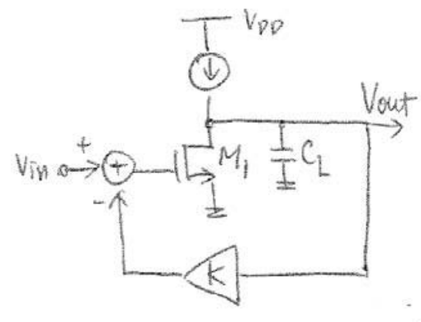
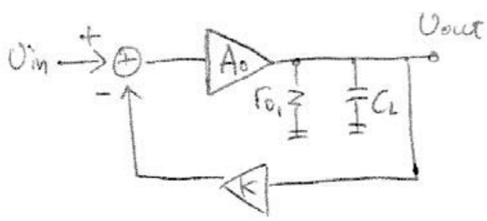
10. An equivalent circuit is shown below:





Open-loop transfer function (without feedback):

$$A(s) = \frac{A_0}{1+\frac{s}{\omega_p}} = \frac{-g_{m1}r_{o1}}{1+\frac{s}{r_{o1}C_L}}$$

$$\text{Loop Gain} = A_0 K = g_{m1} r_{o1} K$$

$\Rightarrow$ Closed-loop −3dB bandwidth

$$= B = (r_{o1}C_L)(1+A_0K) = r_{o1}C_L(1+g_{m1}r_{o1}K)$$

$$\therefore K = \left(\frac{B}{r_{o1}C_L} - 1\right) \times \frac{1}{g_{m1}r_{o1}}$$

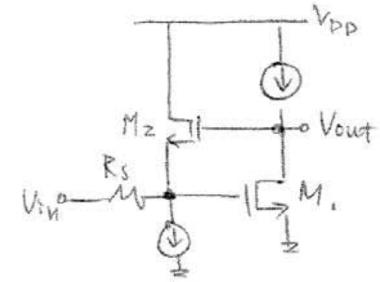
3dB带宽指幅值等于最大值的二分之根号二倍时对应的频带宽度

$$闭环传递函数H(S) = -\frac{g_{m1}r_{01}/\left(1\text{-}g_{m1}r_{01}K\right)}{1+Sr_{01}c_L/\left(1\text{-}g_{m1}r_{01}K\right)}$$

$$由\left|\mathrm{H(j}B)\right| = \frac{1}{\sqrt{2}}\left|\mathrm{H(j0)}\right|$$

$$得到\mathrm{K}=-\frac{\mathrm{B}r_{01}c_L\text{-}1}{g_{m1}r_{01}}$$

23. First, recognize that
(a) both input & output are voltages.



* V_{in} primarily drives the Gate of M_1.

Sequence: Suppose v_{in} <u>increases</u> by Δv_{in}

$\Rightarrow$ v_{out} <u>drops</u> by $+g_{m_1}\Delta v_{in} \times r_{o_1}$ (Common-Source)

$\Rightarrow$ Source of M_2 <u>decreases</u> by same amount (Source follower)

$\therefore$ $v_{in} \uparrow \Rightarrow V_{M_1,D} \downarrow \Rightarrow V_{M_1,G} \downarrow$

$\Rightarrow$ effective v_{in} driving $M_{1,G} \downarrow$

$\Rightarrow$ negative feedback

(b) $v_{in} \uparrow \Rightarrow v_{out} \downarrow \Rightarrow v_{M_2,G} \uparrow$

$\Rightarrow$ effective v_{in} driving $M_{1,G} \uparrow$

$\Rightarrow$ positive feedback.

(c) $v_{in} \uparrow \Rightarrow v_{out} \downarrow \Rightarrow v_{M1,G} \downarrow$

$\Rightarrow$ effective v_{in} driving $M_{1,G}$ $\downarrow$

$\Rightarrow$ negative feedback.

(d) $v_{in} \uparrow \Rightarrow v_{out} \uparrow$ (common-base, M_1)

$\Rightarrow v_{M1,S} \downarrow$

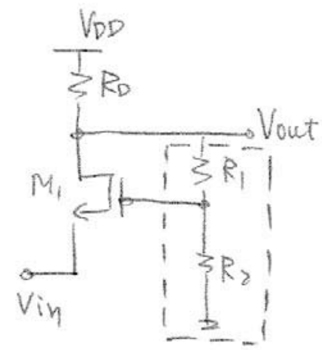
$\Rightarrow$ effective v_{in} driving $M_{1,S}$ $\downarrow$

$\Rightarrow$ negative feedback.

26.

