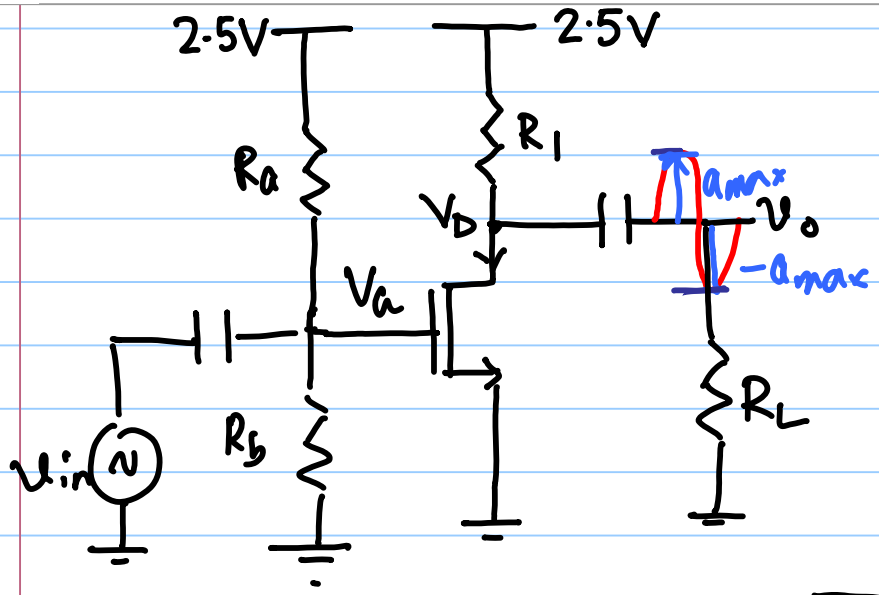
Tutorial Session # 02

Note Title 27-08-2021

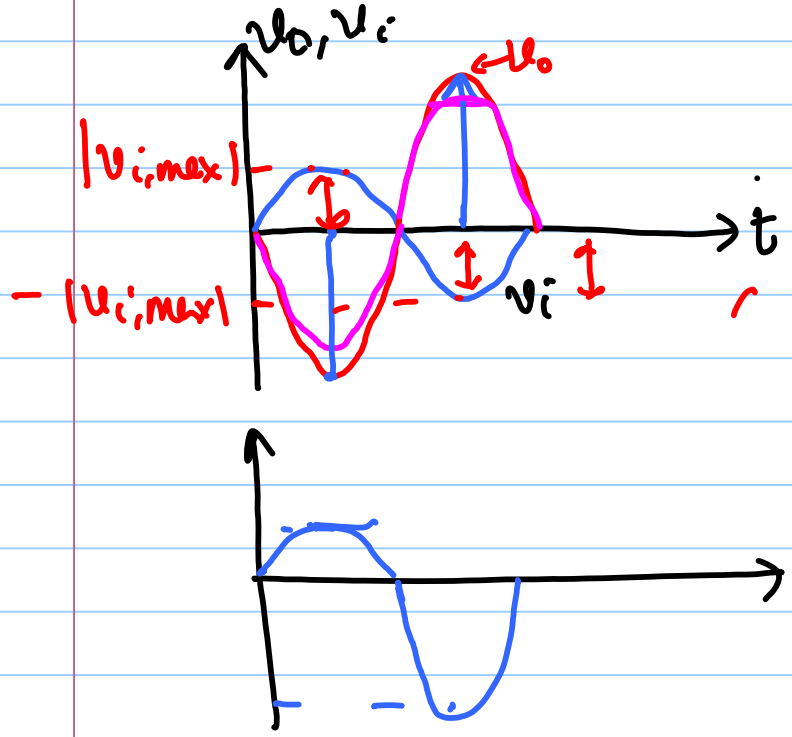


$$\frac{R_b}{R_b + R_a} \cdot 2.5V = 0.9V$$

$V_{th} = 0.7V$, $V_{GS} - V_{th} = 0.2V$.

