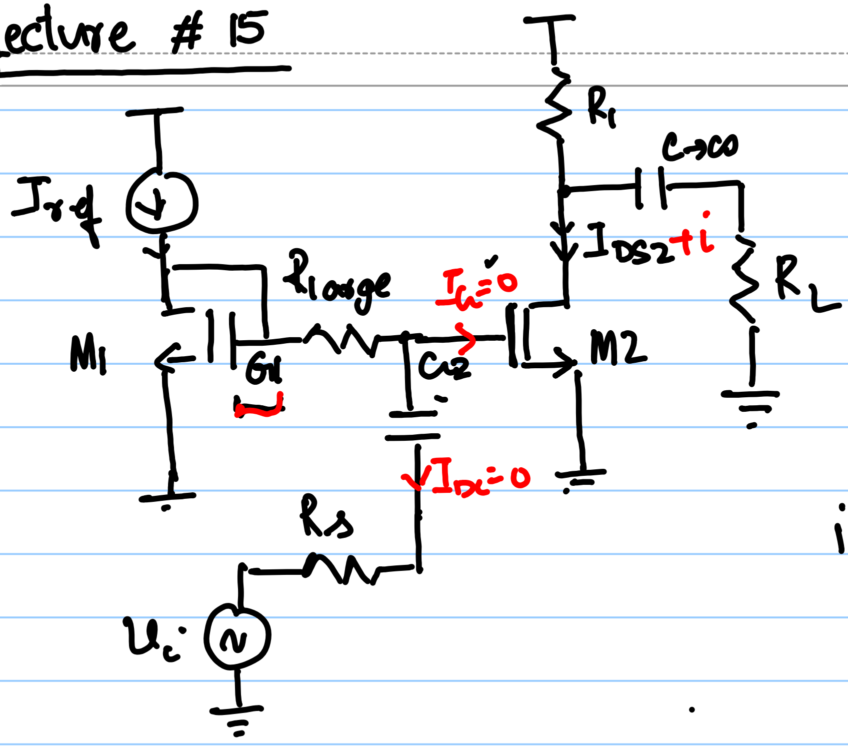
Note Title 02-09-2021

lecture # 15



$$I_{DS1} = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)_1 (V_{GS1} - V_{th1})^2 = I_{ref}$$

$$I_{DS2} = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)_2 (V_{GS} - V_{th2})^2$$

if $\left(\frac{W}{L}\right)_2 = \left(\frac{W}{L}\right)_1$ and $V_{th2} = V_{th1}$

$$I_{DS2} = I_{DS1} = I_{ref}$$

if $V_{th2} = V_{th1} + \Delta V_{th}$

$$I_{DS2} = \underbrace{\frac{\mu_n C_{ox}}{2}}_{K}\left(\frac{W}{L}\right) (V_{GS1} - V_{th1} - \Delta V_{th})^2$$

$$= \frac{KW}{2L}\left[(V_{GS1} - V_{th1})^2 + (\Delta V_{th})^2 - 2\Delta V_{th}(V_{GS1} - V_{th1})\right]$$

$$= I_{DS1} + \frac{KW}{2L}\left[-2(V_{GS1} - V_{th1})\cdot \Delta V_{th} + (\Delta V_{th}^2)\right]$$

$$= I_{ref} + \frac{kW}{L}(V_{a1}-V_{tn1}) \times (-\Delta V_{tn}) + \frac{kW}{2L}(\Delta V_{tn}^2) \checkmark$$

