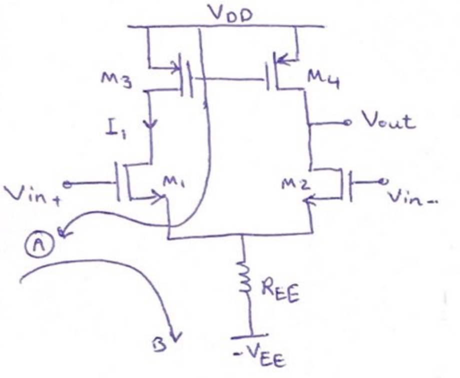
یالطیف

رضا ادیبی پور
۹۸۱۴۳۰۳
تمرین سری ۷ الک ۲

#1



$I_1 = \frac{K'}{2}\frac{W}{L}(V_{SG}-|V_{th}|)^2$

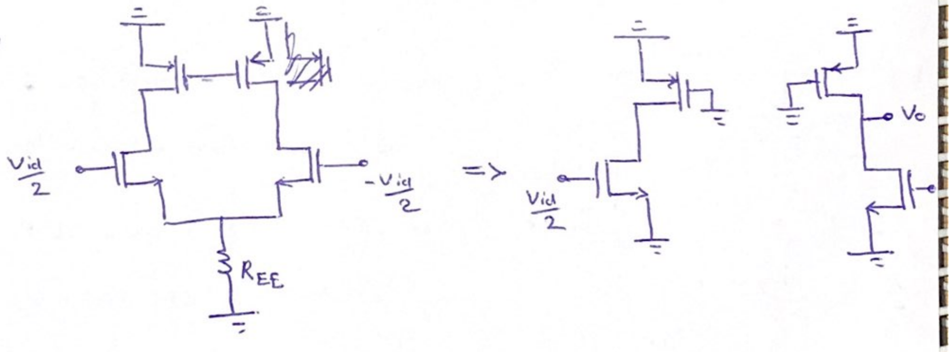
KVL @ A: $-V_{DD}+V_{SD_3}+V_{SD_1} \mp V_{SG}+V_{in,dc}=0$

$V_{in,dc}=V_{DD}-V_{SD_3}-V_{SD_1}+V_{SG}$

KVL @ B: $-V_{in,dc}+V_{GS}+2I_1R_{EE}-V_{EE}=0$

$\Rightarrow V_{in,dc}=V_{GS}+2I_1R_{EE}-V_{EE}$

Diffrential half circuit:



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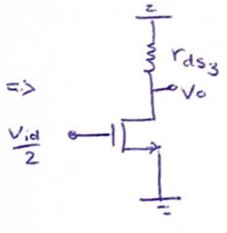
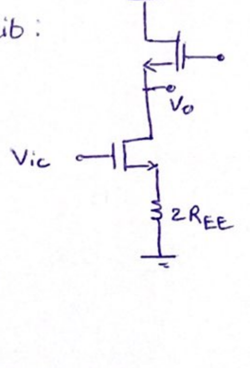


$\Rightarrow \frac{V_o}{V_{id}} = A_{vd} = \frac{1}{2} g_m r_{ds_3} = \frac{1}{2}\left[K'\frac{W}{L}(V_{GS}-V_{th})\right] r_{ds_3}$

$\frac{V_{o+}-V_{o-}}{V_{id}} = \frac{V_{od}}{V_{id}} = -g_m r_{ds_3} = -r_{ds_3}\left[K'\frac{W}{L}(V_{GS}-V_{th})^2\right]$

Common-mode half circuit:



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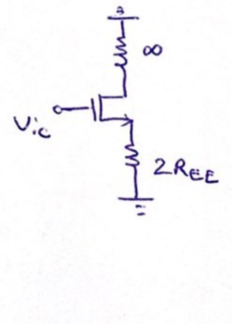
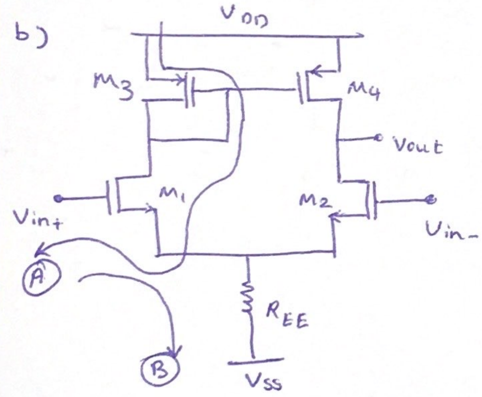


$A_{v_c} = \frac{-\infty}{\frac{1}{g_m}+2R_{EE}}$

b)



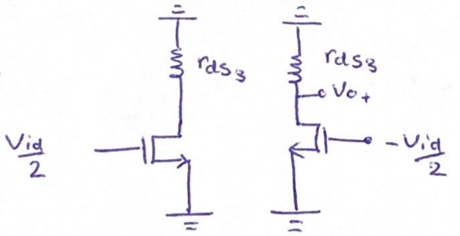
KVL @ A: $-V_{DD} + V_{SG_3} + V_{DS_1} + V_{SG_1} + V_{in,dc} = 0$

