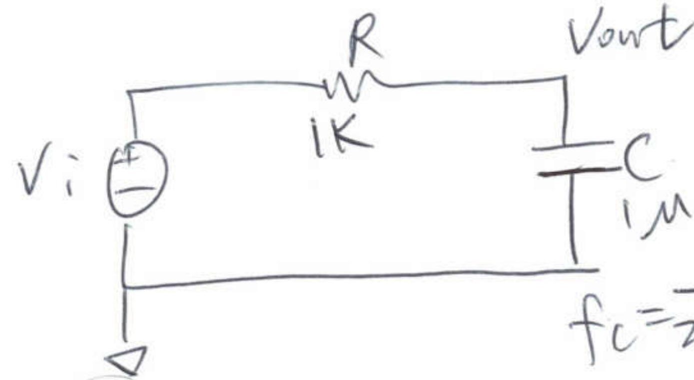
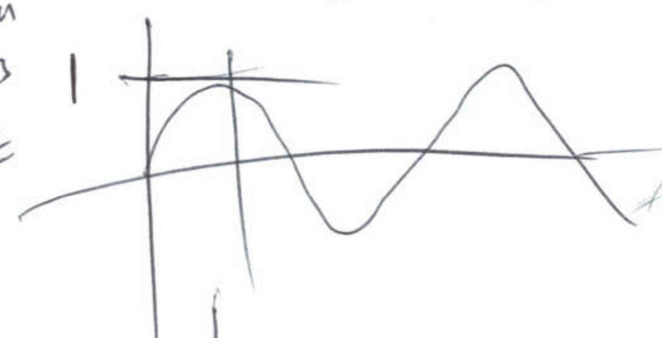


$\boxed{a+jb}$ $\sqrt{a^2+b^2}$

$\arctan\frac{b}{a}$

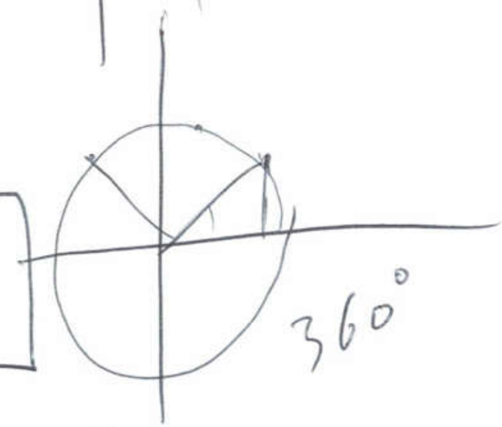
$$f_c = \frac{1}{2\pi \cdot 1K \cdot 1\mu} = \frac{1}{6.28 \cdot 10^{-3}} = 159\,\mathrm{Hz}$$



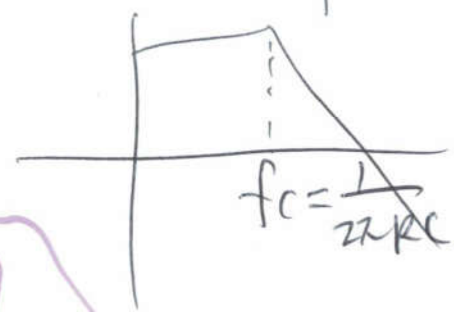
$$\frac{V_{out}}{V_i} = \frac{1/j\omega C}{R + 1/j\omega C} = \frac{1}{1 + j\omega RC}$$

$$\left|\frac{V_{out}}{V_i}\right| = \frac{1}{\sqrt{1^2 + (\omega RC)^2}}, \quad \omega = 2\pi f$$

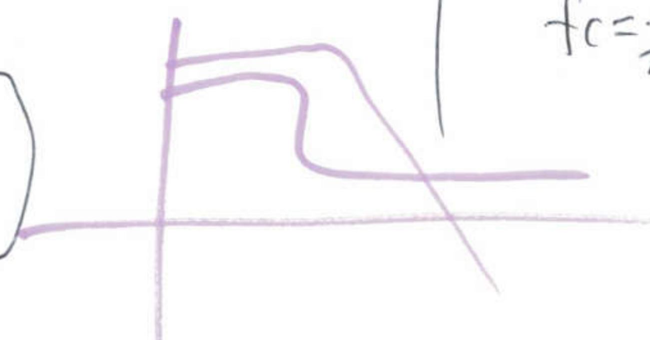
$$= \frac{1}{\sqrt{1^2 + (2\pi f RC)^2}}, \quad \boxed{f_c = \frac{1}{2\pi RC}}$$



