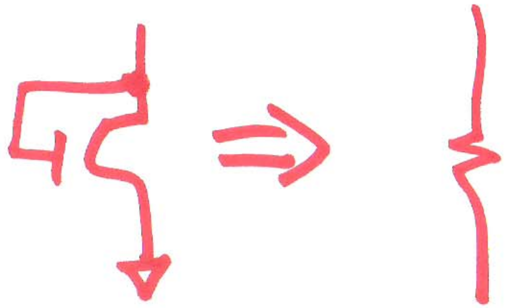
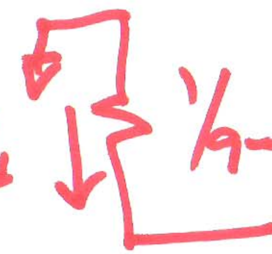
Sec. 21.1

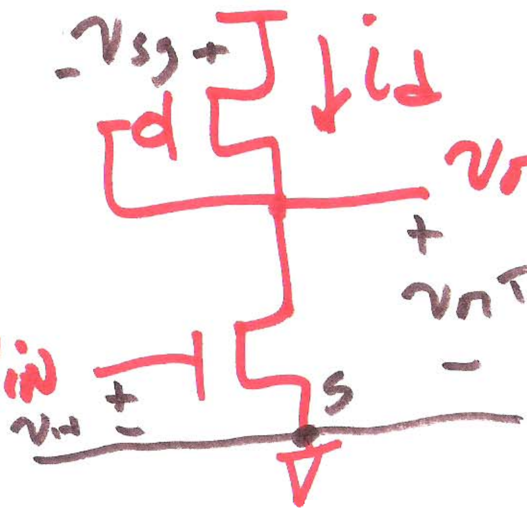
Gate-drain connected loads



$1/g \| r_o \approx \frac{1}{g_m}$

Common Source Amp (C.S.)



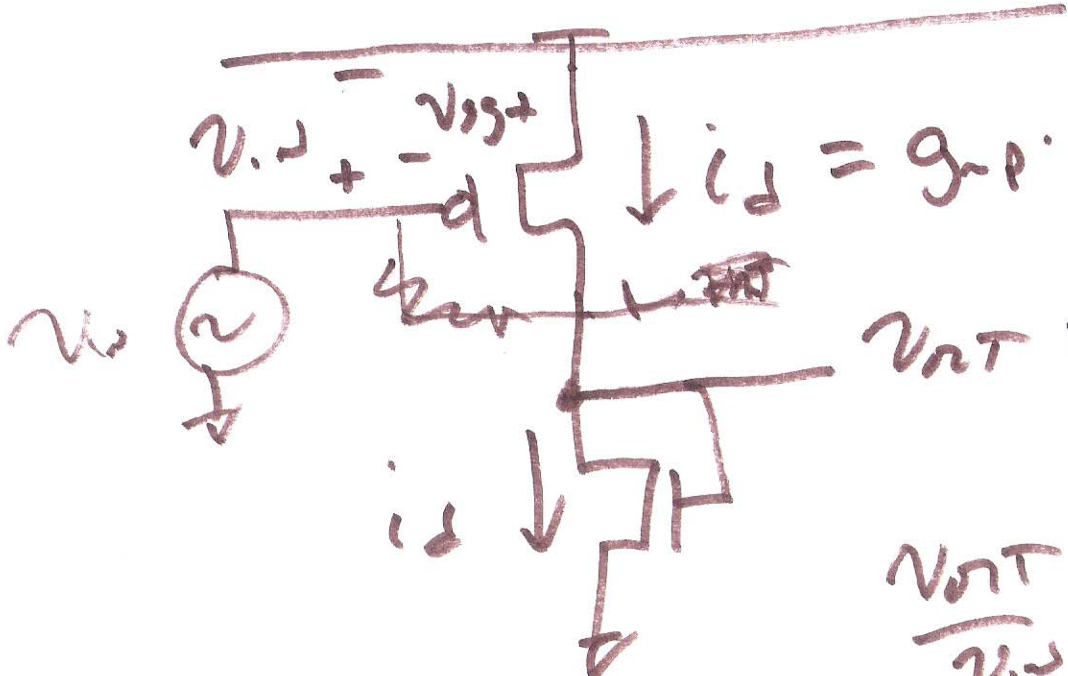


$$v_{out} = -i_d \cdot 1/g_{mp}$$

$$i_d = g_{mn} \cdot v_{in}$$

$$\frac{v_{out}}{v_{in}} = -\frac{1/g_{mp}}{1/g_{mn}} = -\frac{\text{Res. in drain}}{\text{Res. in source}}$$

C.S.

