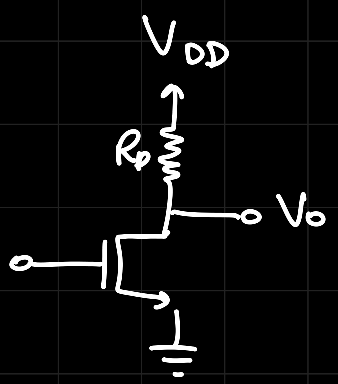
tentative date for simulation → 15th April
project deadline : before endsem

MOSFET AC analysis (small signal operation)

mosfet = Amplifier
only in saturation region
so that linear amplification is achieved



$$V_o = V_{DD} - I_D R_D$$

$$i_D R_D = V_{DD} - V_o = V_{DD} - V_{DS}$$

$$i_D = \frac{V_{DD}}{R_D} - \frac{V_{DS}}{R_D}$$

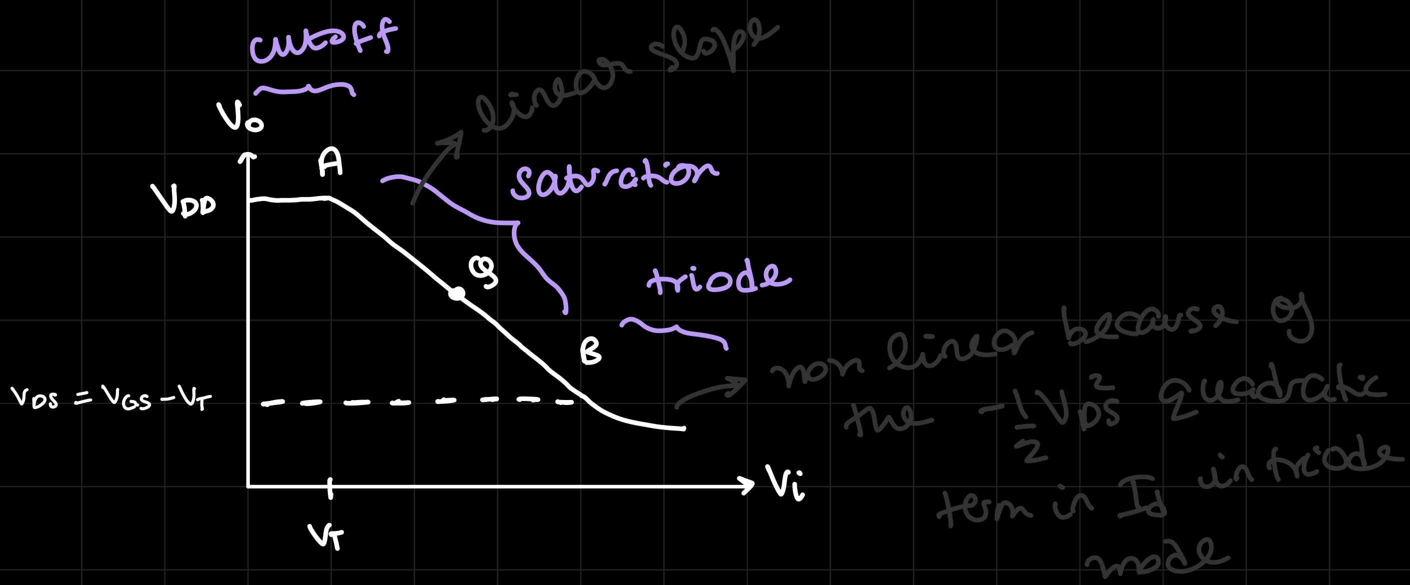
Case 1 → $i_D = 0$
↳ $V_{DS} = V_{DD}$

CUTOFF
($V_i < V_T$)
no channel induced

case 2 → saturation : $V_{DS} > V_{GS} - V_T$

$V_i \uparrow \rightarrow V_{GS} \uparrow \rightarrow i_D \uparrow \rightarrow V_{DS} \downarrow$ until $V_{DS} = V_{GS} - V_T$

$$i_D = \frac{V_{DD} - V_{DS}}{R_D}$$



gain = -ve

(o/p → 180° out of phase)

$$v_{GS} = V_{GS} - v_{gs}$$

$$\text{nt} = DC + AC$$

$$i_D = \underbrace{\frac{1}{2} K_n (V_{GS} - V_T)^2}_{DC} + \underbrace{K_n (V_S - V_T) v_{gs}}_{\text{linear}} + \underbrace{\frac{1}{2} K_n v_{gs}^2}_{\text{non linear}}$$