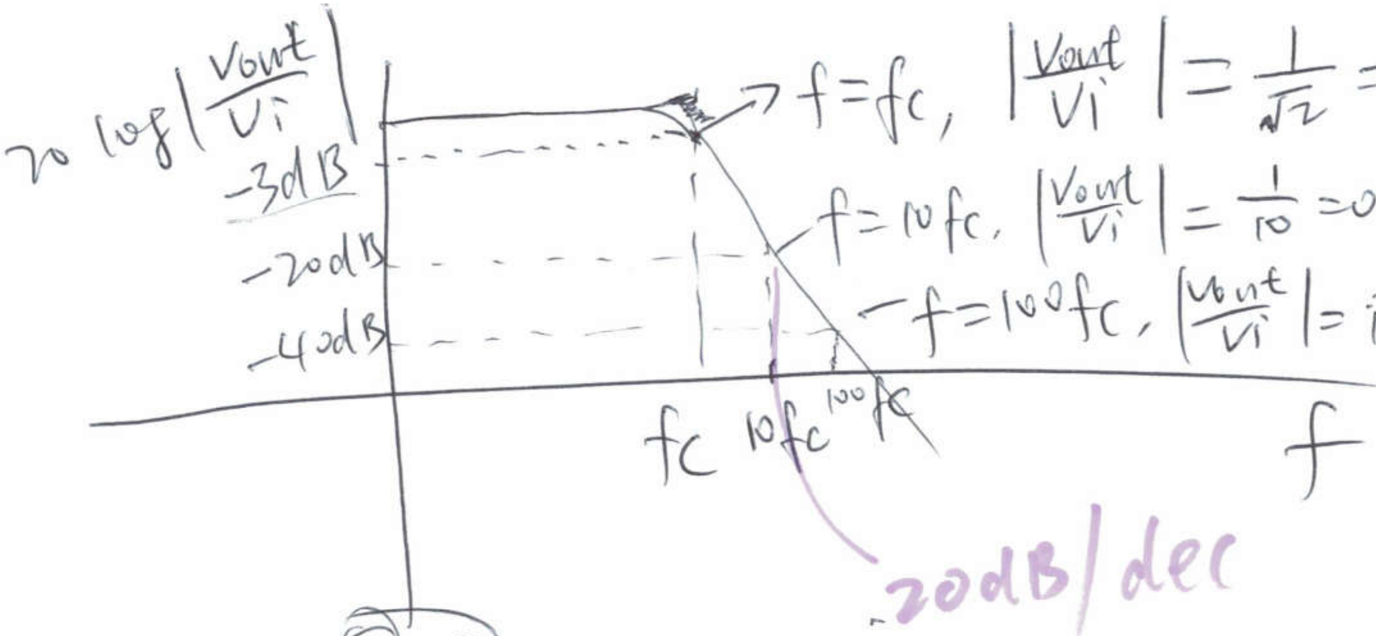
$$= \frac{1}{\sqrt{1 + \left(\frac{f}{f_c}\right)^2}}$$



$$\boxed{\frac{V_{out}}{V_i} = \frac{1}{1 + j\frac{f}{f_c}}}$$



(1)