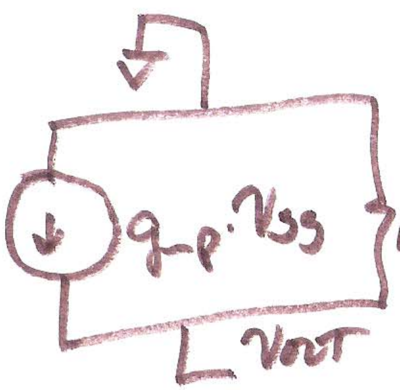


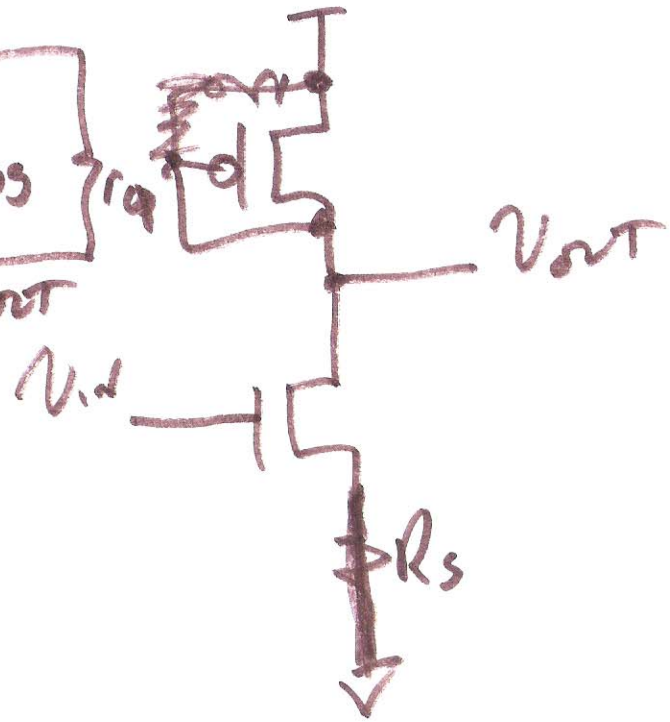
$$i_d = g_{mp} \cdot v_{sg} = -g_{mp} \cdot v_{in}$$

$$v_{out} = i_d \cdot \frac{1}{g_{mn}}$$

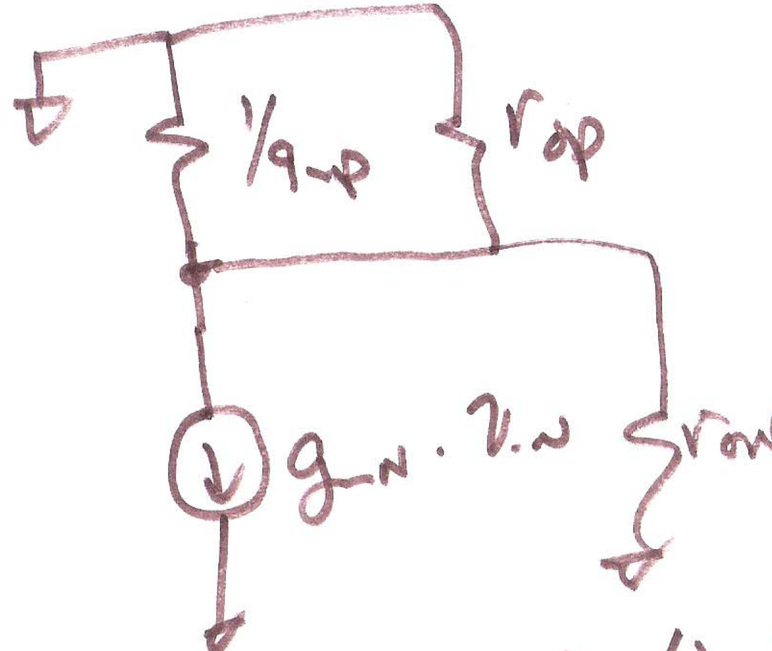
$$\frac{v_{out}}{v_{in}} = -\frac{1/g_{mn}}{1/g_{mp}}$$

Let's not neglect r_o!



