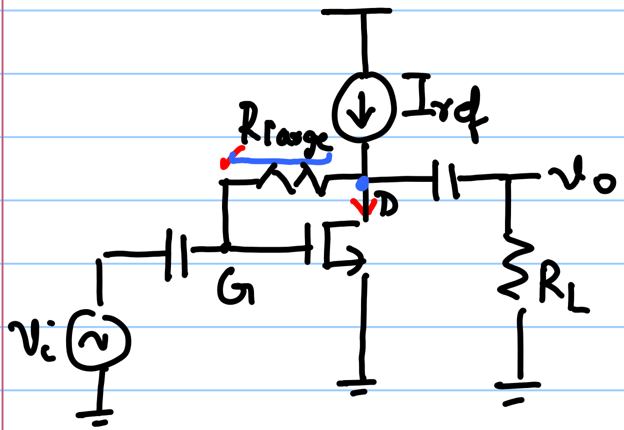
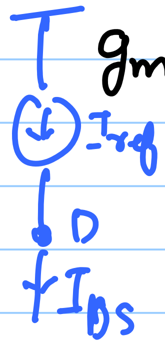
Lecture # 13

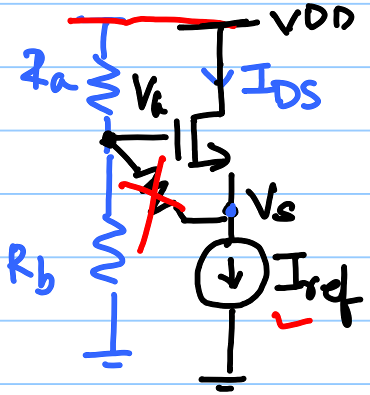
Note Title 31-08-2021

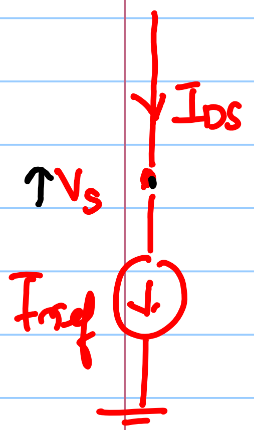




$$g_m = \sqrt{2 I_{DS} \frac{\mu_n C_{ox}}{1} \frac{W}{L}}$$

$$I_{DS} = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_G - V_S - V_{th})^2 = I_{ref}.$$



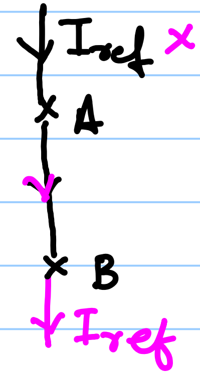


$$V_G = \frac{R_b}{R_b + R_a} V_{DD}$$

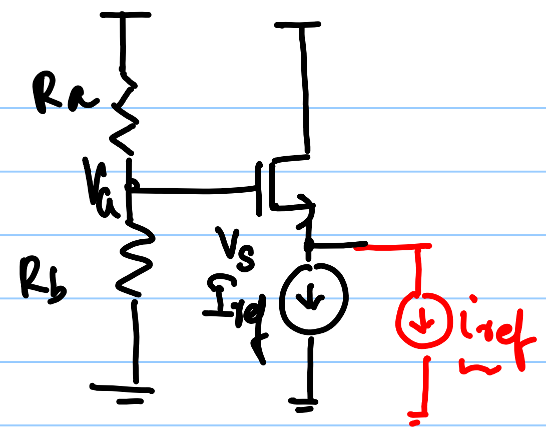
$$I_{DS} = \frac{\mu_n C_{ox}}{2} \frac{W}{L} \left(\frac{R_b}{R_b + R_a} V_{DD} - V_S \uparrow - V_{th} \right)^2$$