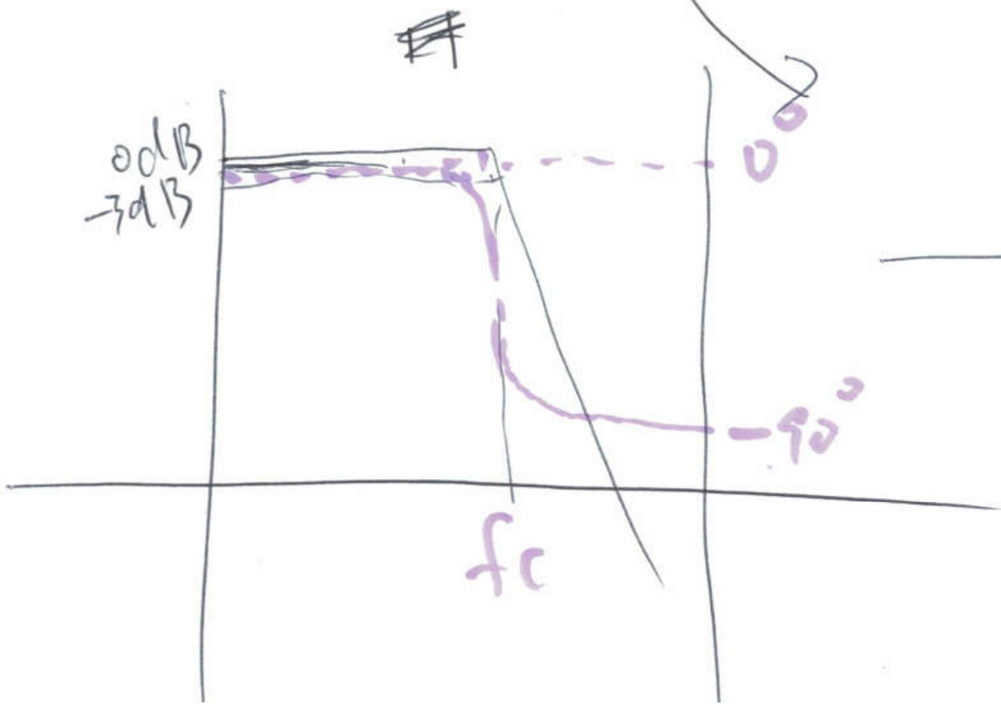


$f = f_c, \left|\frac{V_{out}}{V_i}\right| = \frac{1}{\sqrt{2}} = 0.707 \quad 20\log(0.707) = -3dB$

$f = 10f_c, \left|\frac{V_{out}}{V_i}\right| = \frac{1}{10} = 0.1 \quad 20\log(0.1) = -20dB$

$f = 100f_c, \left|\frac{V_{out}}{V_i}\right| = \frac{1}{100}, \quad 20\log 0.01 = -40dB$