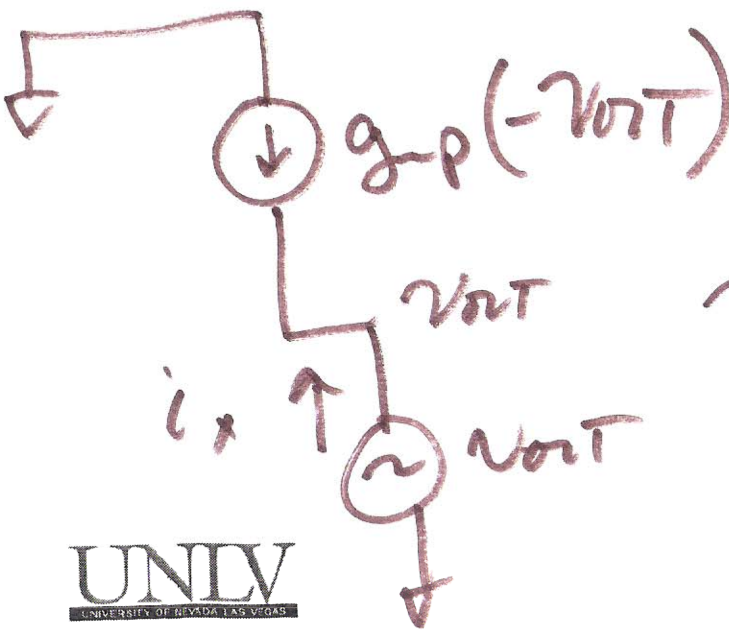


$$v_{out} = -v_{sg}$$

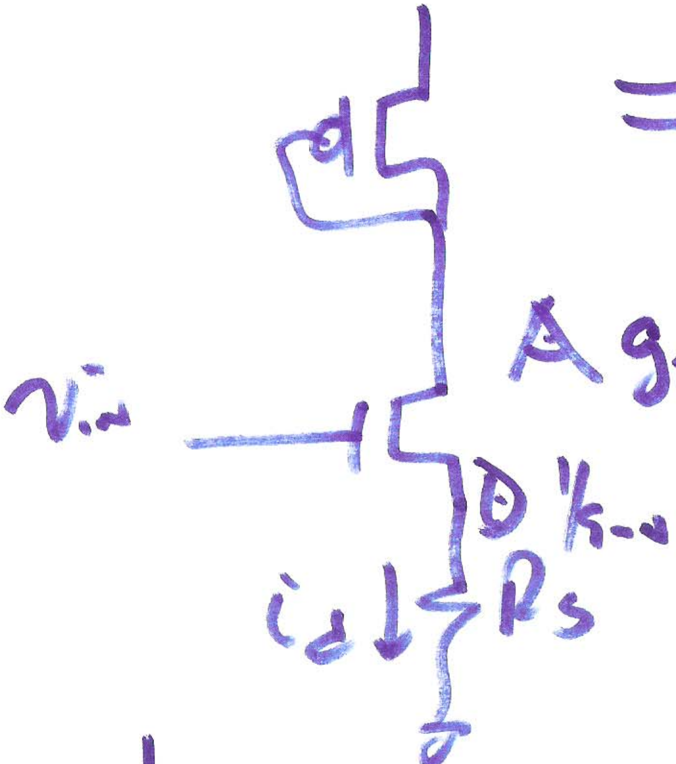


$$v_{out} = -g_{mn} \cdot v_{in} \cdot \left(\frac{1}{g_{mp}} || r_{op}\right)$$

$$\frac{v_{out}}{v_{in}} = -\frac{1/g_{mp} || r_{op} || r_{on}}{1/g_{mn}}$$



$$\frac{v_{out}}{i_x} = \frac{v_{out}}{-(g_{mp}(-v_{out}))} = \frac{1}{g_{mp}}$$



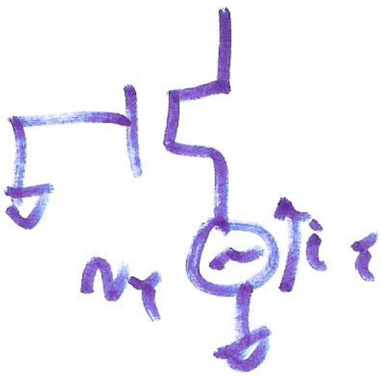
$$\Rightarrow \left\{ 1/g_{mp} \,||\, r_{op} \,||\, (\;) \right)$$

$$A \quad g_m R_s \cdot r_o + r_o = \text{Big}$$

$$v_{out} = -i_d \cdot 1/g_{mp} \,||\, r_{op} \,||\, (\;)$$

$$v_{in} = v_{gs} + i_d \cdot R_s$$

$$= i_d\left(\frac{1}{g_{mn}} + R_s\right)$$



$$\frac{v_{out}}{v_{in}} = -\frac{1/g_{mp} \,||\, r_{op} \,||\, (\;)}{1/g_{mn} + R_s}$$

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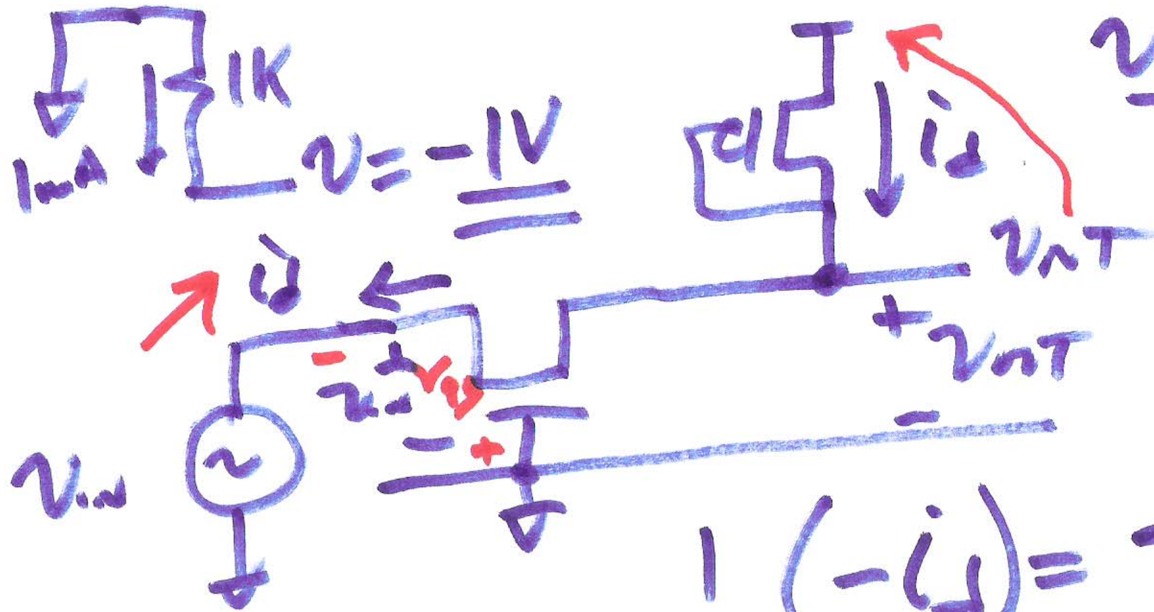


