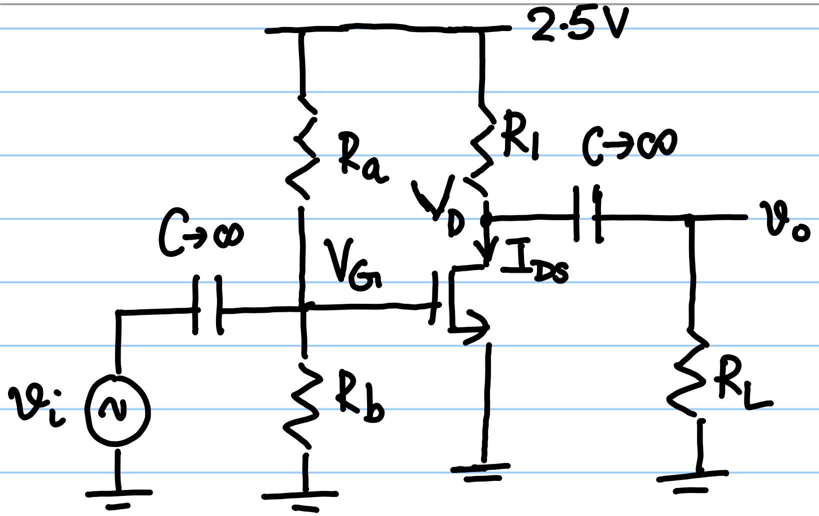
Note Title 24-08-2021

lecture # 10



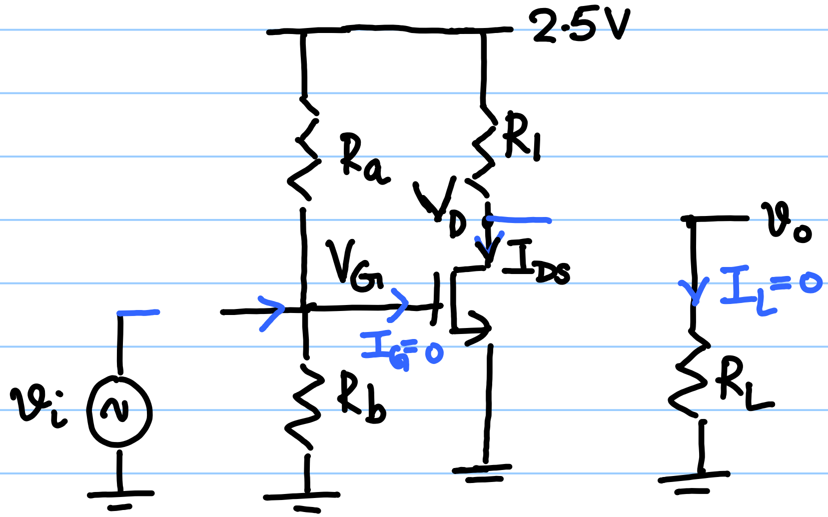
$R_a = 5.2K$, $R_b = 4.8K$, $R_1 = 4K$, $R_L = 4K$

$V_{th} = 0.7V$, $\mu_n C_{ox} = 100\mu A/V^2$, $\frac{W}{L} = 20$

DC Operating point:

$I_G = 0$

$V_G = \frac{R_b}{R_b + R_a} \times 2.5V = \frac{4.8K}{10K} \times 2.5 = 1.2V$



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

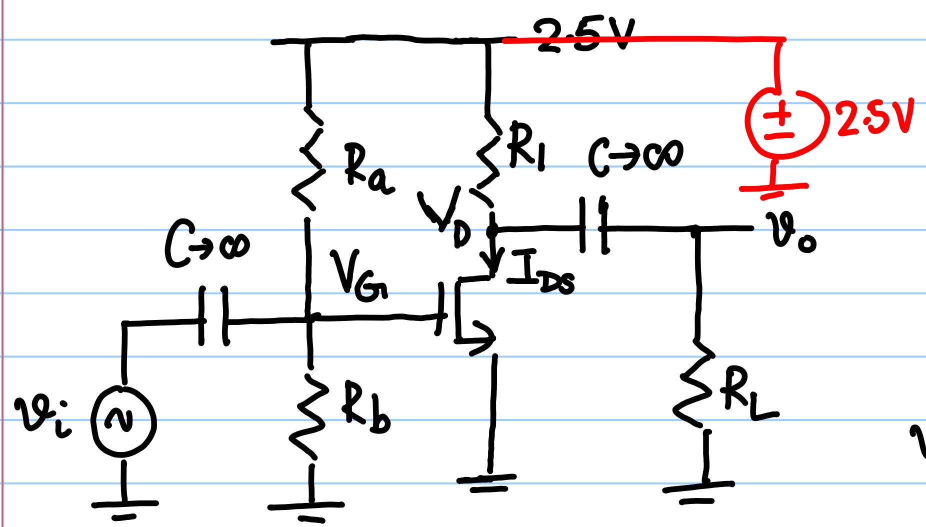
$= \frac{100 \times 10^{-6}}{2} \times 20 \, (1.2 - 0.7)^2$