(Without feedback)

$$\frac{V_{out}}{V_{in}} = A_{O.L.} = g_m R_D$$



$R_1 + R_2 \gg R_D$

$\lambda = 0$

Feedback factor, k :

$$k = \frac{R_2}{R_1+R_2}$$

$$\Rightarrow A_{C.L.} = \left.\frac{V_{out}}{V_{in}}\right|_{C.L.} = \frac{A_{O.L}}{1 + A_{O.L}\cdot K} = \frac{g_m R_D}{1 + \frac{R_2}{R_1+R_2} g_m R_D}$$

$$R_{in,\,CLOSED} = \frac{1}{g_{m1}}\left(1 + \frac{R_2}{R_1+R_2} g_m R_D\right)$$

$$R_{out,\,CLOSED} = \frac{R_D}{1 + \frac{R_2}{R_1+R_2} g_m R_D}$$

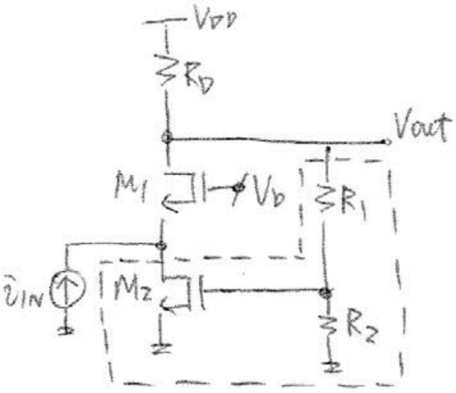
$$A_{OL} = g_m R_D \,||\, (R_1+R_2) \,||\, r_{01} \approx g_m R_D \,||\, r_{01}$$

$$R_{out,Closed} = \frac{R_D \,||\, r_{01}}{1 + \frac{R_2}{R_1+R_2} g_m R_D}$$

34.

$$R_{O.L.} = \frac{v_{out}}{i_{IN}} \quad (\text{no feedback})$$

$$= R_D$$



$\lambda = 0$

$R_1 + R_2 \gg 1.$

K (feedback factor)

$$= g_{m2} \times \frac{R_2}{R_1 + R_2}$$

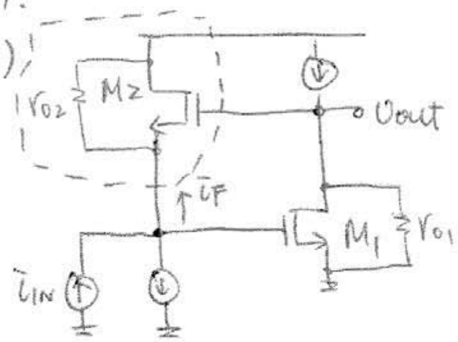
$$\Rightarrow R_{C.L.} = \frac{v_{out}}{i_{IN}} = \frac{R_D}{1 + R_D \times g_{m2} \frac{R_2}{R_1 + R_2}}$$

$$r_{in}\big|_{C.L.} = \frac{1/g_{m1}}{1 + R_D \times g_{m2} \frac{R_2}{R_1 + R_2}}$$

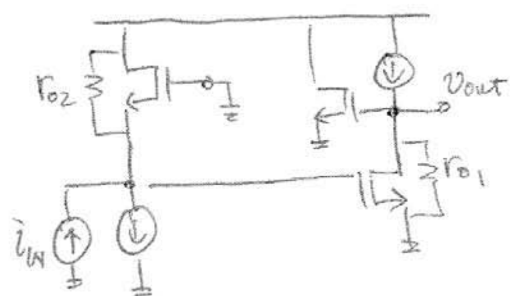
$$r_{out}\big|_{C.L.} = \frac{R_D}{1 + R_D \times g_{m2} \frac{R_2}{R_1 + R_2}}$$

59.

(a)



Breaking the feedback network results in the following:

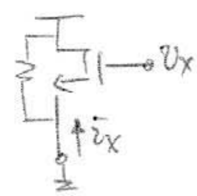


$$R_{OL} = \frac{v_{out}}{i_{IN}} = -\left(r_{o2} \parallel \frac{1}{g_{m2}}\right) g_{m1} r_{o1}$$

$$R_{in,open} = r_{o2} \parallel \frac{1}{g_{m2}}$$

$$R_{out,open} = r_{o1}$$

K:



$$K = \frac{i_x}{v_x} = g_{m2}$$

$$\therefore \quad R_{CL} = \frac{R_{OL}}{1 + R_{OL}K} = \frac{\left(r_{o2} \parallel \frac{1}{g_{m2}}\right) g_{m1} r_{o1}}{1 + g_{m1} g_{m2} r_{o1} \left(r_{o2} \parallel \frac{1}{g_{m2}}\right)}$$

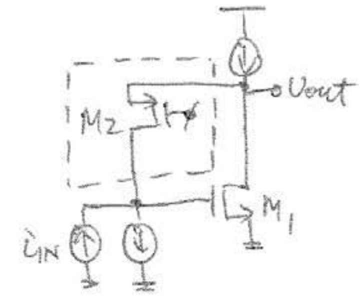
$$R_{IN,closed} = \frac{\left(r_{o2} \parallel \frac{1}{g_{m2}}\right)}{1 + g_{m1} g_{m2} r_{o1} \left(r_{o2} \parallel \frac{1}{g_{m2}}\right)}$$

