Hw6

1. (1) $A_v = -\dfrac{g_m R}{1+g_m R_s}$

① $-10 = -\dfrac{g_m R_D}{1+0.5 g_m}$

② short $A_v = -g_m R_D = -20$

$\Rightarrow g_m = 2mA/V$ #

(2) $A_v = -\dfrac{g_m R_D}{1+g_m R_s} = -16$

$\Rightarrow 16 = \dfrac{20}{1+2\times10^{-3} R_s}$

$\Rightarrow R_s = 125\Omega$ #

2. (1) $R_{in} = \dfrac{1}{g_m} = \dfrac{1}{2\times10^{-3}} = 500\Omega$ #

(2) $G_v = \dfrac{(R_D \| R_L)}{R_{sig}+\frac{1}{g_m}}$

$= \dfrac{\frac{5}{2}}{0.75+0.5} = 2\,V/V$ #

3. $I_D = \frac{1}{2} k_n (V_{GS}-V_t)^2$

KVL:

(1) $V_G - V_{GS} - I_D R_s = 0$

$\Rightarrow I_D = \dfrac{(V_G - V_{GS})}{R_s}$

$\frac{1}{2} k_n (V_{GS}-V_t)^2 = \dfrac{(V_G - V_{GS})}{R_s}$

$\Rightarrow \frac{1}{2}\times 2\times10^{-3}\times(V_{GS}-1)^2 = \dfrac{(5-V_{GS})}{3\times10^3}$

$\Rightarrow 3(V_{GS}-1)^2 = 5 - V_{GS}$

$\Rightarrow 3V_{GS}^2 - 5V_{GS} - 2 = 0$

$\Rightarrow V_{GS} = 2$ or -0.33 (負不合)

$\therefore V_{GS} = 2V$

$I_D = \dfrac{V_G - V_{GS}}{R_s} = \dfrac{5-2}{3k} = 10^{-3}A = 1mA$ #

(2) $k_n' = 1.5 k_n = 3mA/V^2$

$\frac{1}{2}\times 3\times10^{-3}\times(V_{GS}-V_t)^2 = \dfrac{(5-V_{GS})}{3\times10^3}$

$\Rightarrow 4.5(V_{GS}-1)^2 = 5 - V_{GS}$

$\Rightarrow 9V_{GS}^2 - 16V_{GS} - 1 = 0$

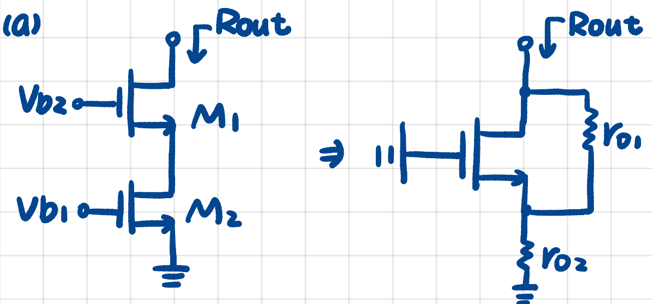
$\Rightarrow V_{GS} = 1.838$ or -0.06 (負不合)

$\Rightarrow V_{GS} = 1.838V$

$I_D = \dfrac{5-1.838}{3\times10^3} = 1.054mA$

$\dfrac{1.054-1}{1} = 0.054 = 5.4\%$ #

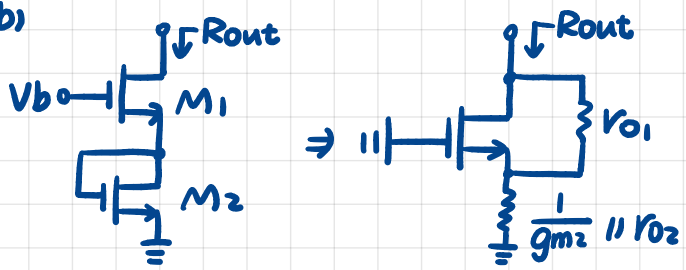
4. (a)



The impedence that degenerates the CS stage is r_o.