$= 1 mA/V^2 \times 0.25 = 0.25 \, mA$

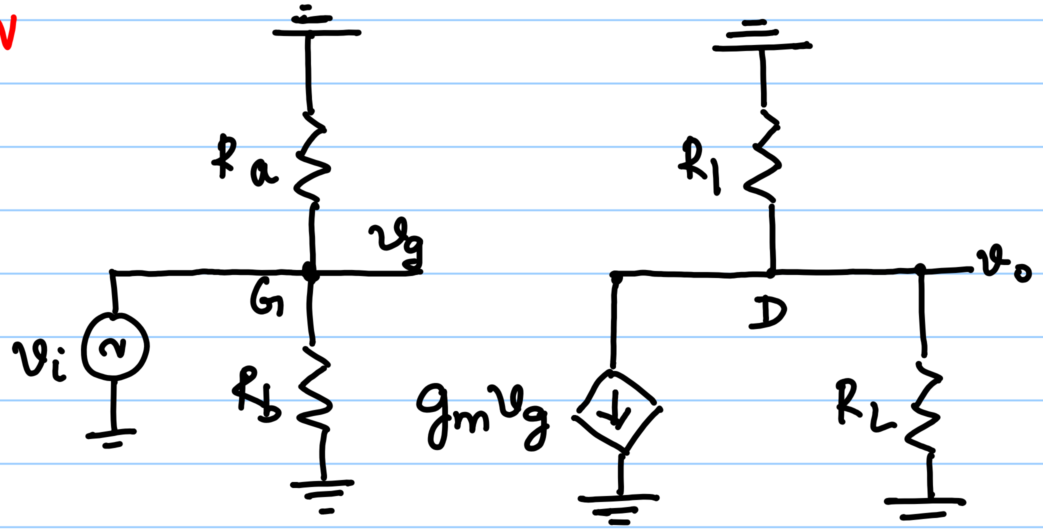
$V_{DS} = 2.5 - I_{DS} \times R_1 = 2.5 - 4K \times 0.25 \, mA$

$= 1.5V$

$V_{GS} - V_{th} = 1.2 - 0.7 = 0.5 < V_{DS}$ ✓



AC Small-signal gain.