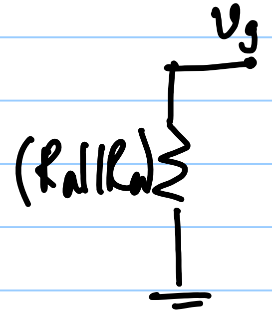
$V_{GS} \downarrow$

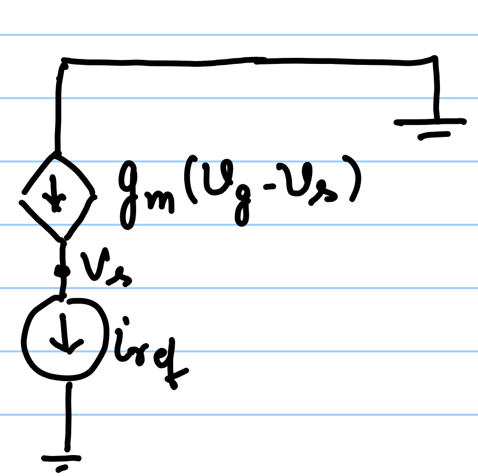
$= I_{ref}.$



if $I_{DS} > I_{ref}$



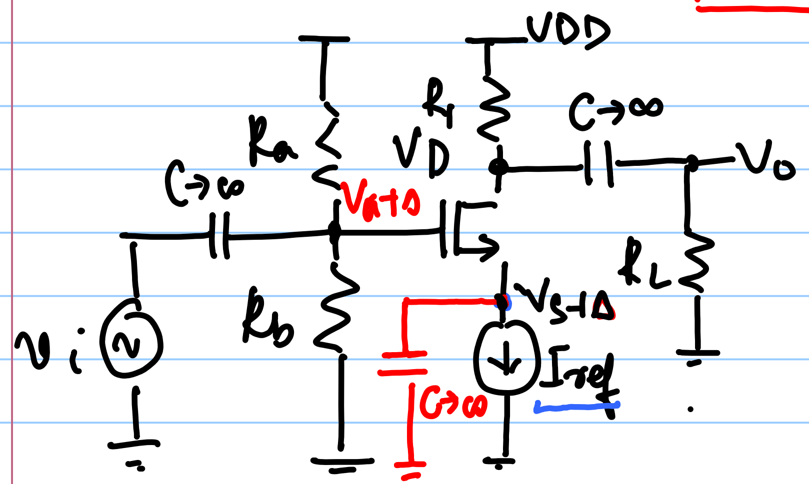




$v_g = 0,$

$g_m(0 - v_s) = i_{ref}$

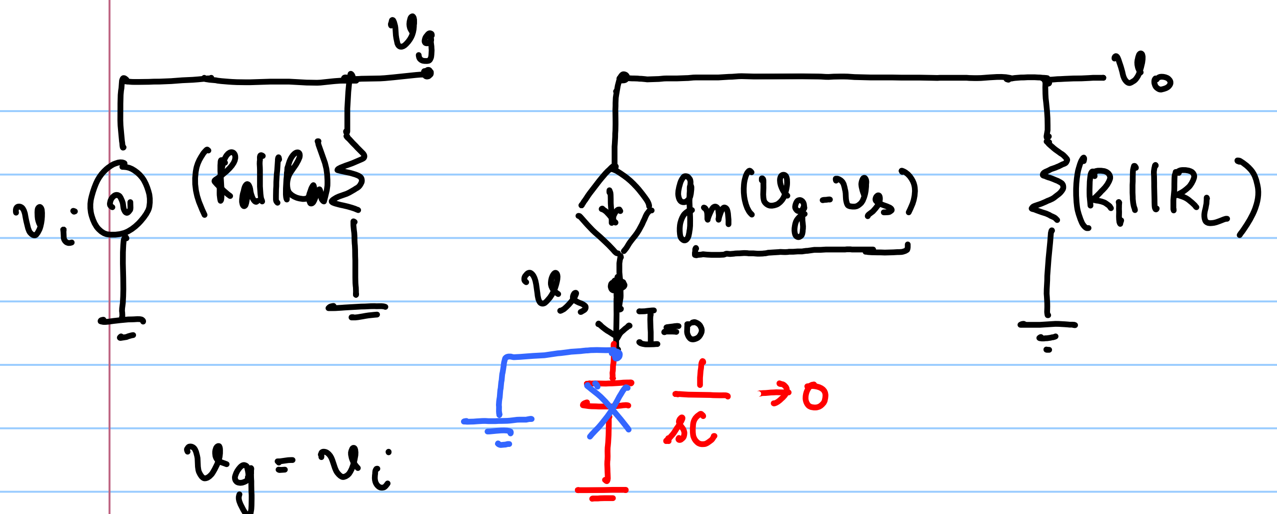
$$v_s = \frac{-i_{ref}}{g_m}$$

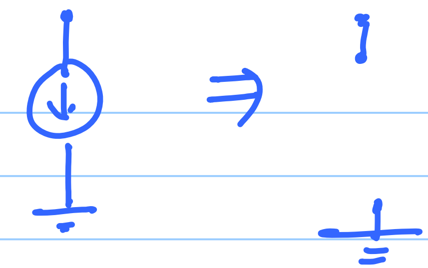


$V_a = \frac{R_b}{R_b + R_a} VDD, \quad V_D = VDD - I_{ref} \cdot R_1$

$V_D > V_a - V_{th}$ saturation region