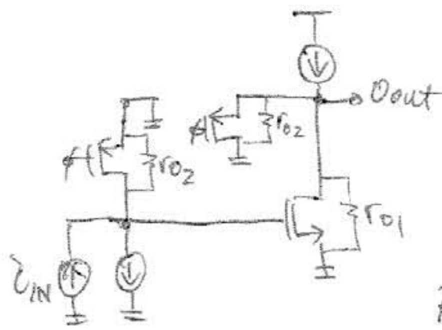
$$R_{out,closed} = \frac{r_{o1}}{1 + g_{m1} g_{m2} r_{o1} \left(r_{o2} \parallel \frac{1}{g_{m2}}\right)}$$

$$K = \frac{i_x}{V_x} = -gm_2$$

$$A_{C,L} = -\frac{gm_1 r_{01}\left(\frac{1}{gm_2} \parallel r_{02}\right)}{1 + gm_1 gm_2 r_{01}\left(\frac{1}{gm_2} \parallel r_{02}\right)}$$

(b) Breaking the feedback network results in the following:





$$R_{OL} = \frac{v_{out}}{i_{IN}}$$

$$= -r_{O2} \times g_{m1}\left[r_{O1} \| r_{O2} \| \frac{1}{g_{m2}}\right]$$

$$R_{in,\,OPEN} = r_{O2}$$

$$R_{out,\,OPEN} = r_{O1} \| r_{O2} \| \frac{1}{g_{m2}}$$

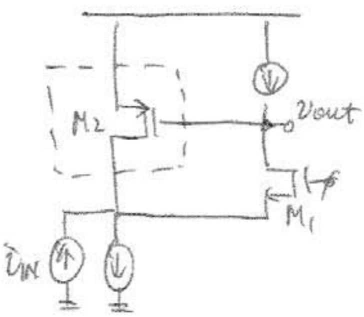
$$K = \frac{i_X}{v_X} = -g_{m2}$$

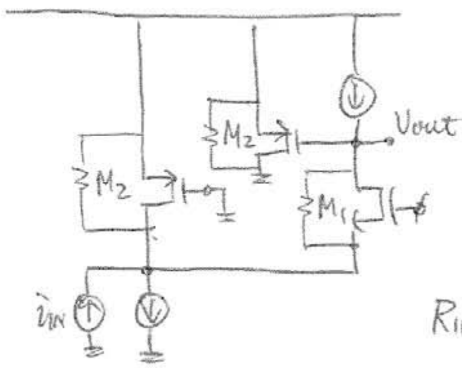
$$\therefore \; R_{CL} = \frac{R_{OL}}{1 + R_{OL}K} = \frac{-g_{m1}r_{O2}\left[r_{O1} \| r_{O2} \| \frac{1}{g_{m2}}\right]}{1 + g_{m1}g_{m2}r_{O2}\left[r_{O1} \| r_{O2} \| \frac{1}{g_{m2}}\right]}$$

$$R_{IN,\,CLOSED} = \frac{r_{O2}}{1 + R_{OL}K}$$

$$R_{out,\,CLOSED} = \frac{r_{O1} \| r_{O2} \| \frac{1}{g_{m2}}}{1 + R_{OL}K}.$$

(c) Breaking the feedback network results in the following:





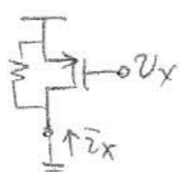
$$R_{OL} = \frac{v_{out}}{i_{IN}}$$

$$\approx \left(\frac{1}{g_{m1}} \parallel r_{o2}\right)(1 + g_{m1} r_{o1})$$

$$R_{in,\,OPEN} \cong \frac{1}{g_{m1}} \parallel r_{o2}$$

$$R_{out,\,OPEN} \simeq r_{o2} + r_{o1}(1 + g_{m1} r_{o2})$$

K:



$$K = \frac{i_X}{v_X} = g_{m2}$$

$$\therefore\ R_{CL} = \frac{R_{OL}}{1 + R_{OL} K} = \frac{\left(\frac{1}{g_{m2}} \parallel r_{o2}\right)(1 + g_{m1} r_{o1})}{1 + g_{m2}\left(\frac{1}{g_{m1}} \parallel r_{o2}\right)(1 + g_{m1} r_{o1})}$$

$$R_{IN,\,CLOSED} = \frac{\frac{1}{g_{m1}} \parallel r_{o2}}{1 + R_{OL} \cdot K}$$

$$R_{out,\,CLOSED} = \frac{r_{o2} + r_{o1}(1 + g_{m1} r_{o2})}{1 + R_{OL} \cdot K}$$