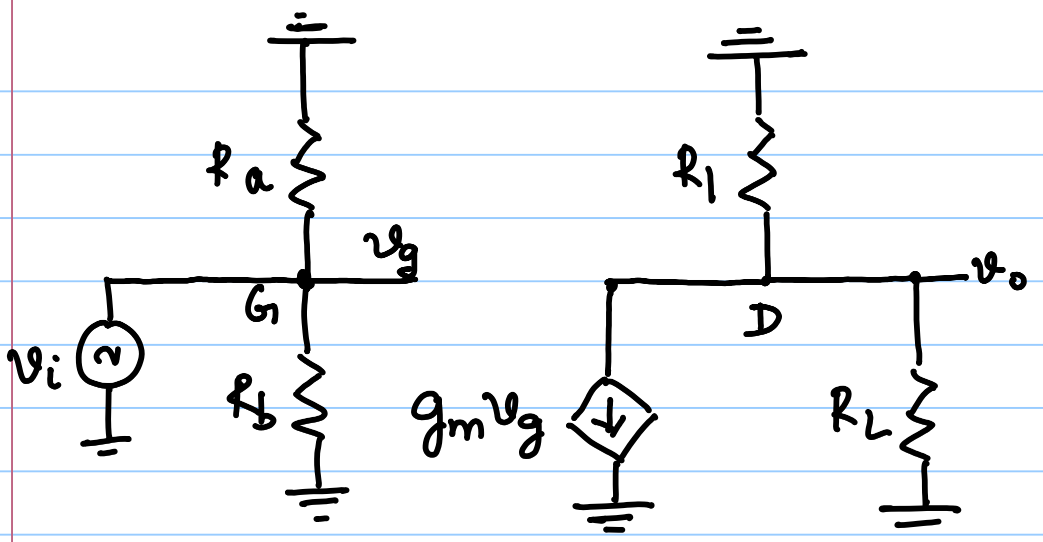


$$\frac{1}{sC} = \frac{1}{j\omega C}$$

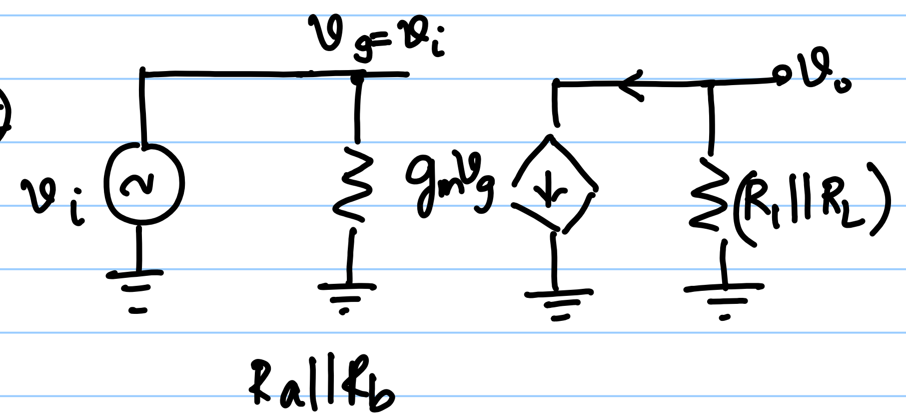
All independant voltage sources are shorted.

If Mosfet is in linear region.

$$I_{DS} = \mu_n C_{ox} \frac{W}{L} \left[(V_{GS} - V_{th}) V_{DS} - \frac{V_{DS}^2}{2} \right] = \frac{V_{DD} - V_{DS}}{R_1}$$