$$\frac{v_{out}}{v_{in}} = ?$$

$$\frac{1}{g_{mp}}(-i_d) = v_{out}$$

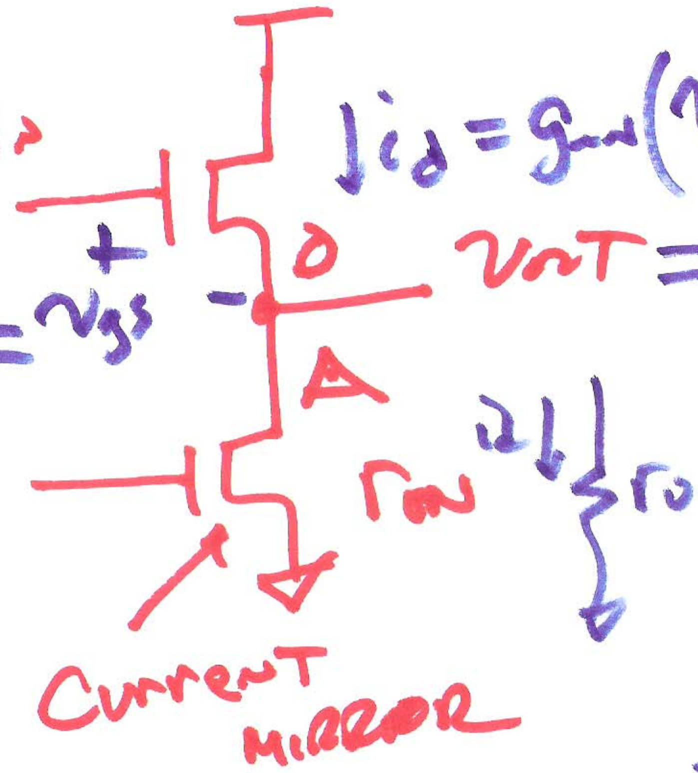
C.G. Amp

$$v_{in} = -v_{gs} = -\frac{i_d}{g_{mn}}$$

$$-i_d = v_{in} \cdot g_{mn}$$

$$\frac{v_{out}}{v_{in}} = \frac{g_{mn}}{g_{mp}} = \frac{1/g_{mp}}{1/g_{mn}}$$

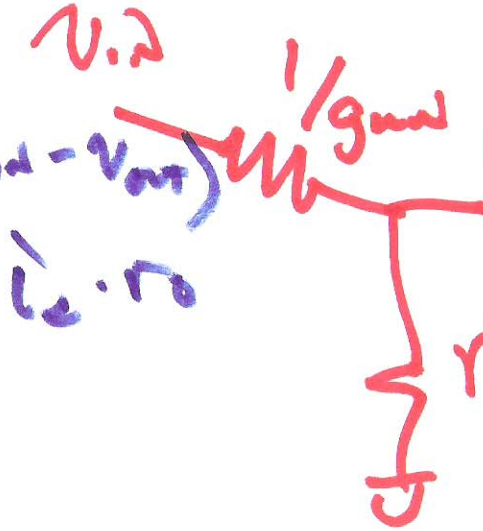
C.D. (source follower)



$i_d = g_{mn}(v_{in} - v_{out})$

$v_{out} = i_d \cdot r_o$

$v_{in} - v_{out} = v_{gs}$



$$v_{out} = \frac{v_{in} \cdot r_{on}}{r_{on} + 1/g_{mn}}$$

$$\frac{v_{out}}{v_{in}} = \frac{g_{mn} \cdot r_{on}}{1 + g_{mn} \cdot r_{on}}$$

$$\frac{v_{out}}{v_{in}} = \frac{i_d \cdot r_o}{\cancel{}} =$$

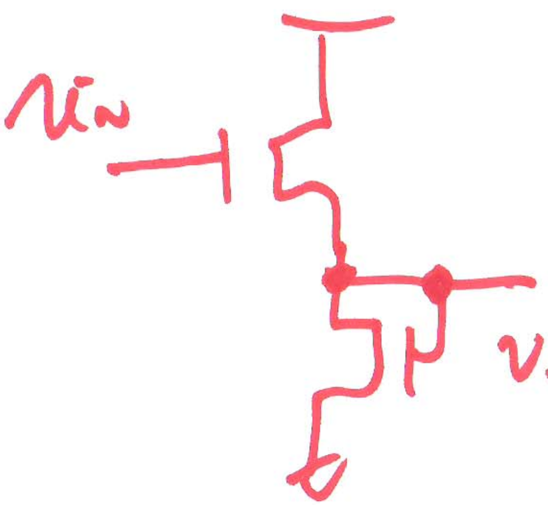
$$i_d \quad g_{mn} \cdot (v_{in} - v_{out}) \, r_o$$