$$v_{gs} \ll 2(V_{GS} - V_T)$$

$$g_m = \frac{i_d}{v_{gs}} = K_n (V_{GS} - V_T)$$

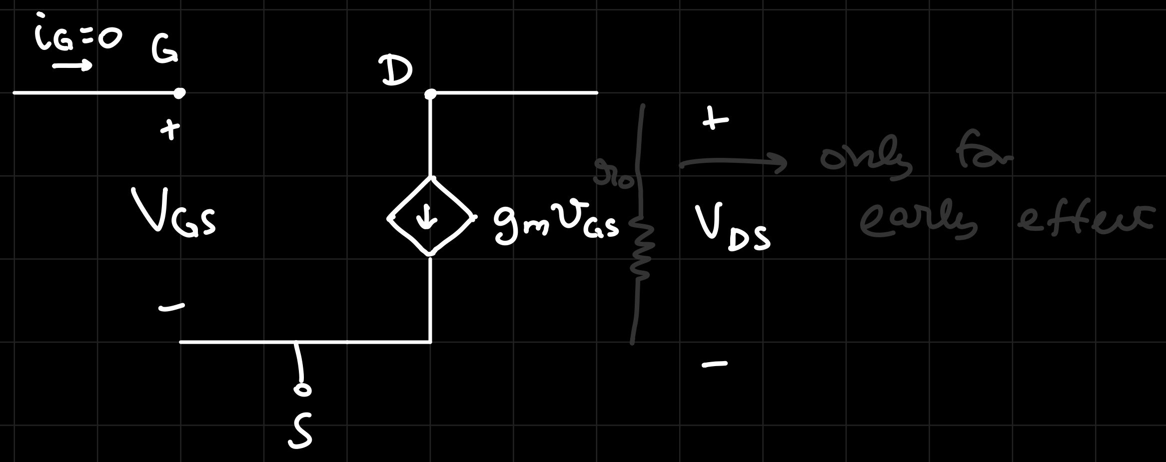
$$g_m = \left. \frac{\partial i_d}{\partial v_{GS}} \right|_{v_{GS} = V_{GS}}$$

$$A_V = \frac{v_d}{v_{gs}} = -g_m R_D$$

for saturation →

$$v_{GS} - V_T < v_D < V_{DD}$$

π model



early effect impedance →

$$i_D = K(v_{GS} - V_T)^2 (1 + \lambda v_{DS})$$

$$r_o = \frac{1}{\lambda K (V_{GS} - V_T)^2}$$

$$r_o = \left[\left. \frac{\partial i_D}{\partial v_{GS}} \right|_{v_{GS} = V_{GS}} \right]^{-1}$$

$$r_o = \left(K(v_{GS} - V_T)^2 \lambda \right)^{-1}$$

SMALL SIGNAL OPERATION

① DC Analysis

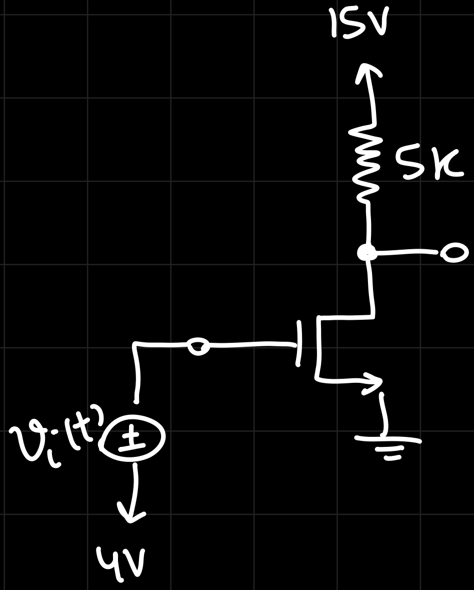
$$g_m = 2K(V_{GS} - V_T)$$

$$r_o = \frac{1}{\lambda K (V_{GS} - V_T)^2}$$

② AC analysis

gain

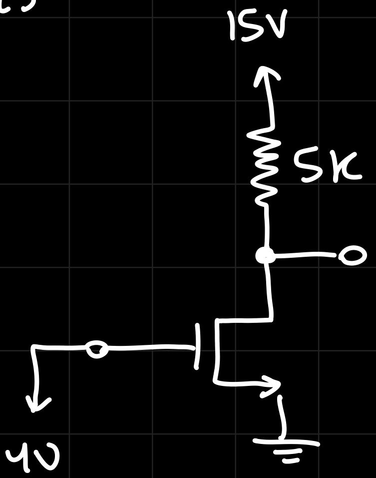
g)



$k = 0.25\ mA/V^2$

$V_T = 2V$

① DC Analysis



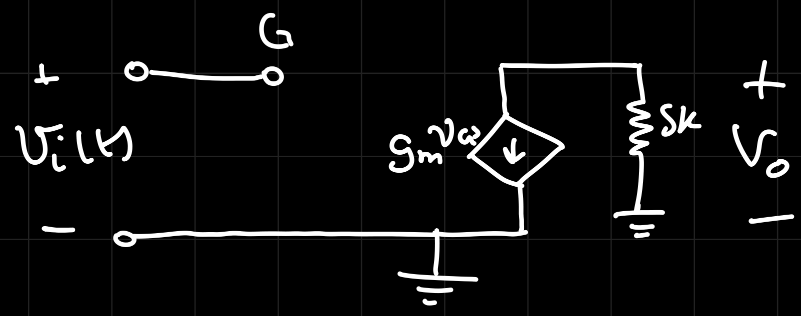
$V_{GS} = 4V$

$i_D = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T)^2$ assuming SAT

$= .25 \times 10^{-3} \times (4-2)^2$

$= 1mA$

params $\begin{cases} g_m = 2k(V_{GS} - V_T) = 1mAV^{-1} \\ r_o = \infty \quad \text{(not considering early effect)} \end{cases}$



$$V_o = -g_m v_{GS}(5k)$$

$$= -g_m V_i(5k)$$

Gain : $A_v = \dfrac{v_o}{v_i} = -g_m(5k) = \underline{\underline{-5}}$