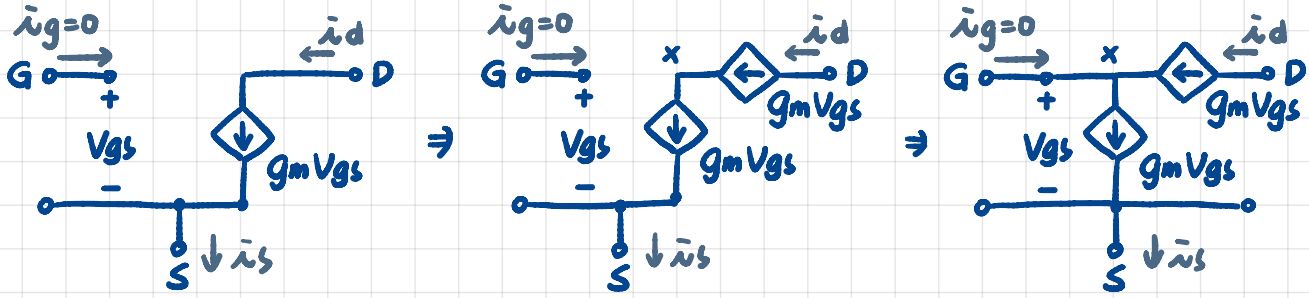
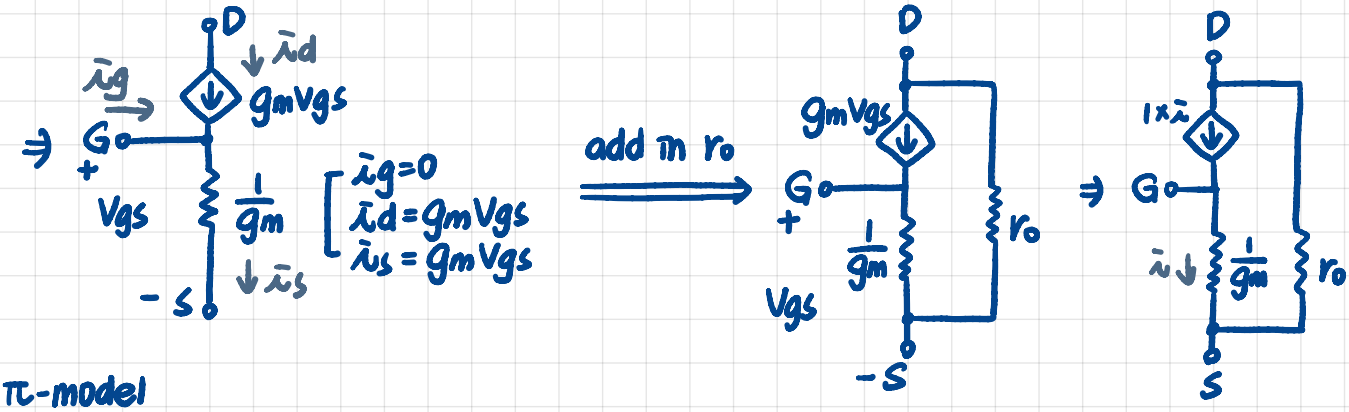
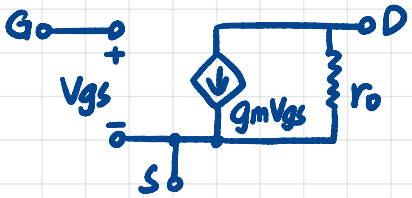
Hw5