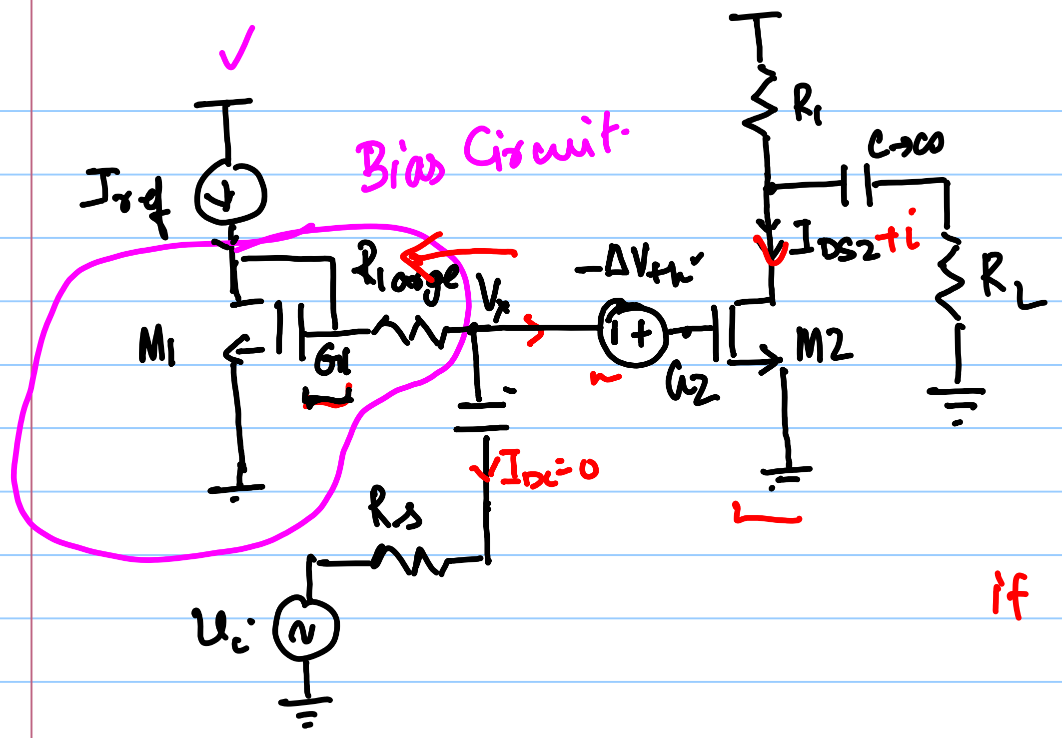
$$\approx I_{ref} + \underbrace{\frac{kW}{L}(V_{a1}-V_{tn1})} \times (-\Delta V_{tn})$$

$$I_{DS2} = I_{ref} + g_{m1}(-\Delta V_{tn}) \quad = i$$

$$g_{m2} = \sqrt{2 I_{DS2} \mu_n C_{ox} \frac{W}{L}} = \sqrt{(I_{ref} - g_{m1}\Delta V_{tn}) \mu_n C_{ox} \frac{W}{L}}$$

$$V_{a2} - V_{tn2} = V_{a1} - (V_{tn1} + \Delta V_{tn}) = (V_{a1} - V_{tn1}) - (\Delta V_{tn})$$