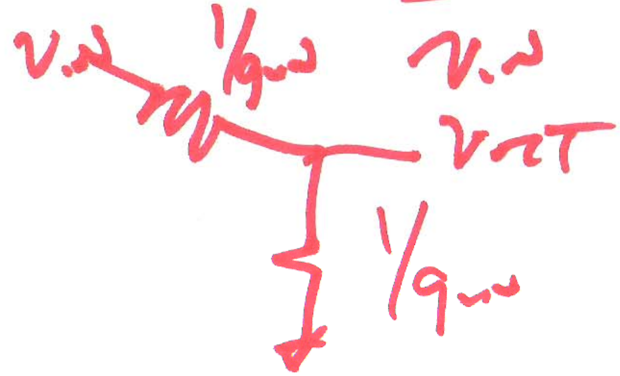
$$v_{out} = g_{mn}(v_{in} - v_{out})\, r_o$$

$$v_{out} = g_{mn} r_o v_{in} - g_{mn} r_o v_{out}$$

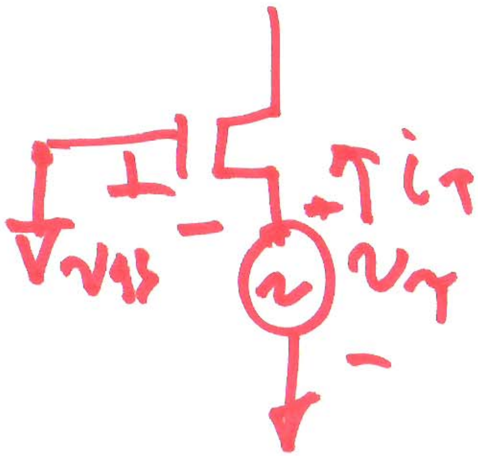
$$v_{out}(1 + g_{mn} r_o) = g_{mn} r_o v_{in}$$

$$\frac{v_{out}}{v_{in}} = \frac{g_m r_o}{1 + g_{mn} r_o}$$





$$\frac{v_{out}}{v_{in}} = \frac{1/g_{mn}}{1/g_{mn} + 1/g_{mn}} = \frac{1}{2}$$



$$R_{\text{into source}} = \frac{v_T}{i_T} = \frac{-\cancel{v_{gs}}}{-g_m \cancel{v_{gs}}} = \frac{1}{g_m}$$

