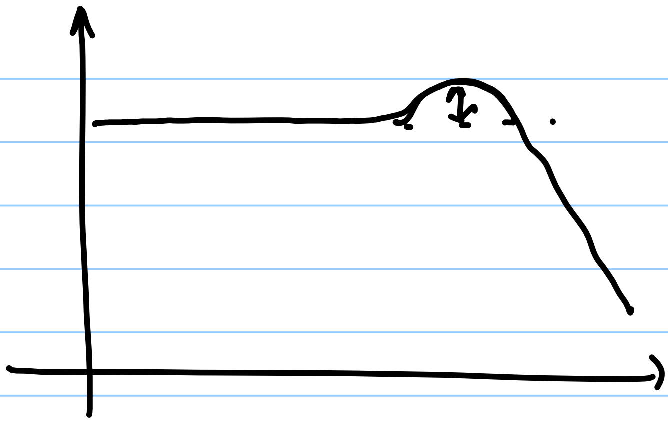
$$\Delta\phi_{out} = 2\pi \cdot \frac{\Delta t}{T_{out}}$$

$$(\Delta t)^2 = \left(\frac{T_{out}}{2\pi}\right)^2 (\Delta\phi_{out})^2$$



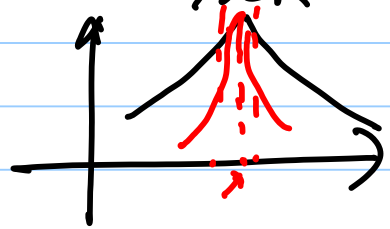




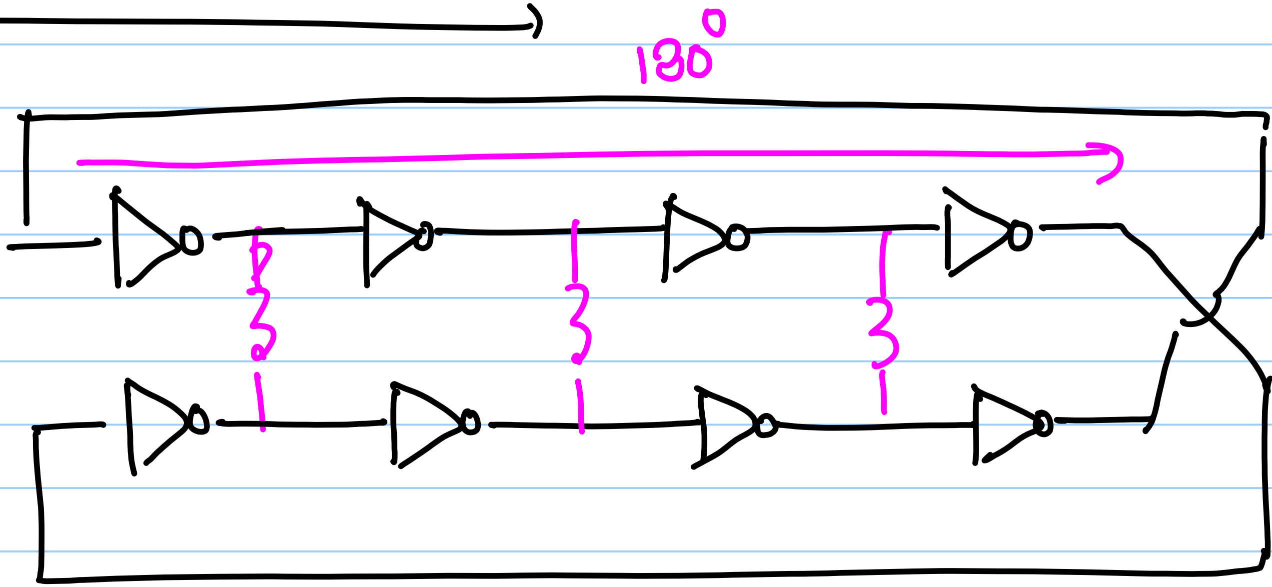


$$\frac{1}{z} = \frac{1}{R} + sC + \frac{1}{sL} = \frac{s^2LCR + sL + R}{sLR}$$

$$z = \frac{sL}{s^2LC + sL/R + 1}$$



$$G_m \cdot \Delta \left(2R \,\|\, \frac{1}{sC/2} \,\|\, 2sL\right)$$



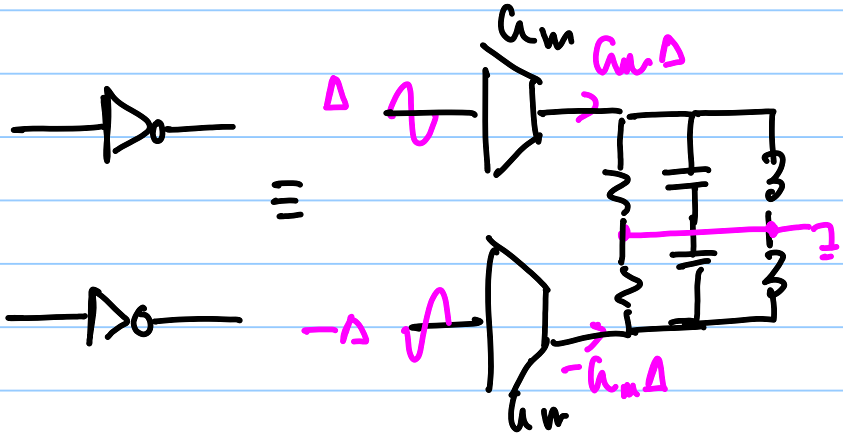
$$H(s) = \left(G_m\Delta \quad \right)^4$$