$$= (V_{a1} - \Delta V_{tn}) - V_{tn1}$$



$$\left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_2$$

$$V_{th1} = V_{th2}$$

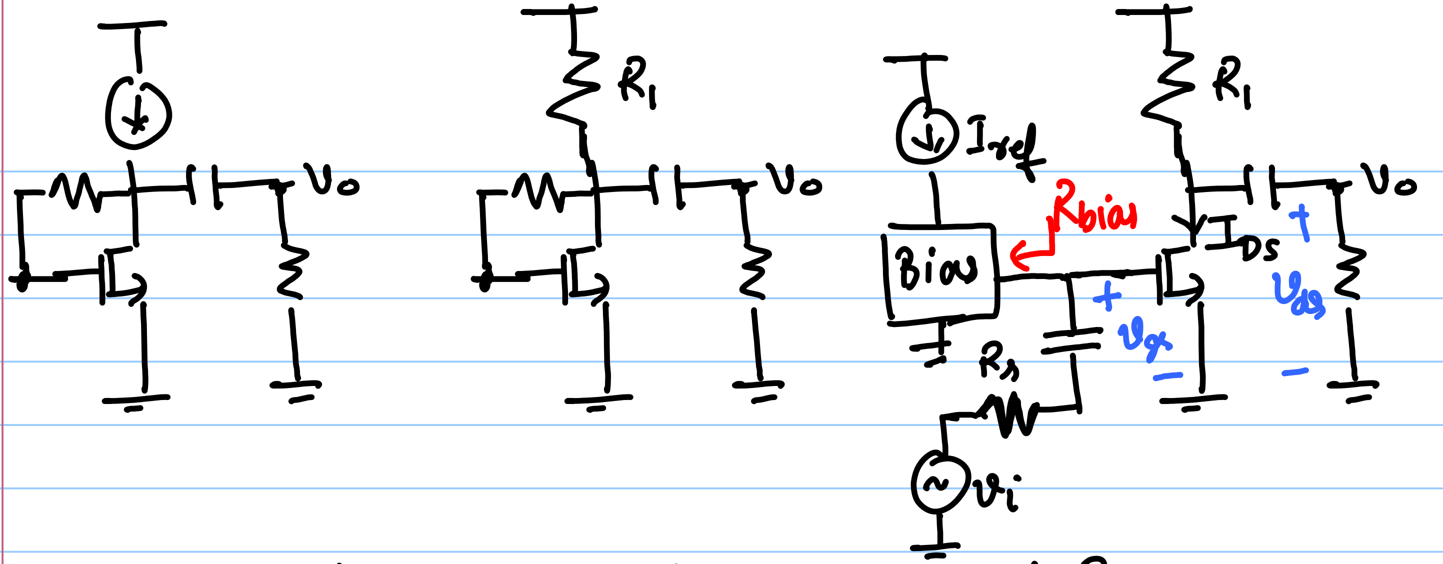
$$V_{G2} = V_{G1} - \Delta V_{th}$$

if $\Delta V_{th} = 0$ then $I_{DS2} = I_{DS1} = I_{ref}$

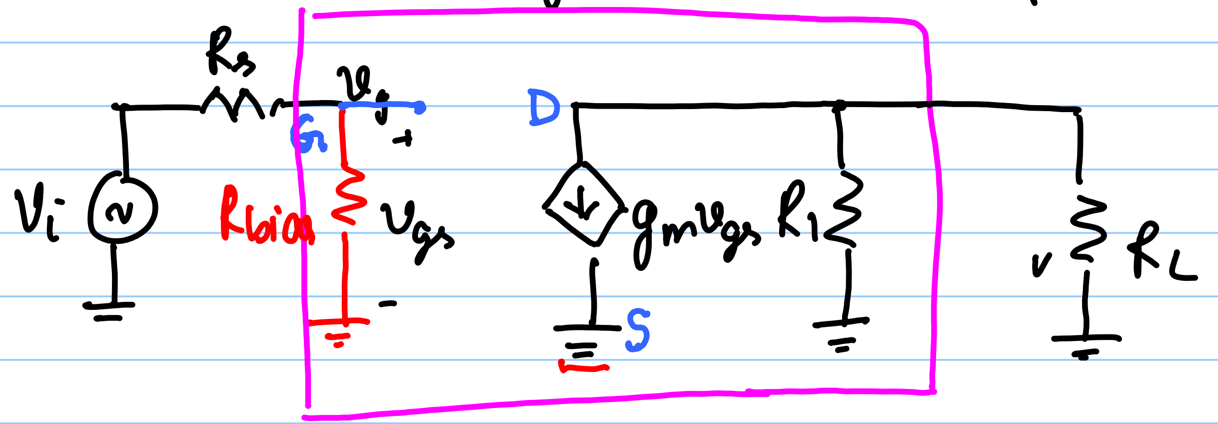
if $\Delta V_{th} \neq 0$ then $\hat{I}_{DS2} = I_{DS1} + g_{m2}(-\Delta V_{th})$

$$I_{DS2} = I_{ref} - g_{m2} \cdot \Delta V_{th}$$

- Change in threshold voltage can be represented as change in gate voltage w/ -ve sign.



- MOSFET is biased with fixed current I_{ref}.

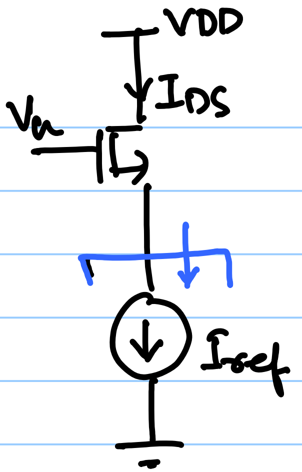


"Common Source Amplifier" (CS)