$\Rightarrow$



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

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

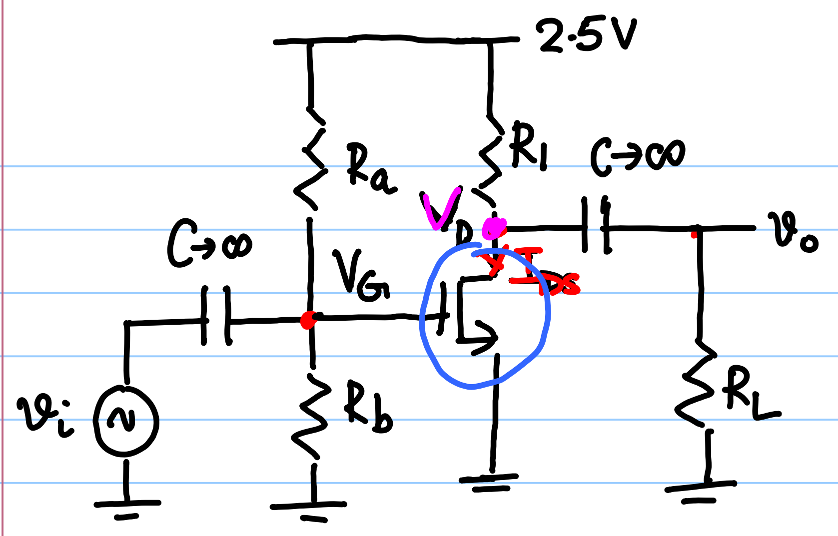
$$= -1\,mA/V \times 2k\Omega$$

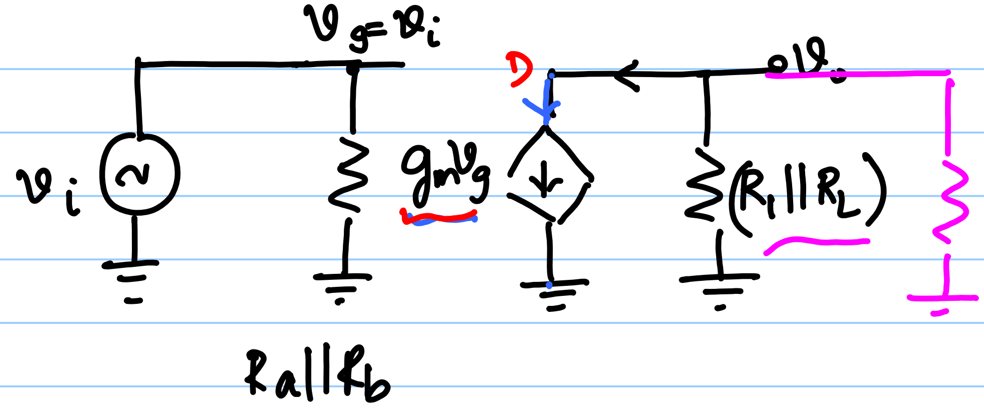
$$= -2\ V/V$$