$$v_T = -v_{gs}$$

$$i_T = -i_d$$

$$i_d = g_m v_{gs}$$

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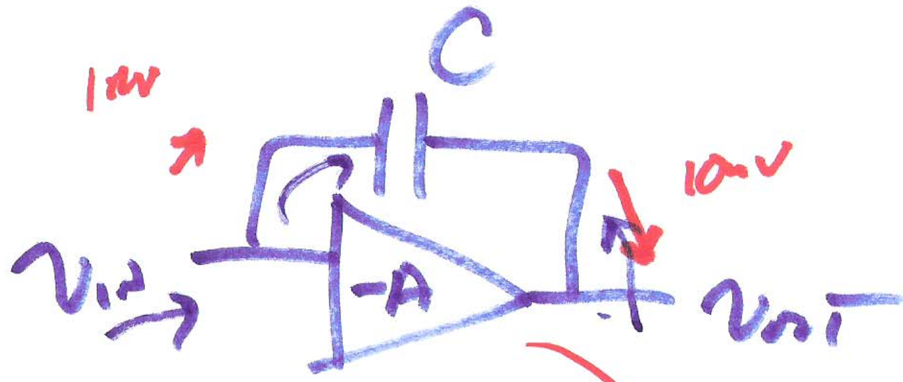
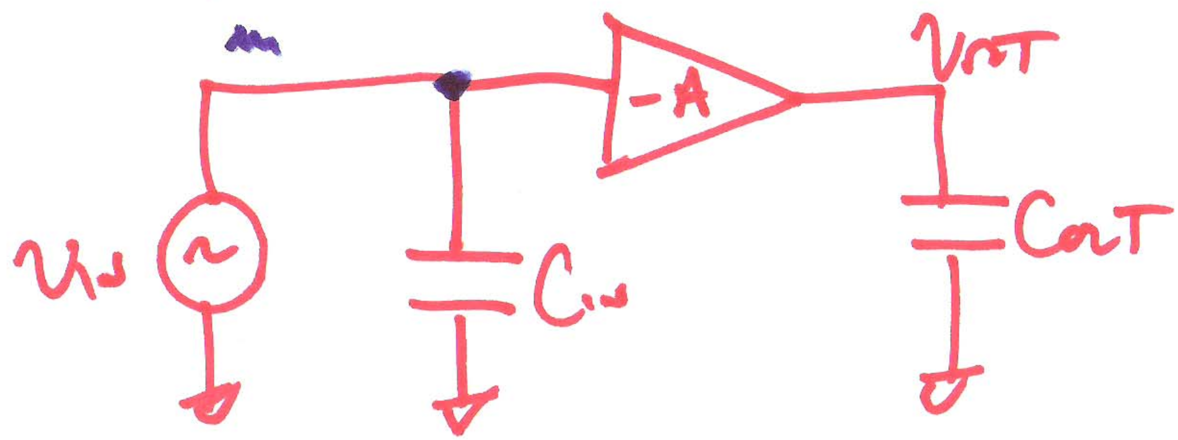
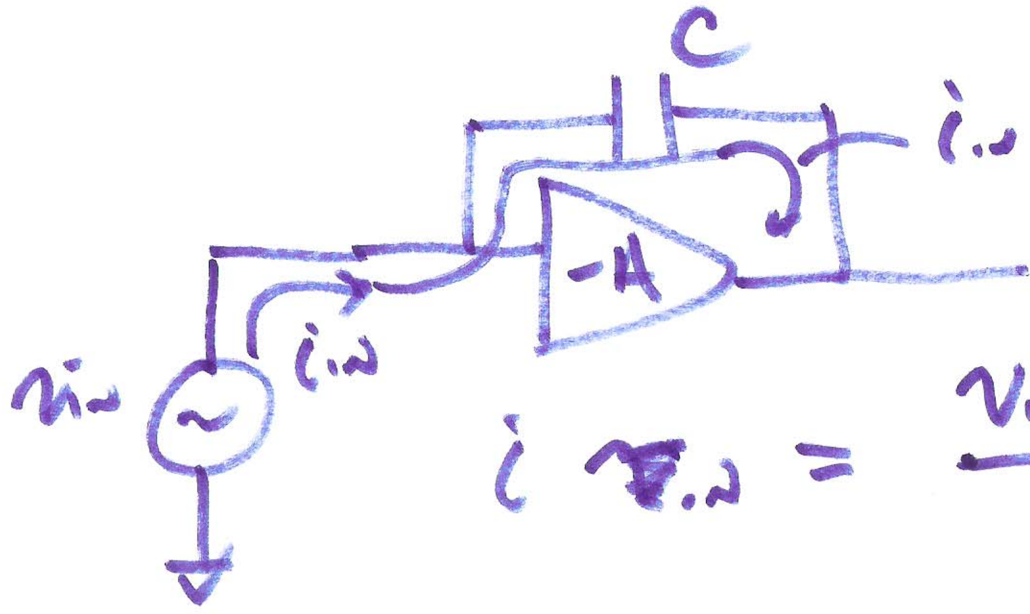
$$i = C\frac{dv}{dt}$$