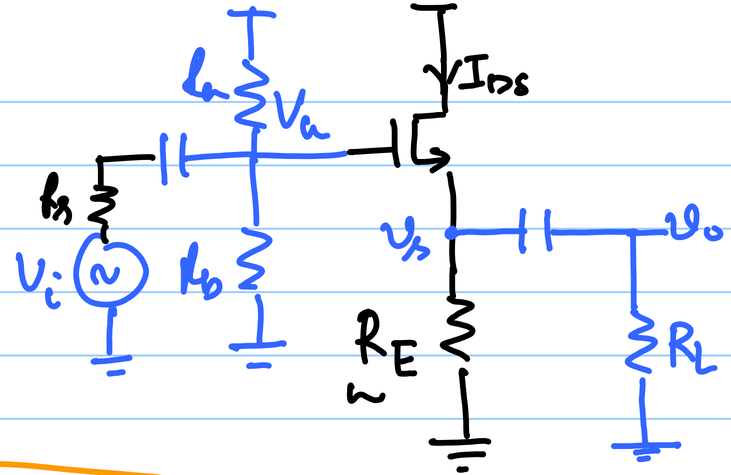
$$\frac{v_o}{v_i} = -g_m (R_1 \| R_L)$$

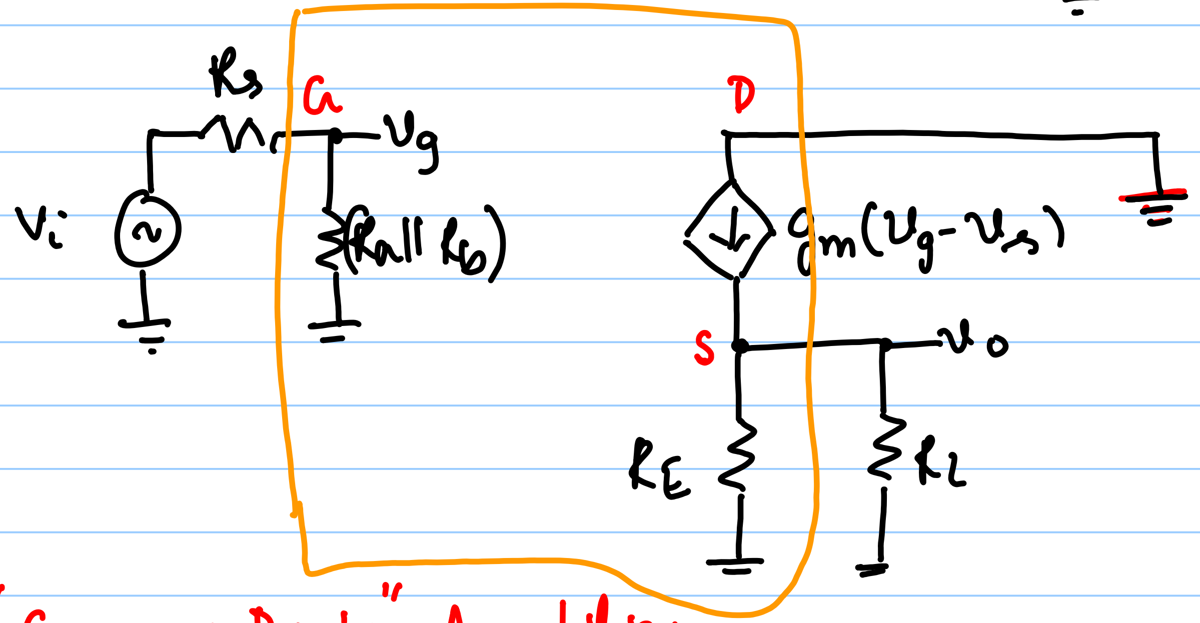
$$g_m = \sqrt{2 I_{ref} \mu_n C_{ox} \frac{W}{L}}$$

- Gain depends on R_L.