Gain = A V/V = 9 V/V ✓

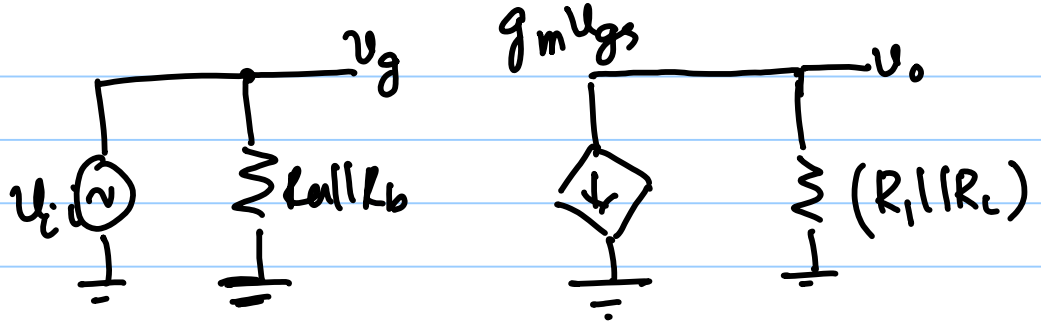
$\frac{W}{L} = ?$, $R_1 = ?$, $R_L = ?$, $\lambda = 0$, $\mu_n C_{ox} = 100\ \mu A/V^2$

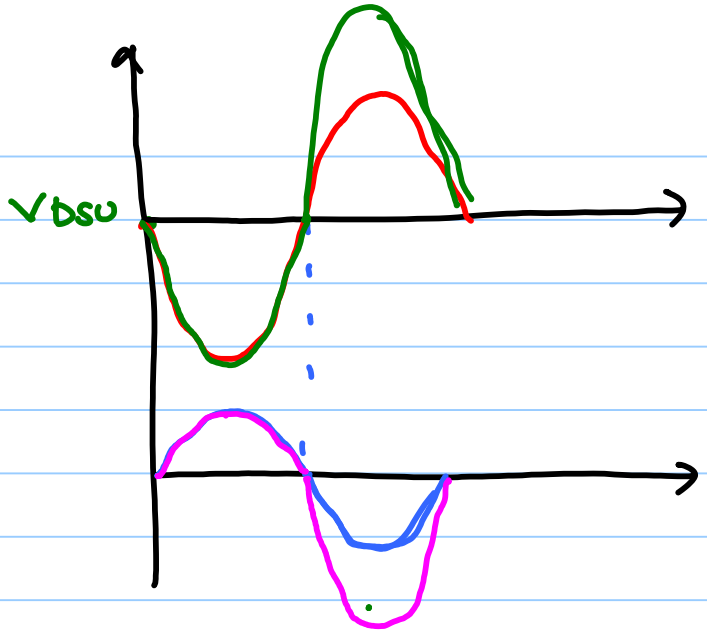


$$I_{DS} = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_{GS} - V_{th})^2$$

$$= \frac{100 \times 10^{-6}}{2} \frac{W}{L} (0.2)^2$$

$$g_m = \frac{2 I_{DS}}{V_{GS} - V_{th}} = \frac{2 I_{DS}}{0.2} = 10 I_{DS}\ A/V$$