$$\frac{V_{out}}{V_i} = \frac{1+0j}{1+j\frac{f}{f_c}}$$



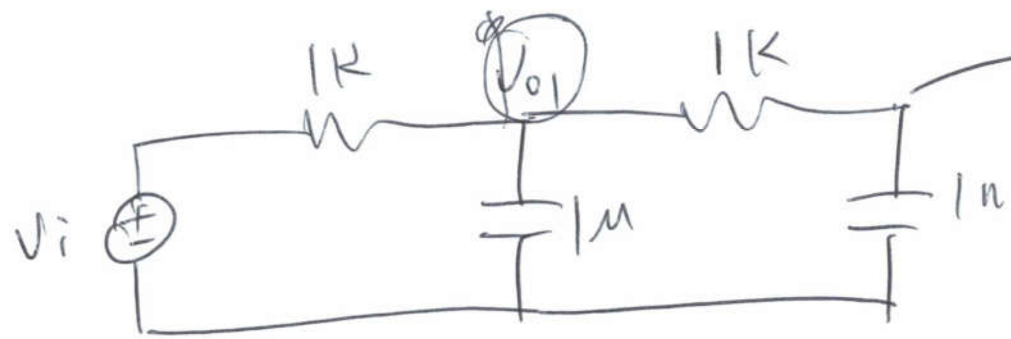
$\angle 0°$

$f\uparrow, \frac{V_{out}}{V_i} = \frac{1+0j}{1+j\,\text{huge}}$

$\angle 90°$

$= \angle 0° - \angle 90°$

$= -90°$

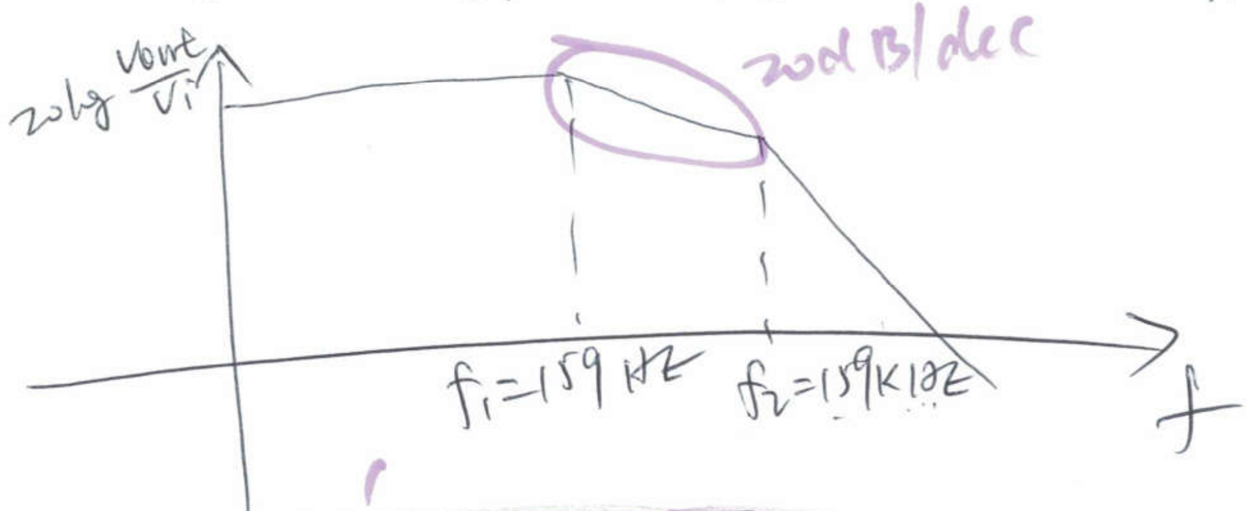


$$\begin{cases} f_1 = \frac{1}{2\pi \cdot 1K \cdot 1\mu} = 159\ Hz \\ f_2 = \frac{1}{2\pi \cdot 1K \cdot 1n} = 159\ KHz \end{cases}$$

$f_2 \gg f_1$

$$\frac{V_{o1}}{V_i} = \frac{1}{1+j\frac{f}{f_1}} \ ①, \quad \frac{V_{out}}{V_{o1}} = \frac{1}{1+j\frac{f}{f_2}} \ ②$$

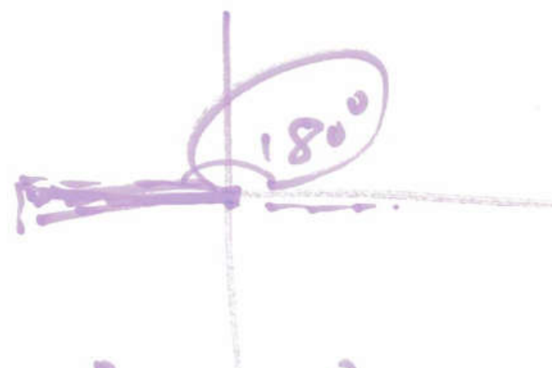
$$①\times② \quad \cancel{\frac{V_{o1}}{V_i}} \times \cancel{\frac{V_{out}}{V_{o1}}} = \frac{V_{out}}{V_i} = \frac{1}{(1+j\frac{f}{f_1})(1+j\frac{f}{f_2})}$$



low f: $\frac{1}{(1+j\frac{f}{f_1})(1+j\frac{f}{f_2})}$ $\rightarrow 1$

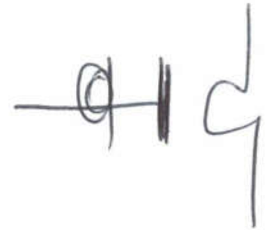
higher f: $\frac{1}{\underbrace{(1+j\frac{f}{f_1})}_{0.1}\underbrace{(1+j\frac{f}{f_2})}_{0.1}}$ $20\log(0.01) = -40dB$