$$\angle H = 4\left(90^\circ - \tan^{-1}(\quad)\right)$$

$$= 180^\circ$$

$$Q_p = \frac{1}{2\sqrt{3}}$$

$$\omega_{osc} = (2-\sqrt{3})\,\omega_p$$



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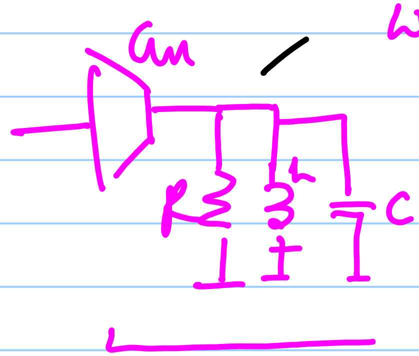
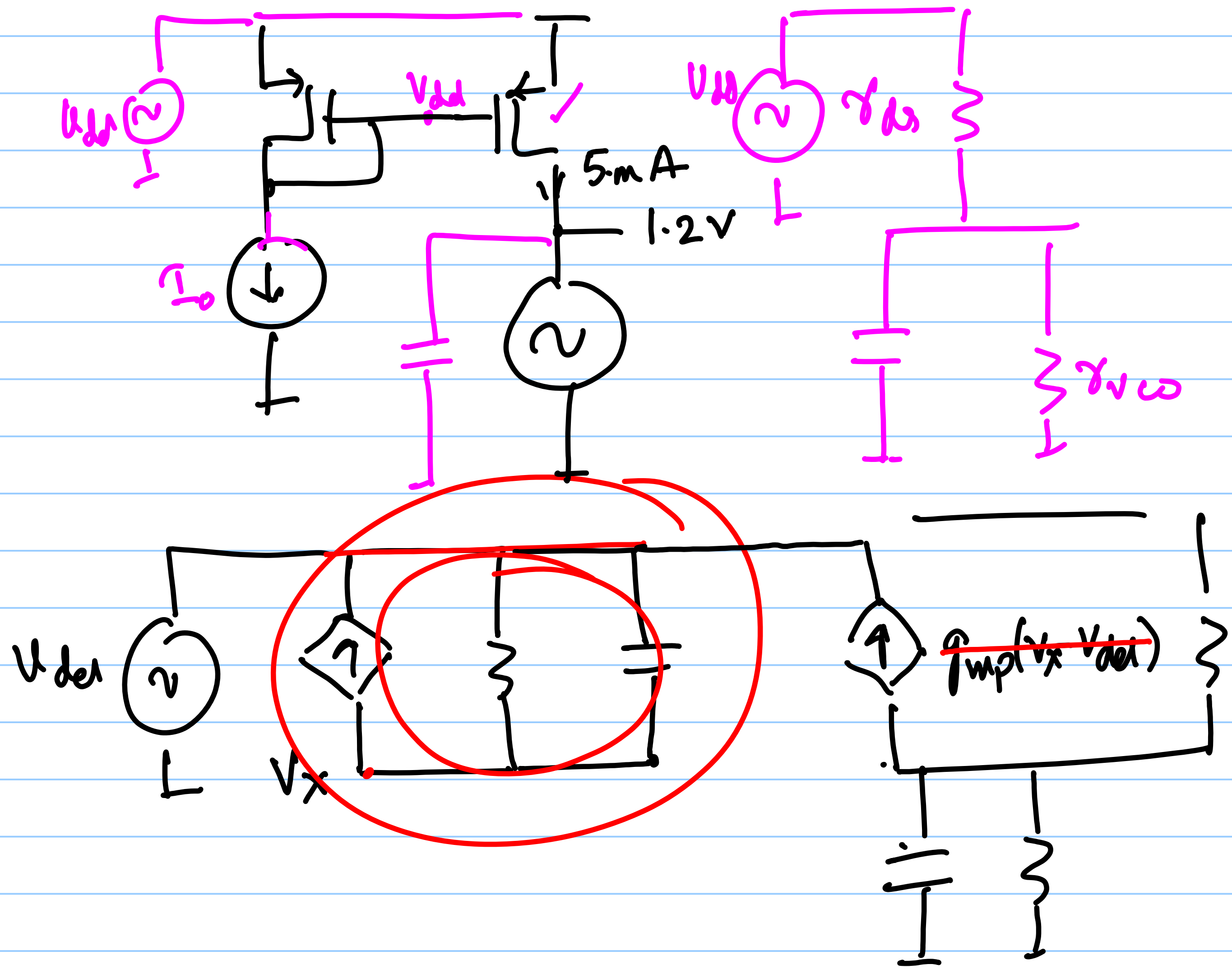
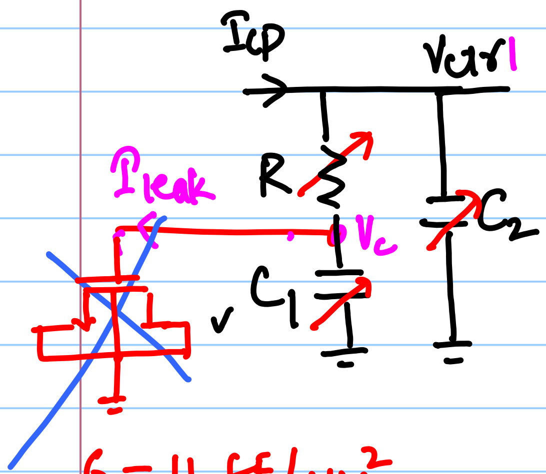