$$(v_{in} + |v_{out}|)\cdot C$$

$$11 \cdot C$$





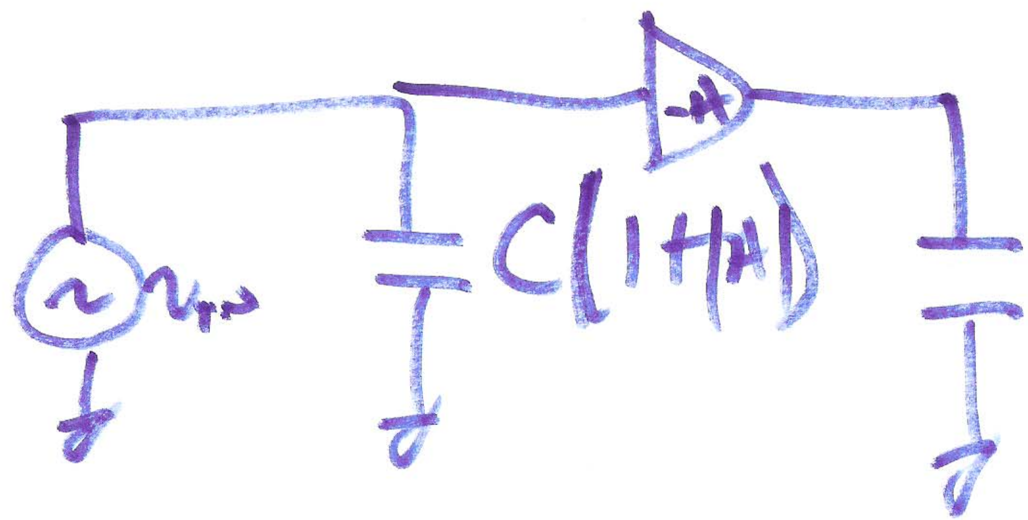
$$v_{in} = -\frac{v_{out}}{A}$$

$$v_{out} = -A \cdot v_{in}$$

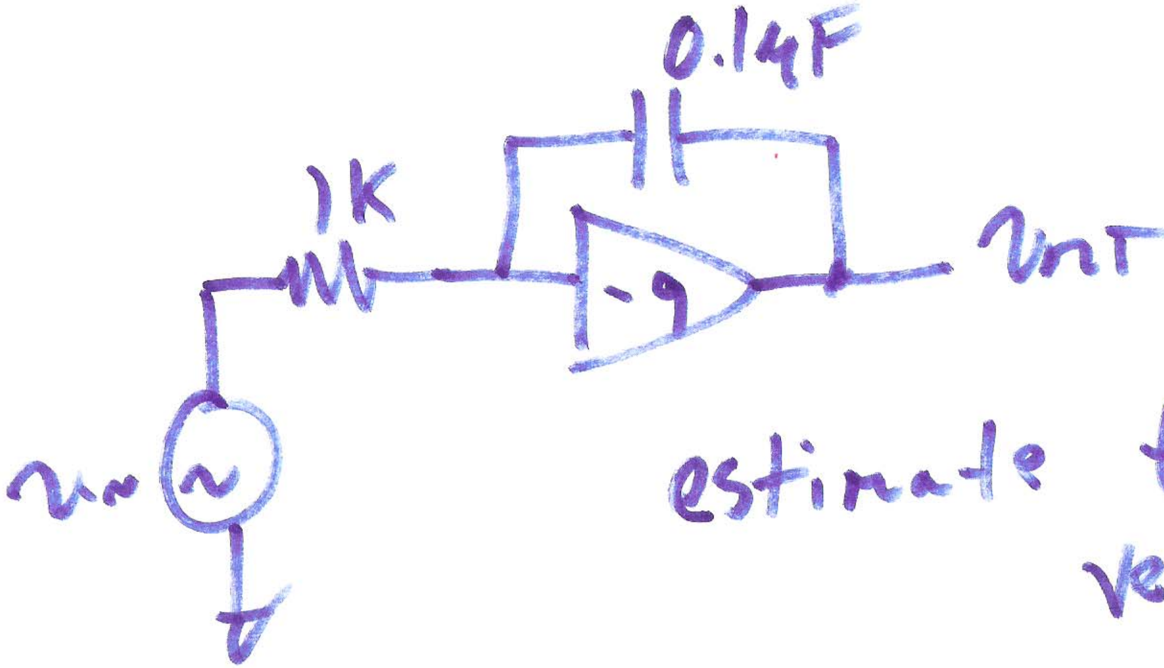
$$v_{out}\left(\frac{1}{A}+1\right)$$

$$i_{in} = \frac{v_{in} - v_{out}}{1/j\omega C} = \frac{v_{in}(1+A)}{1/j\omega C}$$

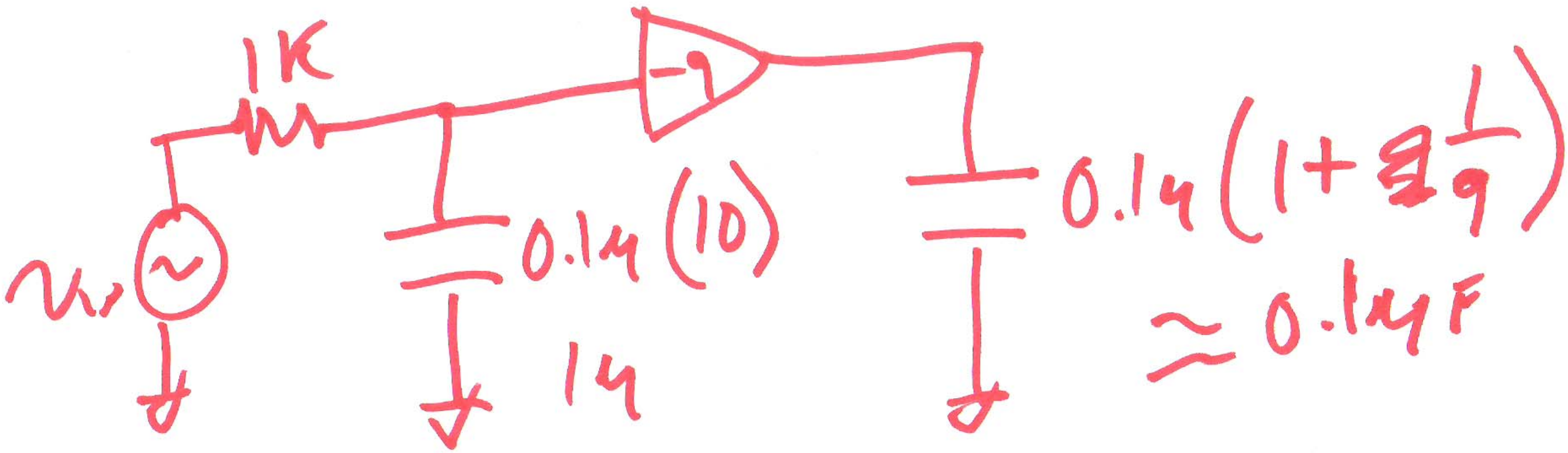
$$= \frac{v_{in}}{\frac{1}{j\omega C(1+A)}}$$