$$g_m = \frac{2 I_{DS}}{V_{GS} - V_{th}} = \frac{2 \times 0.25\,mA}{0.5\ V}$$

$$= 1\ mA/V$$

$$R_1 || R_L = (4k || 4k) = 2k\Omega$$



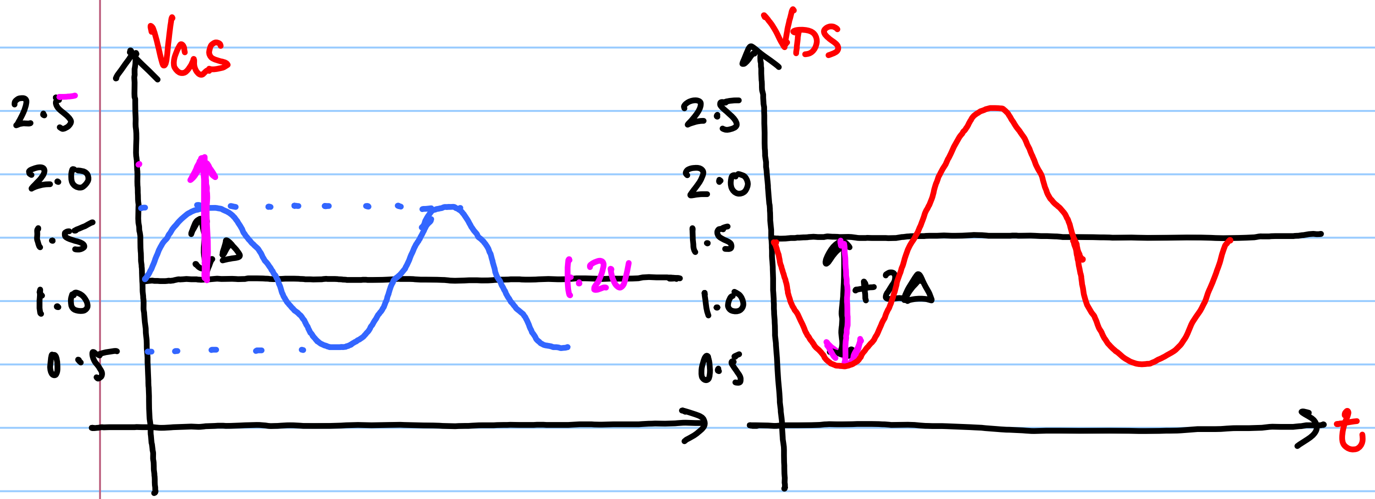


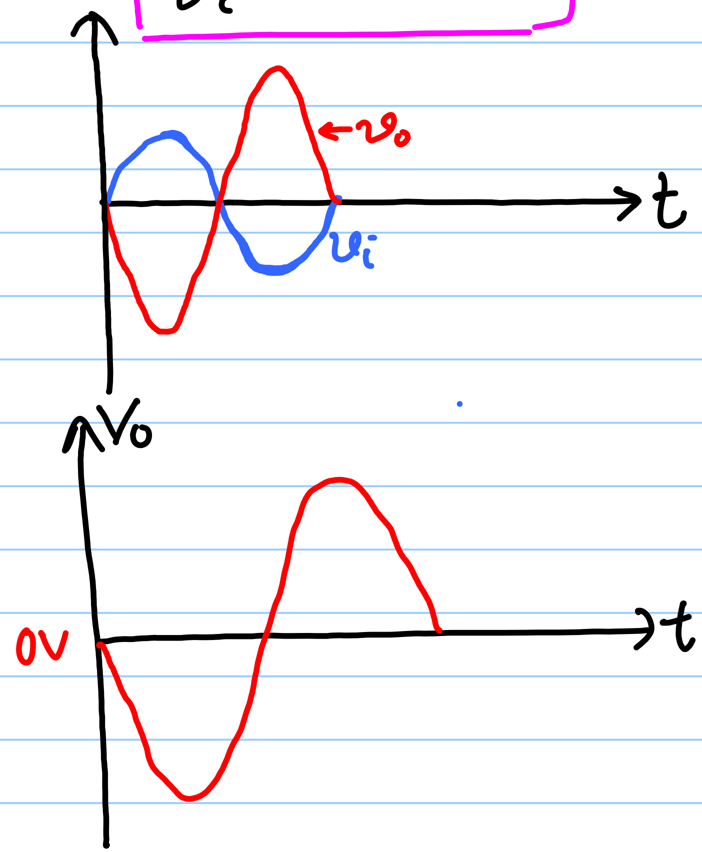
$$\frac{v_o}{v_i} = -2V/V$$

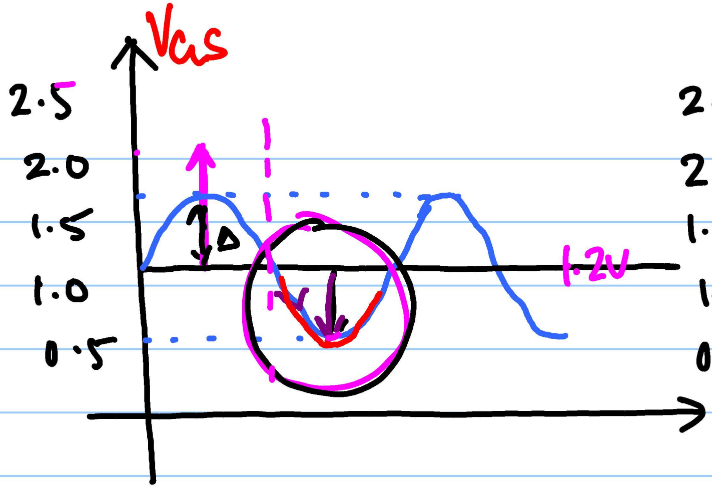
Absolute voltage.