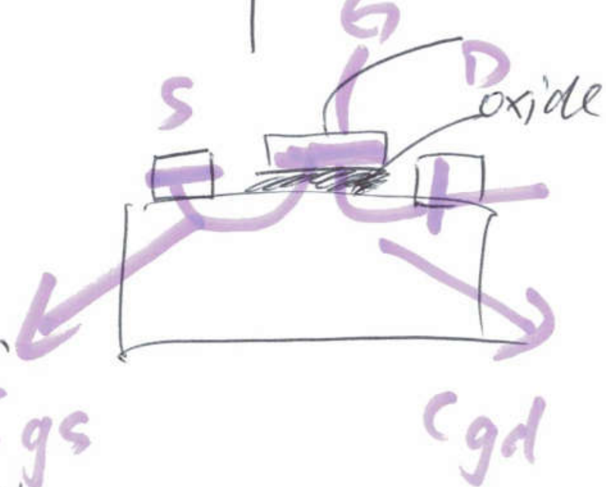
$$\frac{V_{out}}{V_i} = \frac{1}{(1+j\frac{f}{f_1})(1+j\frac{f}{f_2})} = \frac{1}{1+j\frac{f}{f_2}+j\frac{f}{f_1}-\frac{f^2}{f_1 f_2}} = \frac{\overset{1+j0\ \angle 0^\circ}{1}}{\left(1-\frac{f^2}{f_1 f_2}\right)+j\left(\frac{f_2 f+f_1 f}{f_1 f_2}\right)}$$



$\angle 0^\circ - \angle 180^\circ = -180^\circ$

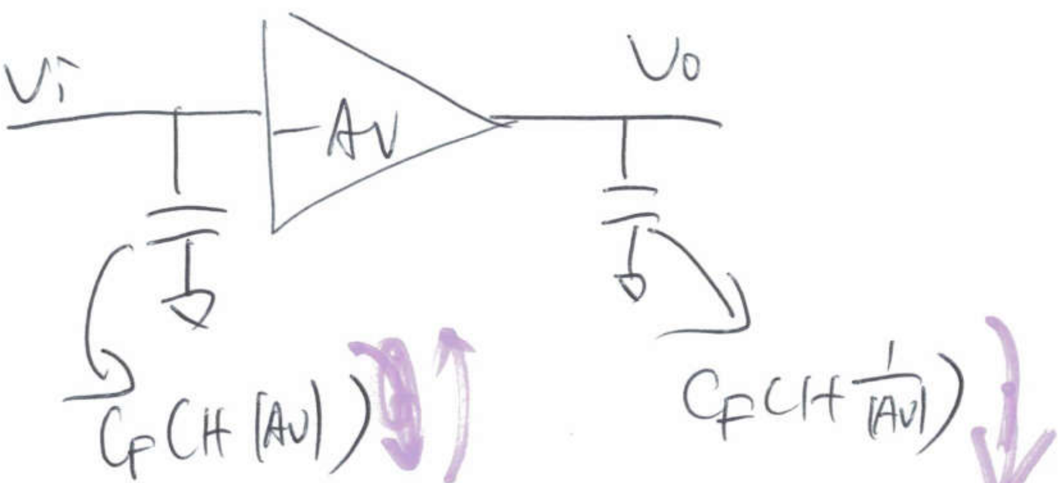
Miller Effect (Theorem)

