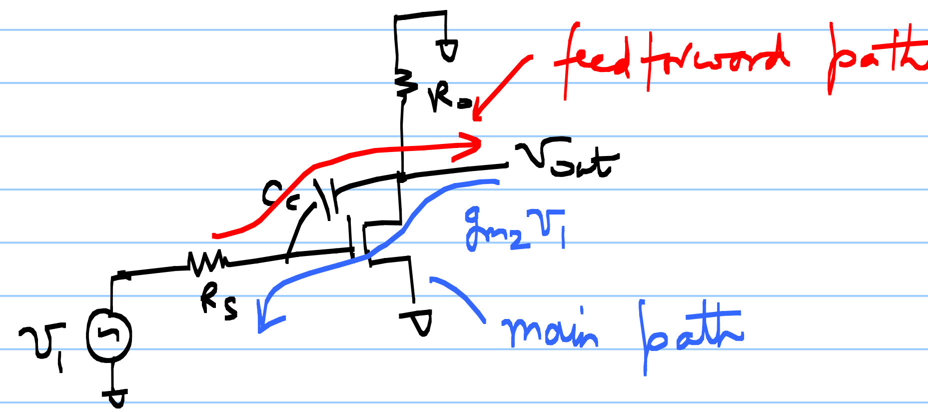
# Zero Discussion

Note Title 4/9/2011

$$\omega_z = +\frac{g_{m2}}{C_c}$$

↳ RHP zero

↳ arises due to the direct coupling of the input to the output through $C_c$.




↳ $C_c$ provides a feedforward path that conducts the input signal to the output at very high frequencies

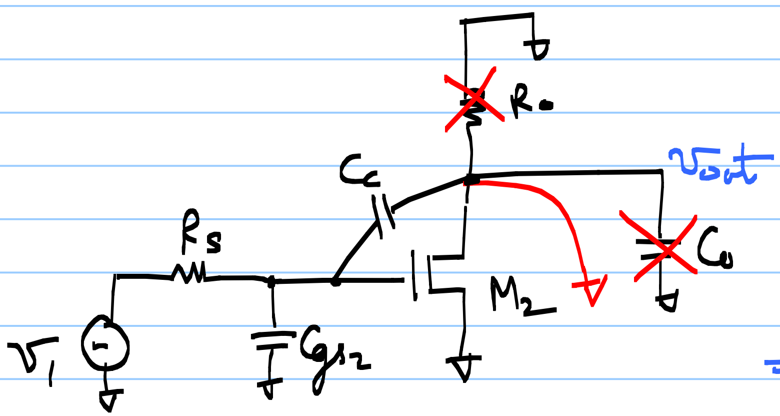
⇒ +20 dB/dec roll-up

↳ RHP zero reduces phase at high frequencies as the signal through $C_c$ adds to the main path output in the opposite phase.

## * Quick Calculation of zero :

$\sigma_z + j\omega_z$ corresponds to $j\omega_z$

at $s = s_z \Rightarrow \dfrac{v_{out}(s)}{v_{in}(s)} = 0$




for a finite $v_{in}$

$\Rightarrow v_{out}(s_z) = 0$

$\Rightarrow$ the output can be shorted to ground at this value of $s = s_z$, with no current flowing through the short

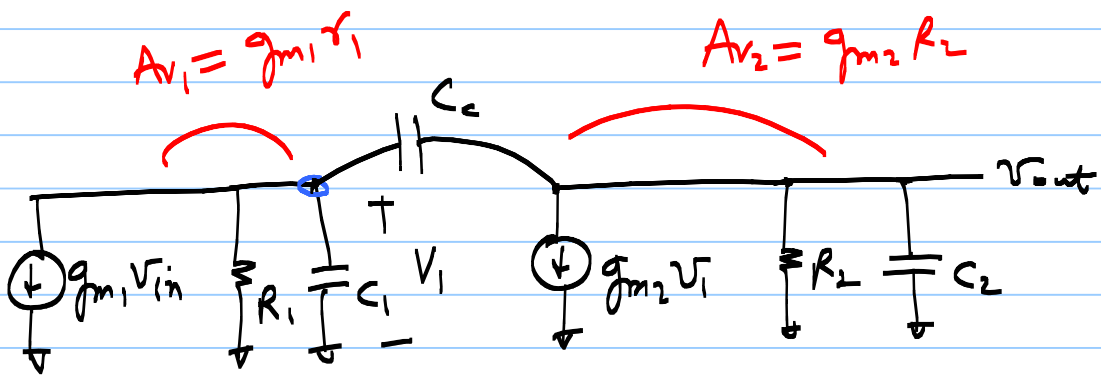
$\Rightarrow$ current through $C_c$ & $M_2$ are equal and opposite

$\Rightarrow \quad v_1 C_c S_z = g_{m2} v_1$

$\Rightarrow \quad \boxed{S_z = +\frac{g_{m1}}{C_{gd1}}}$ RHP zero.

$\Rightarrow$ if the polarity of the current through $C_c$ is inverted then it could lead to an LHP zero.