$$v_o = -g_m(R_1 \| R_L)\, v_i$$

$$\frac{v_o}{v_i} = -g_m(R_1 \| R_L) = -9\ V/V$$

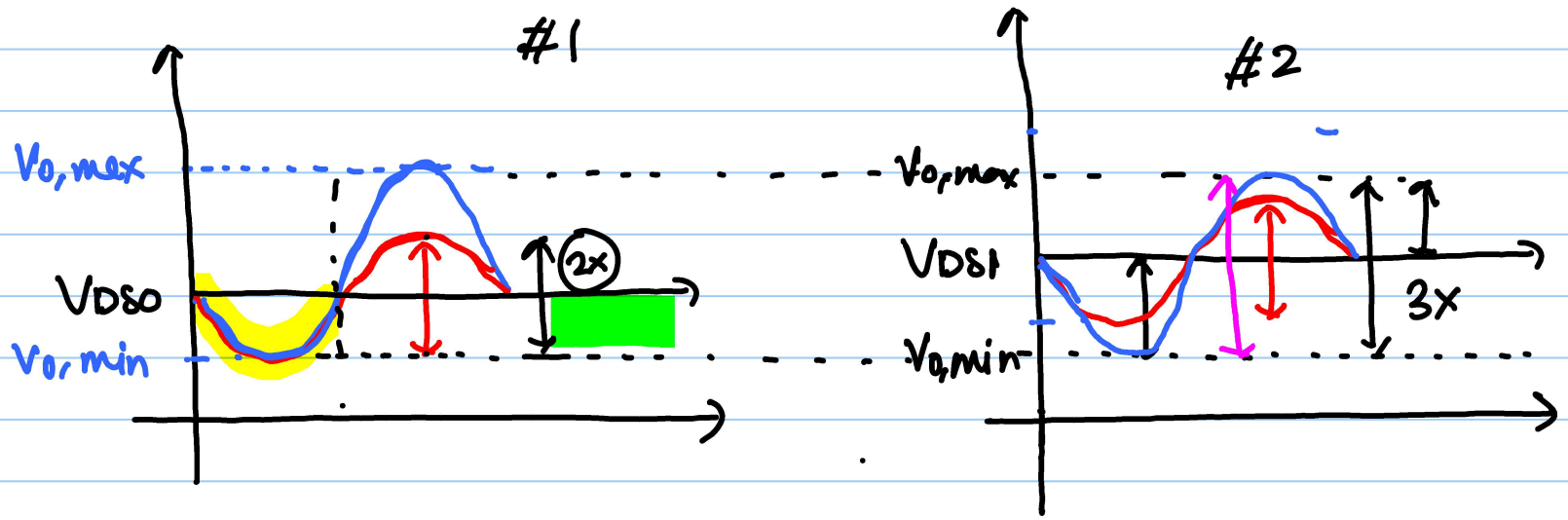
When v_i is the maximum, V_{DS} ↓ . MOSFET will approach triode region.

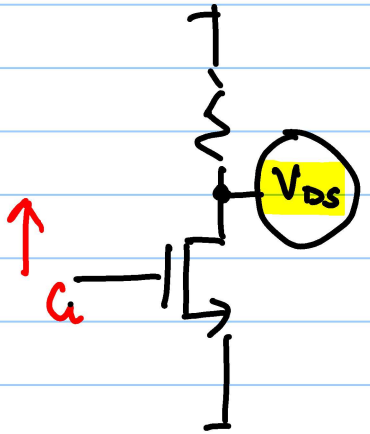
$$V_{GS} - V_{th} \leq V_{DS}$$

$$(V_{GSQ} - V_{th})\,|v_{i,max}| \leq V_{DSQ} - g_m(R_1 \| R_L)\,|v_{i,max}|$$

$$V_{DS} \geqslant V_{GS} - V_{th}$$

$$|v_{i,max}| \leq \frac{V_{DSQ} - (V_{GSQ} - V_{th})}{1 + g_m(R_1 \| R_L)} \quad -(1)$$



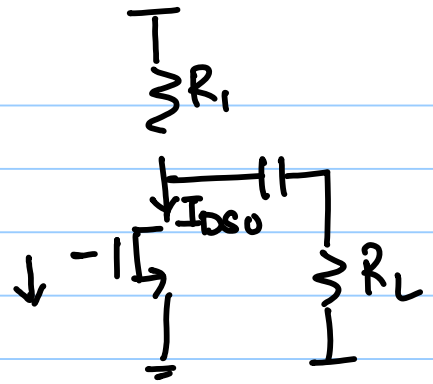


9 V/V

$v_i \longrightarrow v_o$

$\pm\frac{1}{2}$ $\frac{2x}{9}$ $\quad 2x \quad$ #1

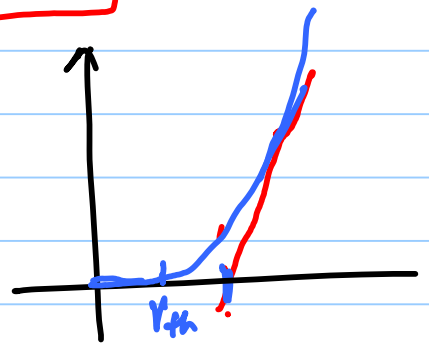
$\pm\frac{1}{2}$ $\frac{3x}{9}$ $\quad 3x \quad$ #2