$\Rightarrow$





"Common Drain" Amplifier

$R_a \| R_b \gg R_s$

$v_g = v_i$

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

$$\frac{v_o}{v_i} = \frac{g_m (R_E \| R_L)}{1 + g_m (R_E \| R_L)}$$

$$\frac{v_o}{v_i} = \frac{(R_E \| R_L)}{\frac{1}{g_m} + (R_E \| R_L)}$$

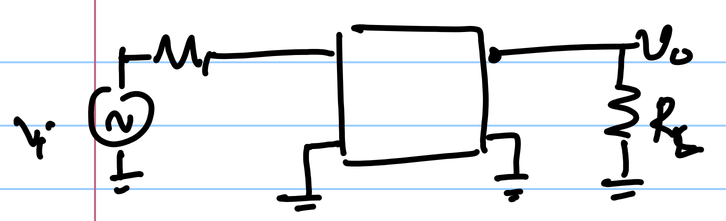
$\frac{1}{g_m} \ll (R_E \| R_L)$

$$\frac{v_o}{v_i} = 1 \longleftarrow$$

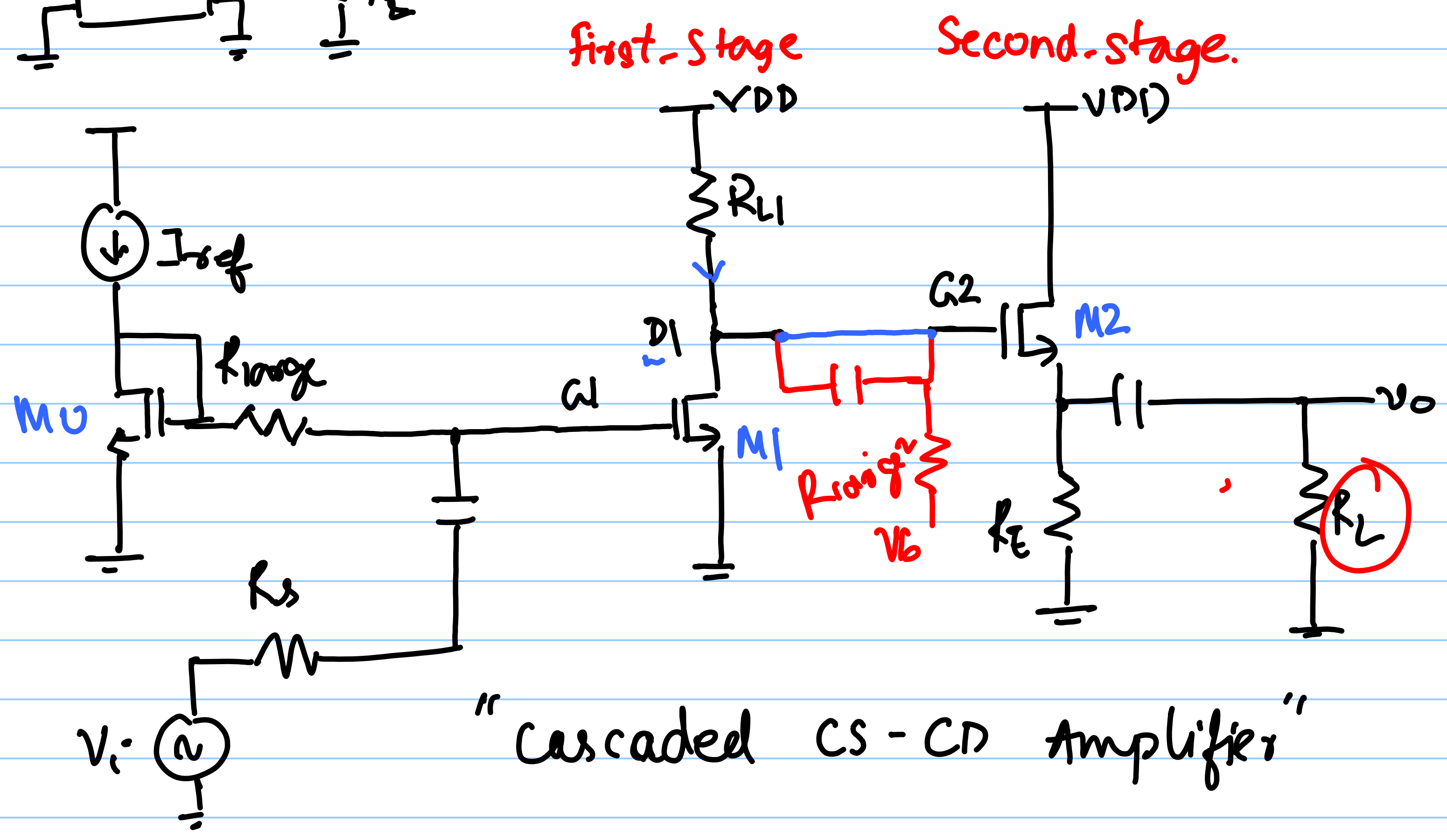
CS : Large gain, Gain depends on R_L $\left(G = -g_m (R_1 \| R_L) \right)$

CD : Unity gain (≈ 1), Gain doesn't depend on R_L $\left(\frac{1}{g_m} \ll (R_E \| R_L) \right)$

Ideal Amplifier



$\frac{v_o}{v_i}$ = large and independent of R_L



"Cascaded CS - CD Amplifier"

$$\frac{v_o}{v_i} = -g_{m1} R_{L1} \cdot \frac{g_{m2}(R_E \| R_L)}{g_{m2}(R_E \| R_L) + 1}$$

$$\frac{v_o}{v_i} \approx -g_{m1} R_{L1}$$