$V_{idc} = V_{DD} + V_{SG_3} + V_{SG_1} - V_{DS_1}$

KVL @ B: $-V_{idc} + V_{GS} + 2I_1 R_{EE} - V_{SS} = 0$

$\Rightarrow V_{idc} = 2I_1 R_{EE} + V_{GS} - V_{SS}$

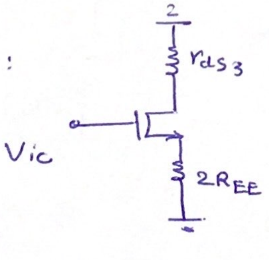
differential half circuit:



$A_v = \frac{V_{o+}}{V_{id}} = \frac{1}{2} g_m r_{ds_3}$

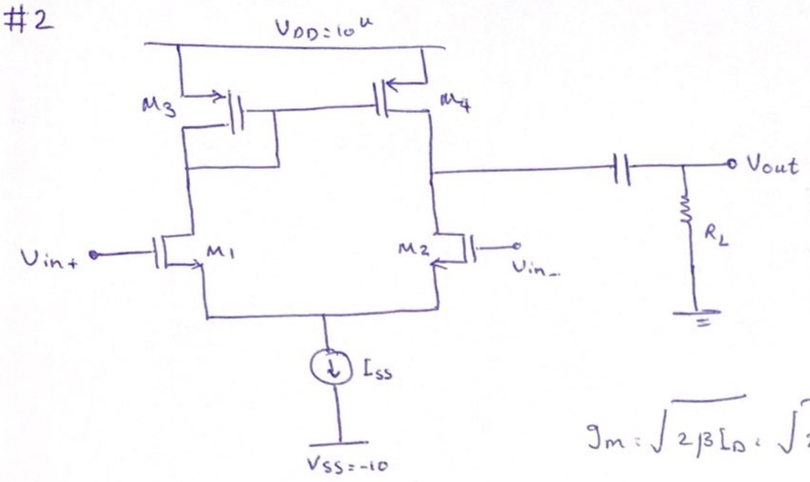
$A_v\Big|_{\substack{\text{diffrential}\\ \text{output}}} = \frac{V_{od}}{V_{id}} = -2 g_m r_{ds}$

common mode half circuit:



$A_v = \frac{r_{ds_3}}{\frac{1}{g_m} + 2R_{EE}}$

#2



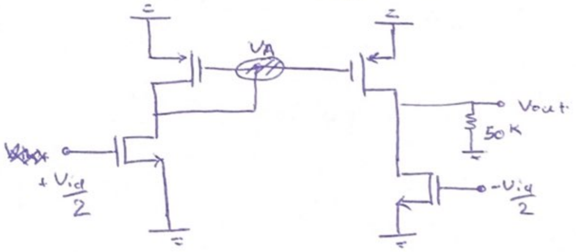
$$\begin{cases} \beta = 1 \frac{mA}{v^2} \\ |V_{th}| = 2v \\ \lambda = (\frac{1}{75})v^{-1} \\ R_L = 50\ k\Omega \end{cases}$$

$I_{ss} = 1mA$

$$g_m = \sqrt{2\beta I_D} = \sqrt{2\times 1\times \frac{1}{2}} = 1\ \text{mmho}$$

$$r_{ds} = \frac{1}{\lambda I_D} = \frac{75}{0.5} = 150^k$$

diffrential inputs:



$$\frac{V_{out}}{\frac{V_{id}}{2}} = \frac{V_{out}}{V_A} \times \frac{V_A}{\frac{V_{id}}{2}}$$

$$\frac{V_{out}}{V_A} = -g_{m4}\left(r_{ds4} \| r_{ds2} \| R_L\right) = -1\left(75^k \| 50^k\right) = -30$$

$$\frac{V_A}{\frac{V_{id}}{2}} = -g_{m1}\left(r_{ds1} \| \frac{1}{g_{m3}}\right) = -g_{m1}\left(\frac{1}{g_{m2}}\right) = -1$$

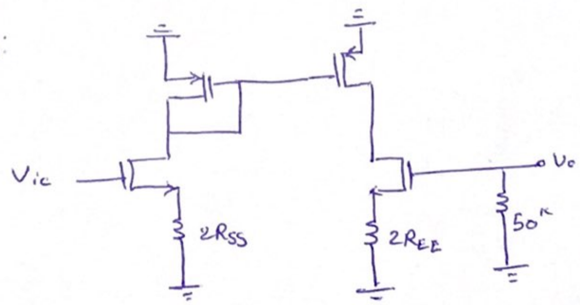
$$\Rightarrow \frac{V_{out}}{\frac{V_{id}}{2}} = -30\left(\frac{-1}{2}\right) = 15$$

$$\Rightarrow \frac{V_A}{V_{id}} = -\frac{1}{2}$$

$$\Rightarrow \underline{\frac{V_o}{V_{id}} = 7.5\ \frac{v}{v}}$$

$$, \quad \frac{V_{out}}{-\frac{V_{id}}{2}} = -15^v \Rightarrow \frac{V_{out}}{-V_{id}} = -\frac{15}{2} = -7.5$$

common mode inputs:



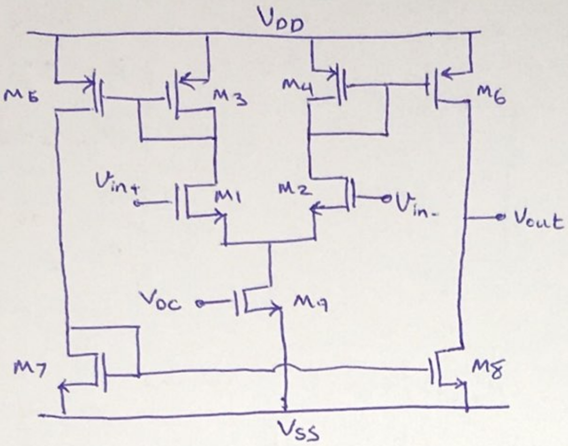
$$A_v = \frac{-r_{ds3}}{\frac{1}{g_m} + 2R_{SS}}$$

هرچه Rss زیادتر باشد

مخرج کسر بزرگ و کل کسر (Av)

کوچک می شود ← بهره common mode کم می شود

#3



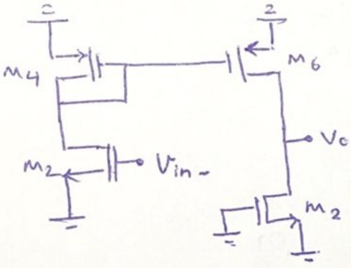
$$\begin{cases} V_{eff_{1,2}} = 0.1^{v} , V_{eff\,3:9} = 0.2^{v} \\ \lambda = 0.1\, v^{-1} \\ I_{D_7} = 1^{mA} \\ \left(\frac{W}{L}\right)_{5,6} = 2\left(\frac{W}{L}\right)_{3,4} \\ \left(\frac{W}{L}\right)_7 = \left(\frac{W}{L}\right)_8 \end{cases}$$

$$r_{ds9} = \frac{1}{\lambda I_D} = \frac{10}{1^{mA}} = 10^{k} , \quad g_{m3,4} = \frac{2I_D}{V_{eff}} = \frac{1}{0.2} = 5 \frac{mA}{v^2} , \quad g_{m1,2} = \frac{1^{m}}{0.1} = 10 \frac{mA}{v^2}$$

$$g_{m5,6} = \frac{2I_D}{V_{eff}} = \frac{2}{0.2} = 10 \frac{mA}{v^2} , \quad g_{m7,8} = g_{m5} = 10 \frac{mA}{v^2}$$

$$\begin{cases} r_{ds_2} = \frac{10}{1} = 10^{k} \\ r_{ds_3} = 10^{k} \end{cases}$$

differential inputs:



$$A_{v,d} = \frac{V_o}{V_A} \times \frac{V_A}{V_{in}} = \frac{V_{out}}{V_{in}}$$

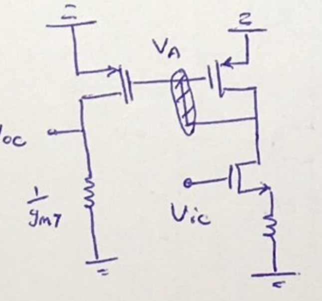
$$\frac{V_{out}}{V_A} = -g_{m6}\left(R_D \,\|\, r_{ds_2}\right) =$$

$$60\left(10^{k} \,\|\, 10^{k}\right) = 50$$

$$\frac{V_A}{V_{in-}} = -g_{m2}\left(R_D \,\|\, r_{ds2}\right) = -g_{m2}\left(\frac{1}{g_{m4}} \,\|\, r_{ds2}\right) = -10\left(\frac{1}{5}\right) = \underline{-2}$$

$$\Rightarrow \frac{V_{out}}{V_{in-}} = -2(-50) = 100$$

Common-mode inputs:



$$A_{vc} = \frac{V_{oc}}{V_{ic}} = \frac{V_{oc}}{V_A} \times \frac{V_A}{V_{ic}}$$

$$\frac{V_{oc}}{V_A} = -g_{m5}\left(R_D \,\|\, r_{ds5}\right) = -10\left(\frac{1}{10} \,\|\, 10^{k}\right) = -1$$

$$\frac{V_A}{V_{ic}} = \frac{-R_D}{R_S + \frac{1}{g_{m1}}} = \frac{-\frac{1}{g_{m3}}}{20^{k} + \frac{1}{g_{m1}}} = \frac{-0.2}{20+0.1} = -0.01$$

$$\Rightarrow A_{vc} = (-1) \times (-0.01) = 0.01$$

$$\Rightarrow CMMR = \frac{A_{vd}}{A_{vc}} = \frac{100}{0.01} = 10000 = \underline{40\,dB}$$

$R_{in\,diff} = \infty$