$I_{DS} = I_{ref}.$





$v_g = v_i$

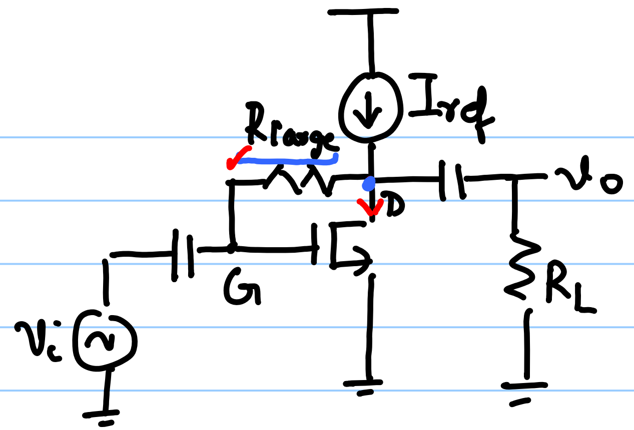
$g_m(v_g - v_s) = 0 \Rightarrow v_s = v_g = v_i$

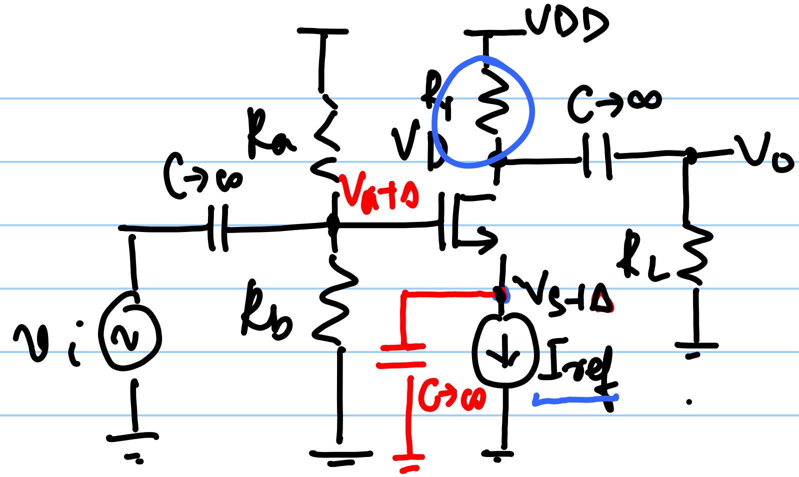
$v_o = 0$

- MOSFET is biased with fixed "dc" current.
- No small signal gain.

$g_m(v_i - 0) = -\frac{v_o}{(R_1||R_L)}$

$\frac{v_o}{v_i} = -g_m(R_1||R_L)$





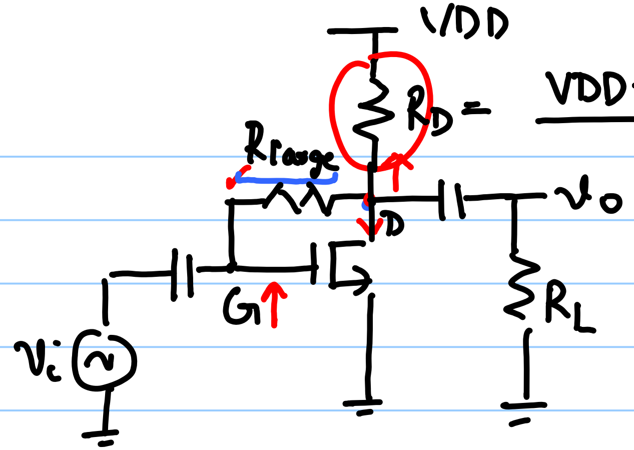
$$I_{DS} = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_G - V_S - V_{th})^2$$