## * Quick Calculation of $f_{un}$ (or $\omega_{un}$) from the circuit.

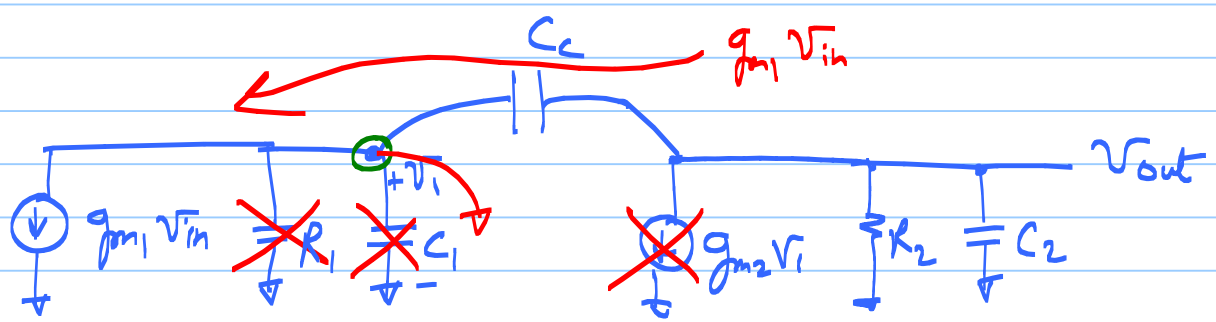



* when the amplifier is operated in feedback, the output of the first stage is given by $v_1 = \dfrac{v_{out}}{A_{v_2}}$ ← gain of the second stage

* if $A_{v_2}$ is large then $v_1 \simeq 0$

$\Rightarrow$ all the current $g_{m1} v_{in}$ flows to the output through $C_c$.

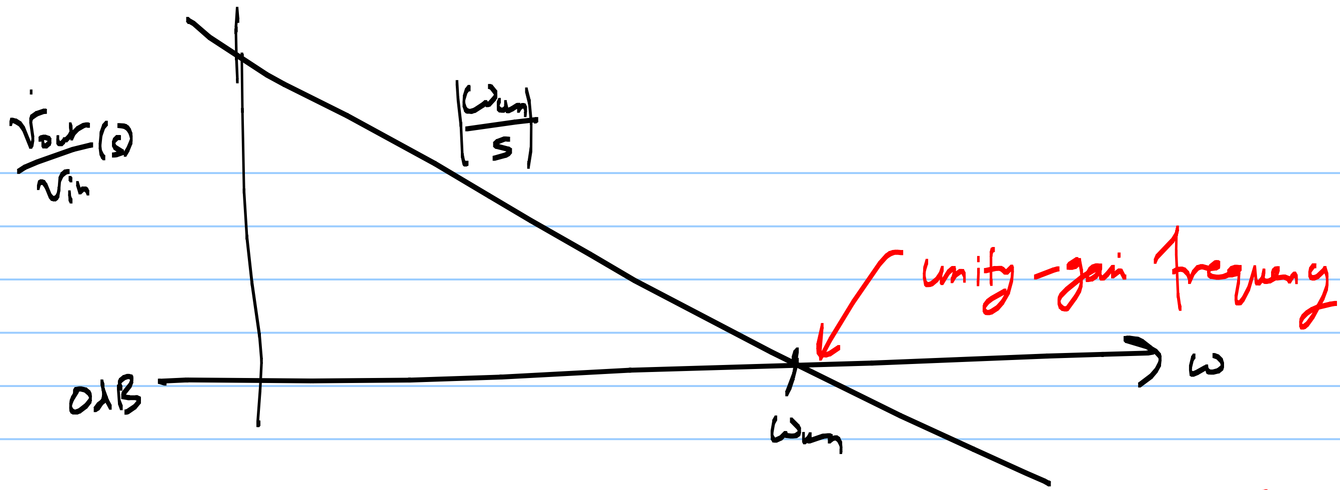
Equivalent circuit $\Rightarrow$




$\Rightarrow$

KCL @ ① $\Rightarrow$ $g_{m1} v_{in} = s C_c v_{out}$

$$\Rightarrow \frac{v_{out}}{v_{in}} \cong \frac{g_{m1}}{s C_c} = \frac{\omega_{un}}{s} \quad \text{where } \omega_{un} = \frac{g_{m1}}{C_c}$$




$$\Rightarrow \boxed{f_{un} = \frac{\omega_{un}}{2\pi} = \frac{g_{m1}}{2\pi C_c}}$$

* Alternatively we can also derive $f_{un}$ as follows :

* Dominant pole response

$$H(s) \simeq \frac{A_{v0}}{1 + s/\omega_{p1}}$$

$$\simeq \frac{A_{v0} \cdot \omega_{p1}}{s} \quad \text{for} \quad \left|\frac{s}{\omega_{p1}}\right| >> 1$$

$$= \frac{\omega_{un}}{s}$$

$$\Rightarrow \quad \omega_{un} = A_{v0} \cdot \omega_{p1}$$

$$= g_{m1} \cancel{R_1} \cdot \cancel{g_{m2}} \cancel{R_2} \cdot \frac{1}{\cancel{g_{m2}} \cancel{R_2} \cancel{R_1} C_c} = \boxed{\frac{g_{m1}}{C_c}}$$