$I_{DS} \geq I_{DSO} + g_m v_i$. (Cut-off region)

$I_{DSO} - g_m |v_{i,max}| = 0$

$$|v_{i,max}| = \frac{I_{DSO}}{g_m} = \frac{I_{DSO}}{2 I_{DSO}/(V_{GSO} - V_{th})}$$



$$|v_{i,max}| = \frac{V_{DSO} - (V_{GSO} - V_{th})}{1 + g_m (R_1 || R_L)} \quad \text{--(1)}$$

$$V_{DSO} = V_{DD} - I_{DSO} \cdot R_1 \quad \text{--(3)}$$

Gate overdrive: $V_{OV} = V_{GS} - V_{th}$

From (1) & (2)

$$\frac{V_{DSO} - (V_{GSO} - V_{th})}{1 + g_m (R_1 || R_L)} = \frac{I_{DSO}}{g_m} = \frac{I_{DSO}}{\frac{2 \cdot I_{DSO}}{V_{GSO} - V_{th}}} = \frac{(V_{GSO} - V_{th})}{2}$$

$$V_{DSO} = \frac{(V_{GSO} - V_{th})}{2} \left(1 + g_m (R_1 || R_L)\right) + (V_{GSO} - V_{th})$$

$V_{ov} = V_{GS} - V_{th} = 0.2V$, $g_m (R_1 \| R_L) = 9$ V/V