$$= I_{ref}$$

$$\frac{\partial I_{DS}}{\partial V_{th}} = 0$$

$\Delta V_G = 0$, $\Delta V_S = -\Delta V_{th}$

$\Delta V_G = \Delta V_{th}$, $\Delta V_{gs} = 0$



$$R_D = \frac{VDD - V_D}{I_{ref}} \checkmark$$

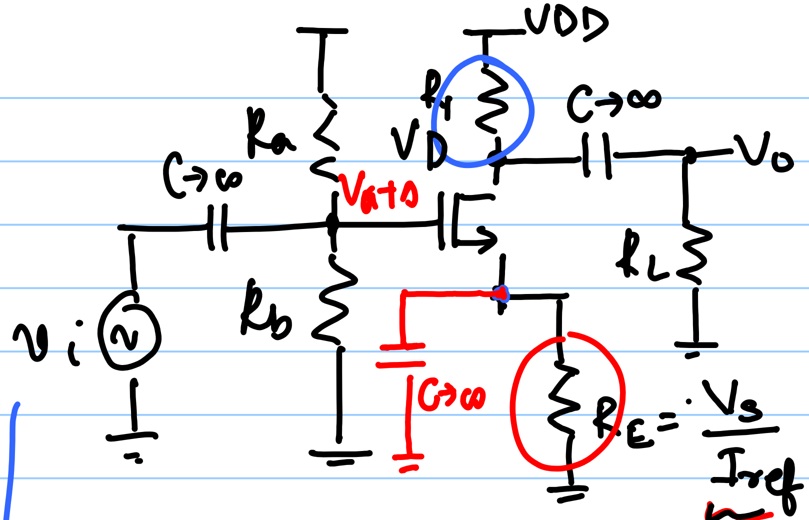
$$I_{DS} = \frac{\mu_n C_{ox}}{2}\frac{W}{L}\left(V_G - 0 - V_{th}\right)^2$$

$$= I_{ref} = \frac{VDD - V_D}{R_D}$$

$$= \frac{VDD - V_G}{R_D}$$

$$\underbrace{\frac{\mu_n C_{ox}}{2}\frac{W}{L} \times 2(V_G - V_{th})}_{g_m} \times \left(\frac{\partial V_G}{\partial V_{th}} - 1\right) = -\frac{\partial V_G}{\partial V_{th}} \times \frac{1}{R_D}$$

$$\left(\frac{\partial V_G}{\partial V_{th}} - 1\right) = -\frac{1}{g_m R_D}\frac{\partial V_G}{\partial V_{th}}$$



$$R_E = \frac{V_S}{I_{ref}}$$

$$I_{DS} = \frac{\mu_n C_{ox}}{2}\frac{W}{L}\left(V_G - V_S - V_{th}\right)^2 = I_{ref}.$$

$$= \frac{V_S}{R_E}$$

$$\frac{\partial}{\partial V_{th}}(L.H.S) = \frac{\partial}{\partial V_{th}}(R.H.S)$$

$$g_m\left(-\frac{\partial V_S}{\partial V_{th}} - 1\right) = \frac{1}{R_E}\frac{\partial V_S}{\partial V_{th}}$$

$$\frac{\partial V_S}{\partial V_{th}} = -\frac{g_m R_E}{1 + g_m R_E}$$

$$\frac{\partial V_u}{\partial V_{th}}\left(1+\frac{1}{g_m R_D}\right) = 1$$

$$\frac{\partial V_u}{\partial V_{th}} = \frac{g_m R_D}{1+g_m R_D}$$

∓

$$\frac{\Delta V_u}{\Delta V_{th}} = \frac{g_m R_D}{1+g_m R_D}$$

$$\Delta V_u = \frac{g_m R_D}{1+g_m R_D}\,\Delta V_{th} \checkmark$$

$$\approx \Delta V_{th}$$

$$g_m R_D \gg 1$$

$$\Delta V_s = \frac{-g_m R_E}{1+g_m R_E}\cdot \Delta V_{th}.$$

$$g_m R_E \gg 1$$