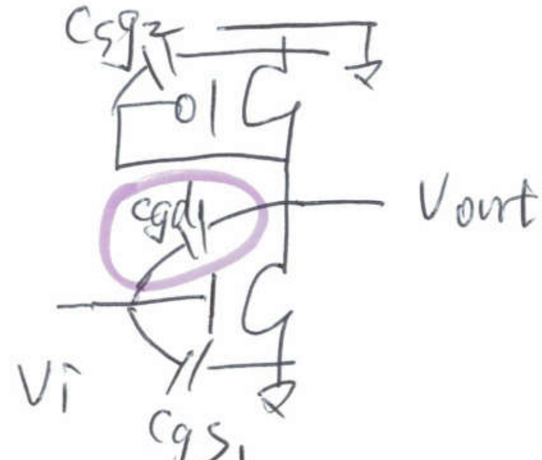


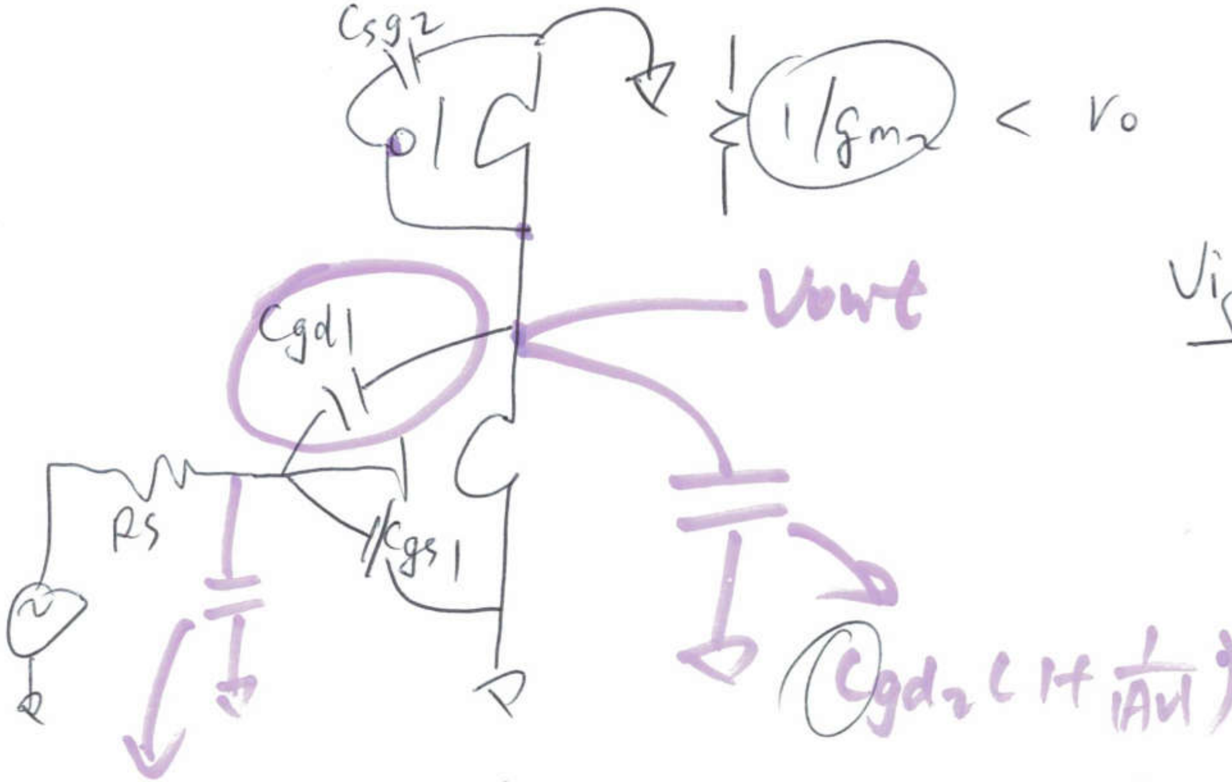


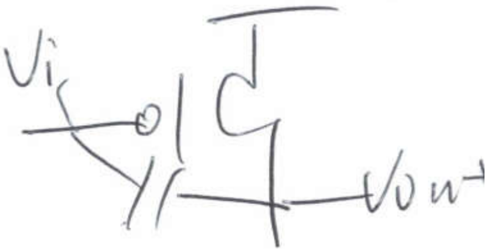
$$\begin{cases} i = \dfrac{V_i - V_o}{1/j\omega C_F} = j\omega C_F (V_i - V_o) \\ V_o = -A_V \cdot V_i \end{cases}$$

$$\begin{cases} i = j\omega C_F (V_i + A_V \cdot V_i) = j\omega \boxed{C_F(1+|A_V|)} \cdot V_i \\ i = j\omega C_F (V_o + \dfrac{1}{|A_V|} V_o) = j\omega \boxed{C_F(1+\dfrac{1}{|A_V|})} V_o \end{cases}$$









$\frac{1}{2\pi C}$

$C_{gd1}(1+|A_v|)$

$$\begin{cases} C_{MI} = C_{gd1}(1+|A_v|) \\ C_{MO} = C_{gd2}\left(1+\frac{1}{|A_v|}\right) \end{cases}$$

$\tau = RC =$ Time

$A_v = -\cancel{\frac{g_{m2}}{g_{m1}}}$ -gm1/gm2

$$\begin{cases} C_{tol\_in} = C_{MI} + C_{gs1} \\ C_{tol\_out} = C_{MO} + C_{sg2} \end{cases}$$

$$\begin{cases} \tau_{in} = R_S \cdot (C_{MI} + C_{gs1}) \\ \tau_{out} = \frac{1}{g_{m2}}(C_{MO} + C_{sg2}) \end{cases}$$

(b)