1. T-model





π-model

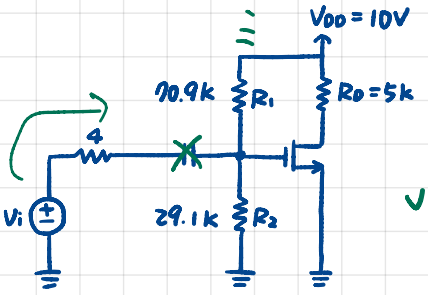


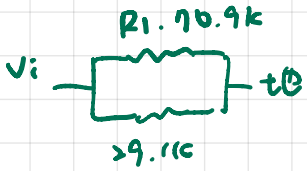
$r_o = \frac{|V_A|}{I_D}$

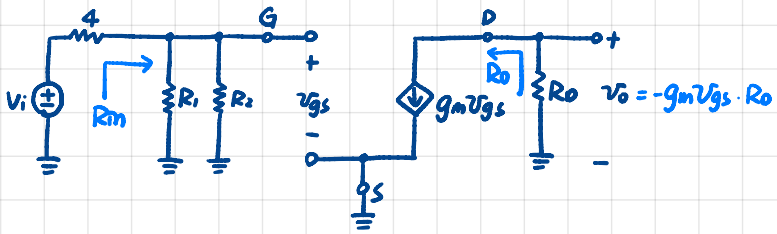
$I_D = \frac{1}{2} k_n V_{ov}^2$

equivalent

2.







① voltage gain $V_o = \frac{R_2}{R_1 + R_2} V_i = \frac{29.1}{100} V_i$

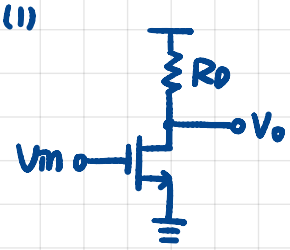
$$\frac{V_o}{V_i} = \frac{29.1}{100} = 291\ mV/V \#$$

② input resistance $R_{in} = R_1 // R_2$

$$= \frac{R_1 R_2}{R_1 + R_2} = \frac{70.9 \times 29.1 \times 10^6}{100 \times 10^3} \doteq 2.063 \times 10^4\ \Omega \doteq 21\ k\Omega \#$$

③ output resistance $R_o = R_D = 5k\Omega \#$

3.(1)



① $R_{in} = \infty$

② $I_D = \frac{1}{2}\mu_n \cdot C_{ox} \cdot \frac{W}{L} \cdot V_{ov}^2$

$\Rightarrow 320\times10^{-6} = \frac{1}{2}\times400\times10^{-6}\times10\times V_{ov}^2$

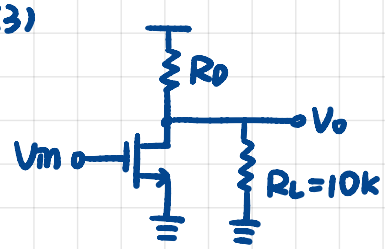
$\Rightarrow V_{ov} = 0.4\,V$

$A_v = -g_m \cdot R_D$

$= \frac{-2I_DR_D}{V_{ov}} = \frac{-2\times320\times10^{-6}\times10\times10^3}{4\times10^{-1}} = -16\ V/V$ #

③ $R_{out} = R_D = 10k\Omega$ #

(2)(3)



$A_v = G_v = \frac{V_o}{V_{sig}} = -g_m(R_D \| R_L)$

$= \frac{-2I_D}{V_{ov}} \times \frac{R_D \cdot R_L}{R_D + R_L}$

$= \frac{-2\times320\times10^{-6}}{4\times10^{-1}} \times \frac{100\times10^6}{2\times10\times10^3} = -8\ V/V$ #

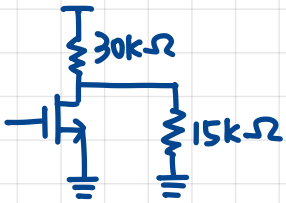
$|G_m| = \frac{V_o}{V_{sig}}$

$\Rightarrow 8 = \frac{0.2}{V_{sig}} \Rightarrow V_{sig} = 0.025V = 25\,mV$ #

4. ① $A_v = -g_m(R_D \| R_L)$

$\Rightarrow 10 = g_m \cdot \frac{450\times10^6}{15\times10^3 + 30\times10^3}$

$\Rightarrow g_m = 10^{-3} = 1mA/V$ #



② $g_m = \frac{2I_D}{V_{ov}}$

$\Rightarrow 1\times10^{-3} = \frac{2I_D}{0.25} \Rightarrow I_D = 0.125mA$ #

③ $A_v = -g_m(R_D \| R_L)$

$= -1\times10^{-3} \times \frac{225\times10^6}{15\times10^3\times2}$

$= -7.5\ V/V$ #