$\therefore R_{out} \approx (g_{m1} r_{o2} + 1) r_{o1}$ #

(b)



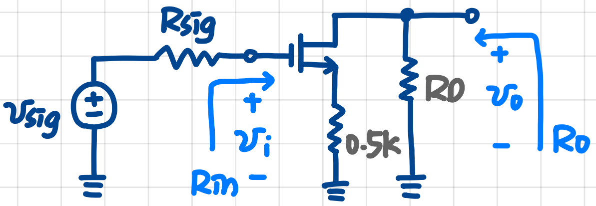
The impedence that degenerates the CS stage is $1/g_m$.

$\therefore R_{out} = r_{o1}(1 + g_{m1}/g_{m2}) + \dfrac{1}{g_{m2}}$ #

When $\dfrac{1}{g_{m2}}$ is parallel with r_{o2}

$\Rightarrow$ just consider $\dfrac{1}{g_{m2}}$ #

1. CS Amp



$R_i = \infty$

$R_o = R_D$

$V_i = V_{gs} + g_m V_{gs} R_s$

$V_o = -g_m V_{gs}(R_D // R_L)$

$A_v = \frac{-g_m(R_D//R_L)}{1+g_mR_s}$

$G_v = \frac{V_o}{V_{sig}} = \frac{R_{in}}{R_{in}+R_{sig}} A_v$

① $\Delta i = \frac{\Delta V_g}{\frac{1}{g_m}+R_s}$

② $\Delta V_o = 0 - \Delta i \cdot R_D$

③ $G_v = \frac{\Delta V_o}{\Delta V_g}$

④ $\frac{1}{g_m} \ll R_s$, $G_v = -\frac{R_D}{R_s}$

$R_S = 0.5k\Omega \rightarrow A_v = -10$

$R_S = \text{short} \rightarrow A_v = -20$

$$\frac{-\cancel{10} = \frac{-g_mR_D}{1+g_m\times0.5\times10^3}}{2\ -\cancel{20} = -g_mR_D}$$

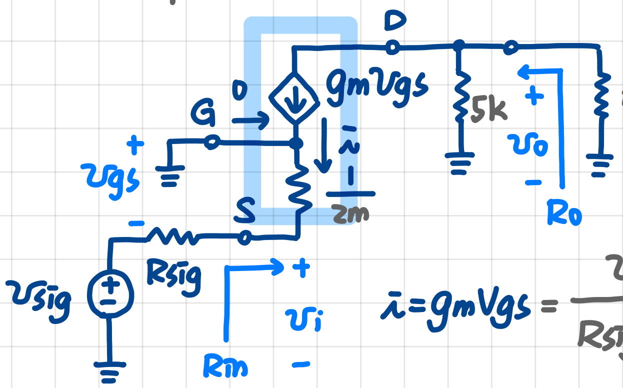
$g_m\times0.5\times10^3 = 1 \rightarrow g_m = 2\times10^{-3}$

$$\frac{\overset{4}{-\cancel{16}}}{\underset{5}{-\cancel{20}}} = \frac{\frac{-g_mR_D}{1+g_m\times R_S}}{-g_mR_D}$$

$\Rightarrow \cancel{1} + 2\times10^{-3}R_S = \frac{1}{4}$

$\Rightarrow R_S = \frac{1}{8}\times10^3 = 0.125k\Omega$ #

2. CG Amp



$i = g_m V_{gs} = \frac{v_{sig}}{R_{sig}+\frac{1}{g_m}}$

$R_{in} = \frac{1}{g_m}$

$R_o = R_D$

$V_i = -V_{gs}$

$V_o = -g_m V_{gs}(R_D//R_L)$

$A_v = g_m(R_D//R_L)$

$G_v = \frac{V_o}{V_{sig}} = \frac{V_o}{V_{in}} \times \frac{V_{in}}{V_{sig}} = A_v \times \frac{R_{in}}{R_{in}+R_{sig}}$

overall voltage gain

$A_{vo} = g_m R_D$

$\frac{V_s}{V_{sig}} = \frac{\frac{1}{g_m}}{\frac{1}{g_m}+R_{sig}}$

$R_{in} = \frac{1}{2m} = 0.5k\Omega$ #

$A_v = 2m \times \frac{1}{\frac{1}{5}+\frac{1}{5}} \times 10^3$

$= 2\times\cancel{10^{-3}} \times \frac{5}{2} \times \cancel{10^3} =$