JTOL



Loop Filter.



6 − 11 fF/μm^2

- C_1 is normally very large.

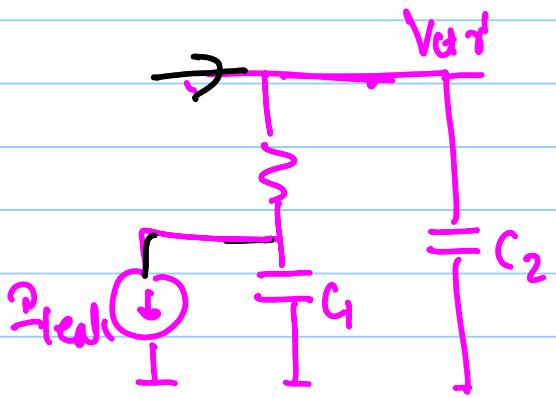
$C_1 =$ 220 pF − mim cap (2 fF/μm^2)

100

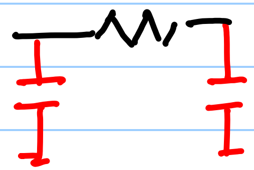
Area : $\frac{\cancel{220} \times 10^{-12}}{\cancel{2} \times 10^{-15}} = 100\,000$

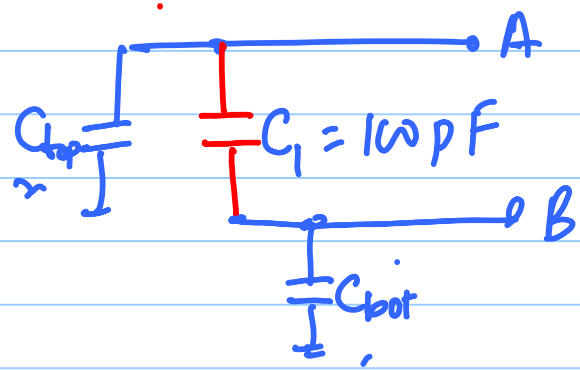
- R, C_1, C_2 PVT variations.

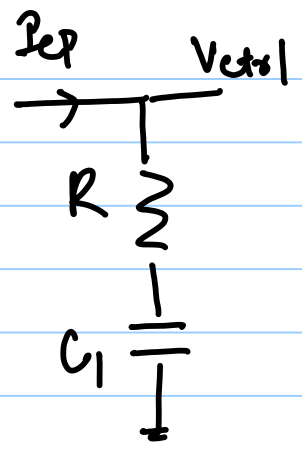
±20%   −20%   0%   ±2%   20% ω_z , ω_u



{ · R
  C_1, C_2 }







$$V_{ctrl}(s) = I_{cp}(s)\left(R + \frac{1}{sC_1}\right)$$

$$= I_{cp}'(s)\,\frac{I_{cp}(s)}{I_{cp}'(s)} \cdot R + \frac{I_{cp}(s)}{sC_1} = K \cdot I_{cp}(s) \cdot R + \frac{I_{cp}'}{sC_1}$$

$$= V_{prop}(s) + V_{int}(s)$$

$$V_{ctrl}(t) = i_{cp}(t) \cdot R + \int \frac{i_{cp}(t)}{C} \cdot dt$$

$$V_{ctrl}(s) = I_{cp}'(s)\left\{\frac{I_{cp}(s)}{I_{cp}'(s)} R + \frac{I_{cp}(s)/I_{cp}'(s)}{sC_1}\right\}$$

$$= I_{cp}'(s)\left\{K \cdot R + \frac{1}{s(C_1/K)}\right\}$$

$$\omega_z = \frac{1}{KRC_1}$$