$$C\left(1+\frac{1}{|A|}\right)$$



estimate the 3dB freq.
verify with SPICE



$$f_{3dB} = 159\,Hz = \frac{1}{2\pi \cdot 1K \cdot 1\mu F}$$

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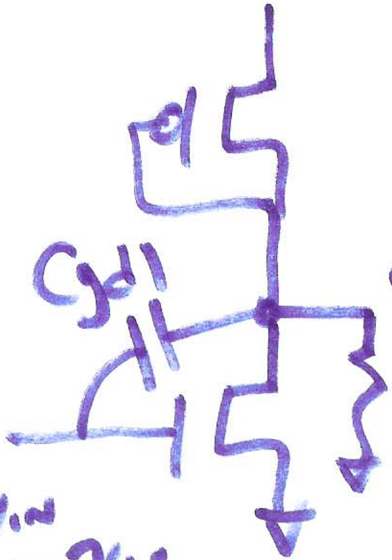
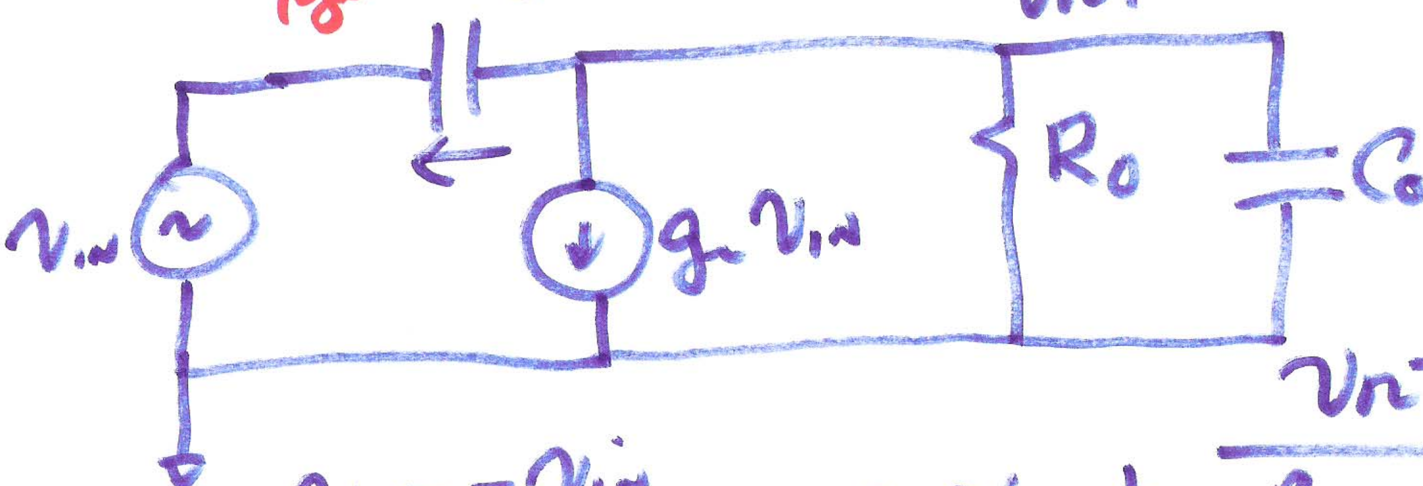


$R_o \left(= \frac{1}{g_m} \| r_{op} \| r_{on}\right)$

$$R_o \| \frac{1}{j\omega C_o} = \frac{R_o \cdot \frac{1}{j\omega C_o}}{R_o + \frac{1}{j\omega C_o}}$$

$$-\frac{R_o}{1/g_m} = -g_m \cdot R_o$$



$$0 = \frac{v_{nT} - v_{in}}{\frac{1}{j\omega C_{gd1}}} + g_m v_{in} + \frac{v_{nT}}{\frac{R_o}{1 + j\omega C_o \cdot R_o}}$$

$$0 = v_{out} \cdot j\omega C_{gd1} - v_{in} \cdot j\omega C_{gd1} + v_{in} \cdot g_m + v_{out} \cdot \frac{1}{R_o} + v_{out} \cdot j\omega C_o$$

$$0 = v_{out}\left(j\omega(C_o + C_{gd1}) + \frac{1}{R_o}\right) + v_{in}\left(g_m - j\omega C_{gd1}\right)$$

$$\frac{v_{out}}{v_{in}} = \frac{-(g_m - j\omega C_{gd1})}{\frac{1}{R_o} + j\omega(C_o + C_{gd1})} = \frac{-g_m R_o\left(1 - \frac{j\omega C_{gd1}}{g_m}\right)}{1 + j\omega(C_o + C_{gd1})R_o}$$