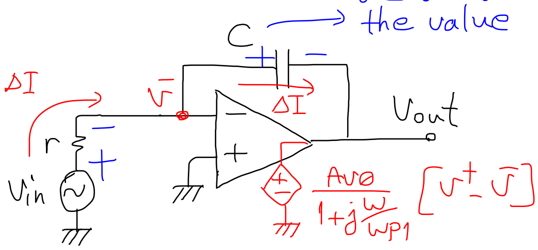
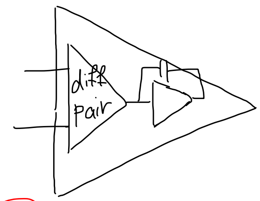
$*$ pole splitting

C → we decide the value

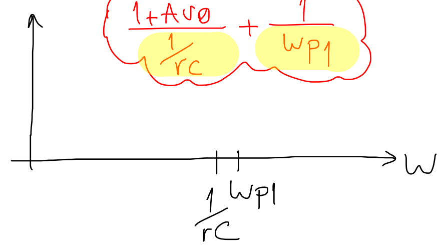


external pole $= \frac{1}{rC}$

internal pole $= \omega_{p1}$



$\frac{1+A_{v0}}{\frac{1}{rc}} + \frac{1}{\omega_{p1}}$



C is much larger than internal transistor capacitor $C \gg C_{gs}$ $\quad \frac{1}{C\omega} \ll \frac{1}{C_{gs}\omega}$

$v^+ = 0$

$$g(v_{in} - \bar{v}) = j\omega C(\bar{v} - V_{out}) \implies \bar{v} = \frac{g \cdot v_{in} + j\omega C V_{out}}{g + j\omega C}$$

$$V_{out} = \frac{A_{v0}}{1+j\frac{\omega}{\omega_{p1}}}\left[v^+ - \bar{v}\right] \implies V_{out} = \frac{A_{v0}}{1+j\frac{\omega}{\omega_{p1}}}\left[0 - \frac{gV_{in} + j\omega C V_{out}}{g + j\omega C}\right]$$

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$$\implies V_{out}\left[1 + \frac{A_{v0}}{1+j\frac{\omega}{\omega_{p1}}}\,\frac{j\omega C}{g + j\omega C}\right] = \frac{-A_{v0}}{1+j\frac{\omega}{\omega_{p1}}}\,\frac{g\,V_{in}}{g+j\omega C}$$

$$\implies V_{out}\left[\left(1+j\frac{\omega}{\omega_{p1}}\right)(g + j\omega C) + j\omega C A_{v0}\right] = -g \cdot A_{v0} V_{in}$$

$$\implies \frac{V_{out}}{V_{in}} = \frac{-gA_{v0}}{g + j\omega\left(CA_{v0} + \frac{g}{\omega_{p1}} + C\right) + (j\omega)^2\frac{C}{\omega_{p1}}} \times \frac{r}{r}$$

closed-loop

$$\implies \frac{V_{out}}{V_{in}} = \frac{-A_{v0}}{1 + j\omega\Big(\underbrace{\frac{(1+A_{v0})}{1/rc}}_{\text{dominant}} + \cancel{\frac{1}{\omega_{p1}}}\Big) + (j\omega)^2\underbrace{\frac{1}{\omega_{p1}} \times \frac{1}{1/rc} \times \frac{1+A_{v0}}{1+A_{v0}}}_{\frac{1}{\omega_{cp1}} \times \frac{1}{\omega_{cp2}}}}$$

$\frac{1}{rc} \approx \omega_{p1}$

$\omega_{cp1} = \frac{1}{rc} \times \frac{1}{1+A_{v0}}$

find ω_{cp2}

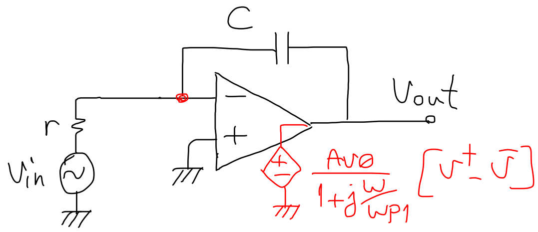
Recall:

$$\frac{V_{out}}{V_{in}} = \frac{N_0 + j\omega N_1 + \cdots}{D_0 + j\omega D_1 + \cdots}$$

$$\frac{V_{out}}{V_{in}} = \frac{A_{v0}\left(1+j\frac{\omega}{\omega_z}\right)}{\left(1+j\frac{\omega}{\omega_{p1}}\right)\left(1+j\frac{\omega}{\omega_{p2}}\right)}$$

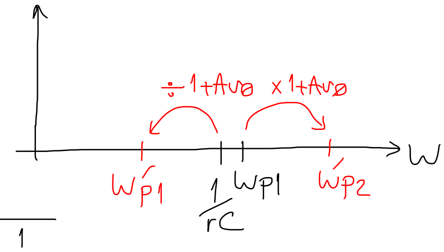
$\implies$ denominator

$$1 + j\omega\left[\frac{1}{\omega_{p1}} + \cancel{\frac{1}{\omega_{p2}}}\right] + (j\omega)^2\frac{1}{\omega_{p1}} \cdot \frac{1}{\omega_{p2}}$$



$$\text{external pole} = \frac{1}{rC}$$

$$\text{internal pole} = \omega_{p1}$$



$$\frac{V_{out}}{V_{in}} = \frac{A_{v0}}{\left(1+j\frac{\omega}{\omega'_{p1}}\right)\left(1+j\frac{\omega}{\omega'_{p2}}\right)} = \frac{1}{1+j\omega\left[\underbrace{\frac{1}{\omega'_{p1}}}_{\text{dominant}}+\cancel{\frac{1}{\omega'_{p2}}}\right]+(j\omega)^2\frac{1}{\omega'_{p1}}\frac{1}{\omega'_{p2}}}$$

new poles

$$\begin{cases} \omega'_{p1} = \frac{1}{rC} \times \frac{1}{1+A_{v0}} \\ \omega'_{p2} = \omega_{p1}\cdot(1+A_{v0}) \end{cases}$$