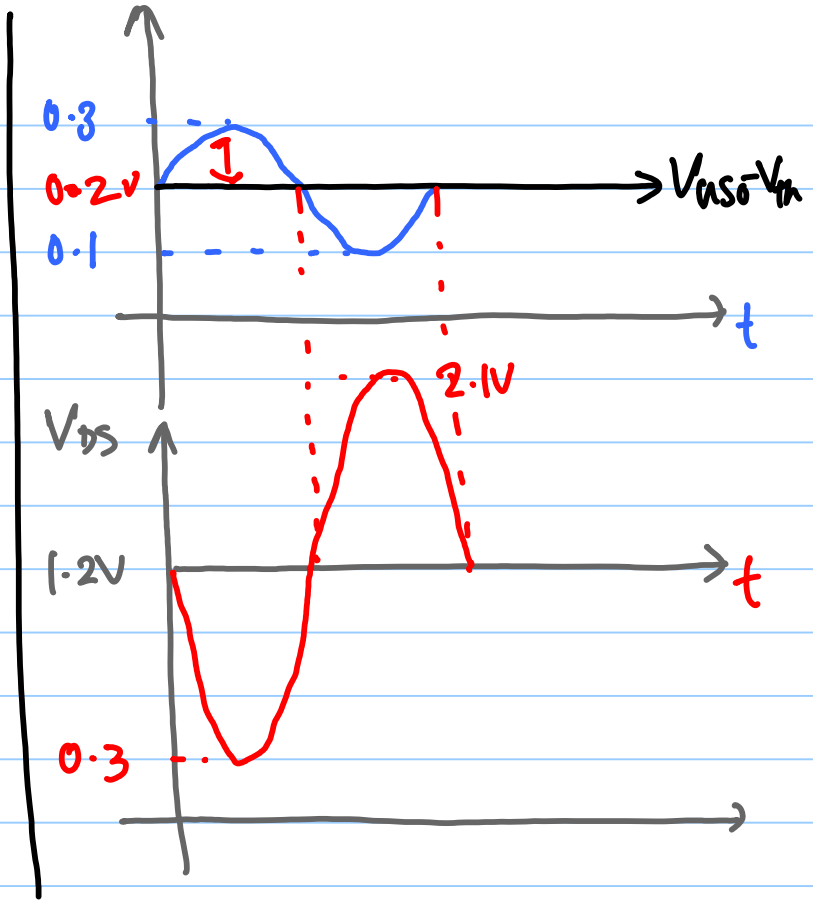
$$V_{DSQ} = \frac{0.2}{2}(1+9) + 0.2$$

$$V_{DSQ} = 1.2\,V$$

I_{DSQ}, R_1, R_2

$$V_{DSQ} = 1.2V = 2.5 - I_{DSQ} \cdot R_1$$

$g_m (R_1 \| R_2) = 9$ V/V ✓



Ld

$I_{DSQ} = 1$ mA $\Rightarrow$ $R_1 = \frac{2.5-1.2}{1\,mA} = 1.3K$

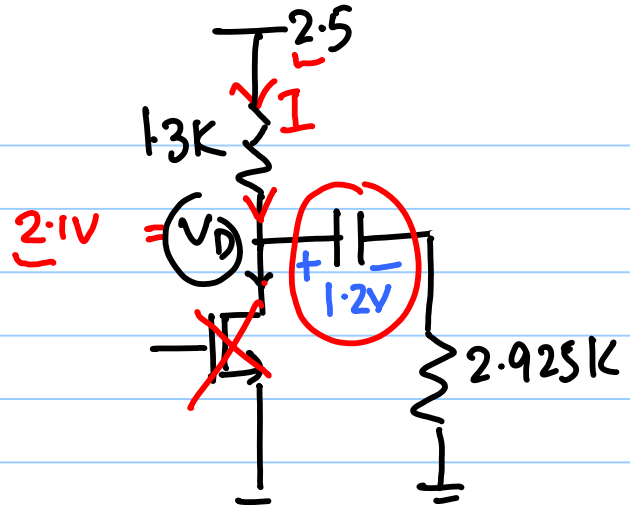
$g_m = \frac{2 \times 1mA}{0.2V}$

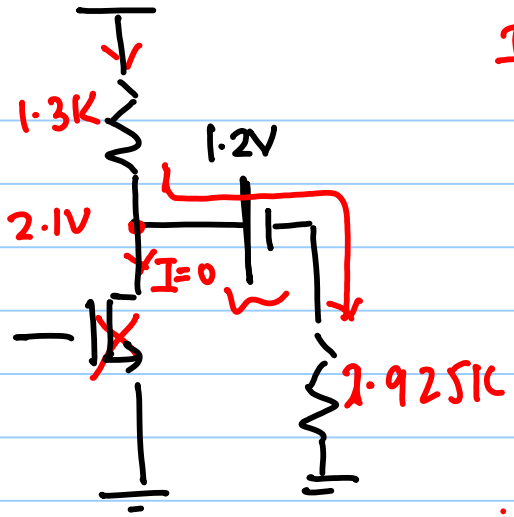
$= 10$ mA/V

10 mA/V $(R_1 \| R_2) = 9$

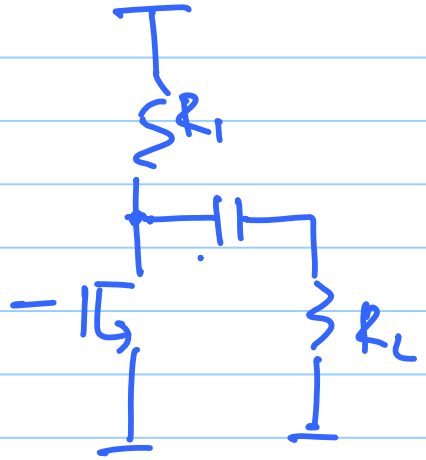
$(R_1 \| R_2) = 0.9$ kΩ

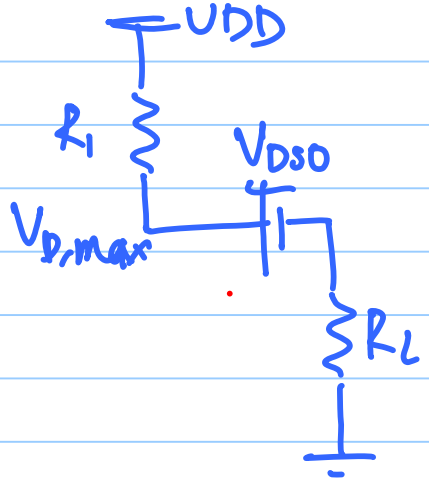
$R_2 = 2.925$ K





$$I = \frac{2.5 - 2.1}{1.3\,K} = \frac{2.1 - V_{DSO}}{2.925\,K}$$





$$\frac{VDD - V_{D,max}}{R_1} = \frac{V_{D,max} - V_{DSO}}{R_L}$$