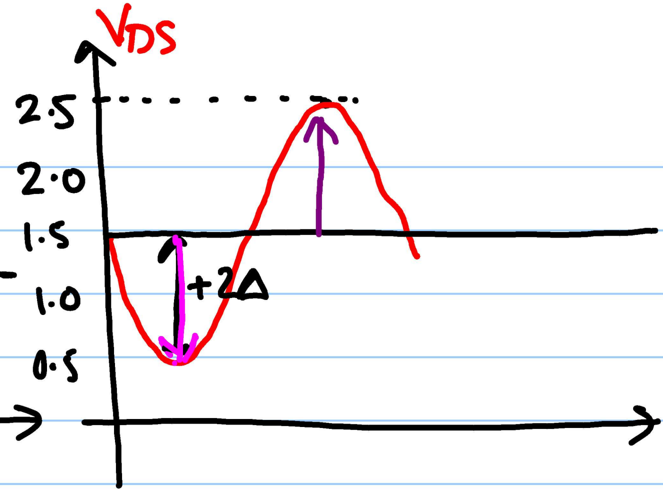
$V_{GS} = 1.2V + v_i$

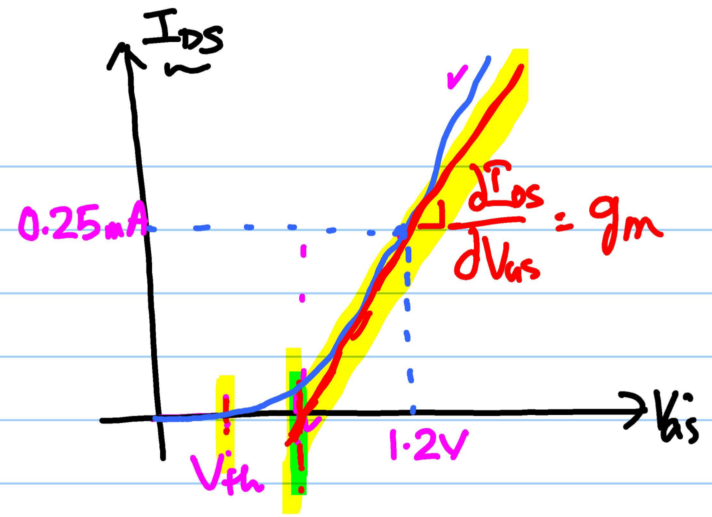
$V_{DS} = 1.5V + v_o$











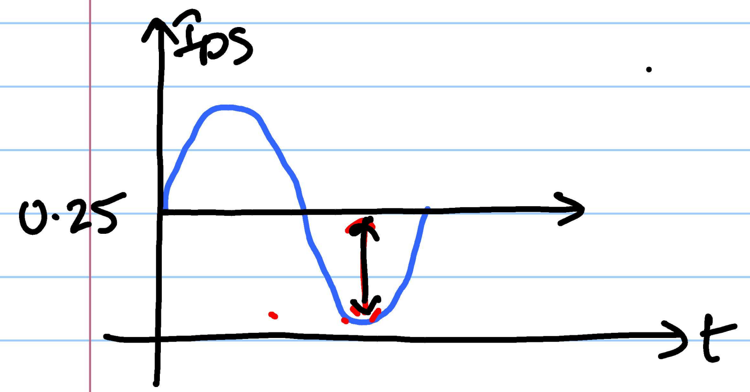
$v_i = a \sin(\omega_0 t)$

$V_{GS} = 1.2V + a$ $\qquad$ $V_{DS} = 1.5 - 2a$

– Transistor always operates in saturation region.

$V_{DS} \geq V_{GS} - V_{th} \Rightarrow 1.5 - 2a \geq 1.2 + a - 0.7 \Rightarrow 1.0 \geq 3a \Rightarrow$ $\boxed{a \leq \frac{1}{3} = 0.333V}$

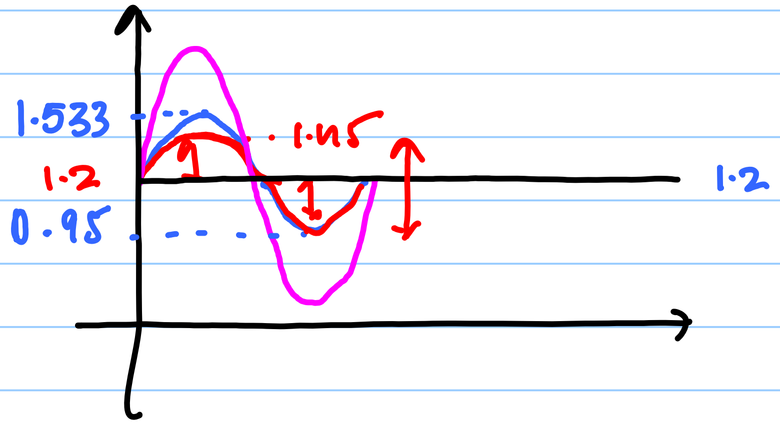
– $V_{GS} - V_{th} \geq 0 \Rightarrow 1.2 - a - 0.7 \geq 0 \Rightarrow a \leq 0.5V$

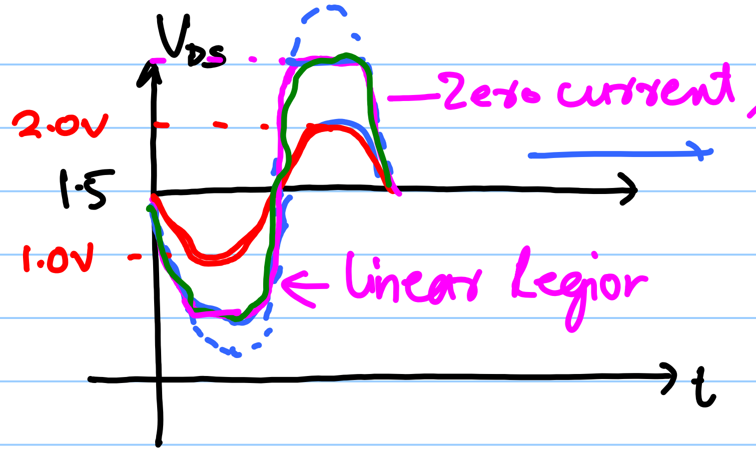


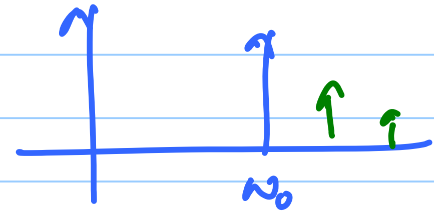
$I_{DS} = 0.25\ mA + g_m v_i = 0$

$0.25\ mA - g_m a \geq 0$

$a \leq \frac{0.25\,mA}{1\,mA/V} \Rightarrow \boxed{a \leq 0.25\,V}$.


1.533
1.2
0.95
1.45
1.2


V_{DS}
2.0V
1.5
1.0V
Zero current, $V_{GS} - V_{th} = 0$
Linear Region
t


ω_0