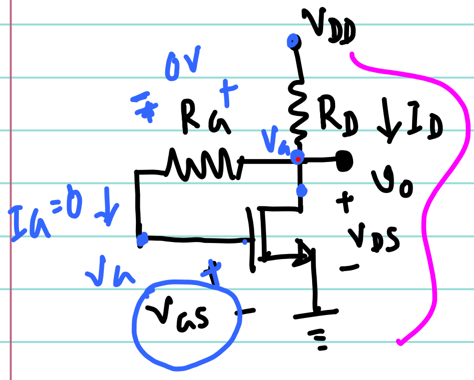
(C) Biasing using Drain to Gate Feedback Resistor:



$V_{GS} = V_{DS}$; $V_{DS\text{-}sat} = V_{GS} - V_{Th}$

$V_{DS} > V_{DS\text{-}sat}$

↓

Saturation

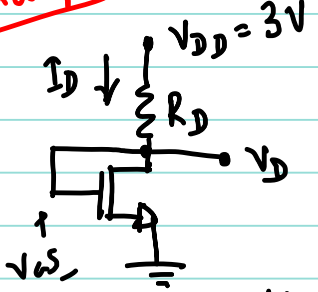
↳ $V_{DD} = I_D R_D + V_{DS}$

$V_{DD} = I_D R_D + V_{GS}$

↳ Negative feed back, Stability

Lec-23

Example:



→ $V_{Th} = 0.6V$, $\mu_n C_{ox} = 200\ \mu A/V^2$

$L = 0.8\ \mu m$, $W = 4\ \mu m$

→ $I_D = 80\ \mu A$

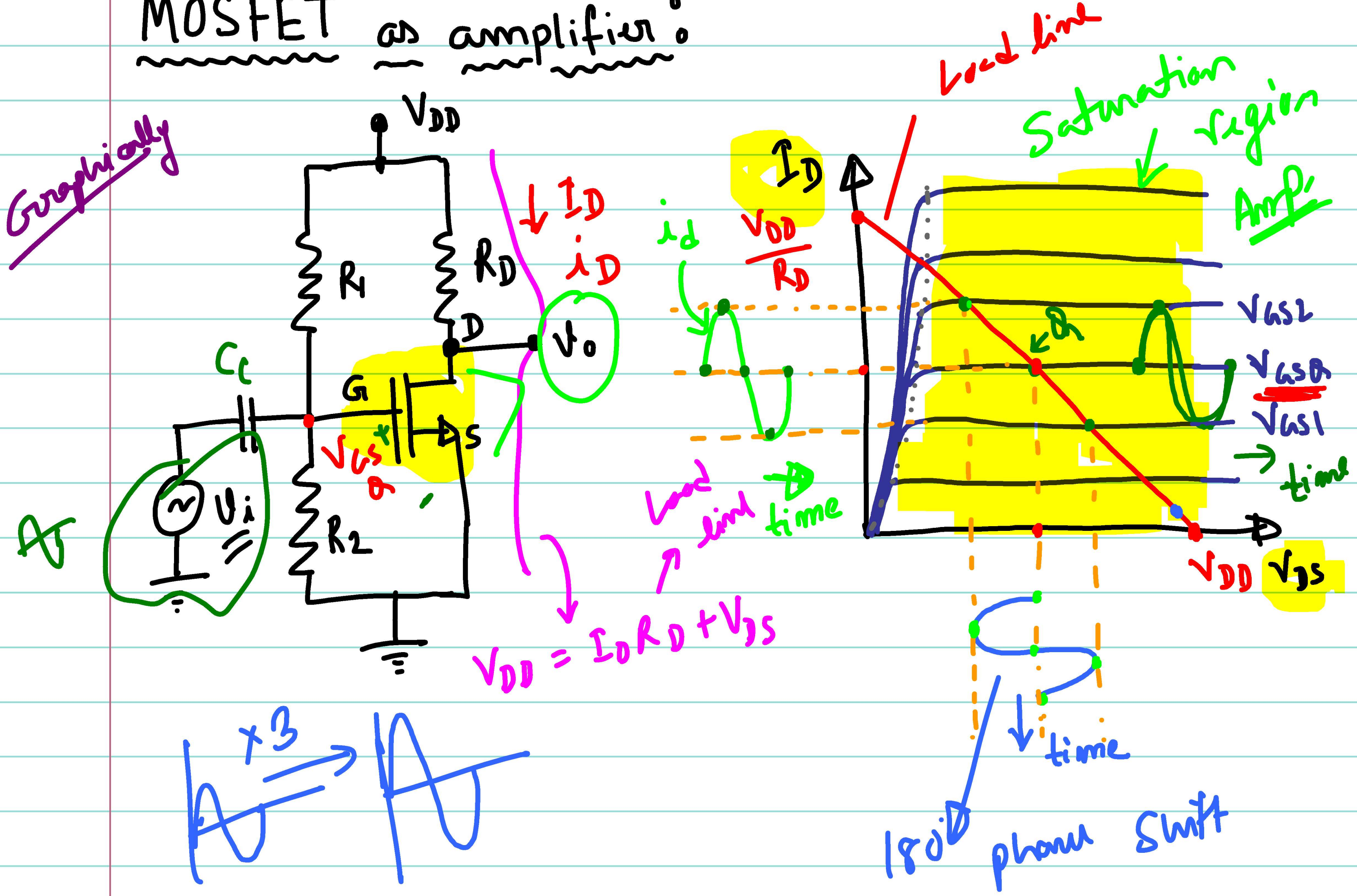
Find V_D.

$V_{GS} = V_{DS}$, saturation region

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{Th})^2$$

$V_{GS} = ??$ $= 1\ V \simeq V_{DS}$; $V_D = 1\ V$

MOSFET as amplifier:



Linear Amplifier

Notation:

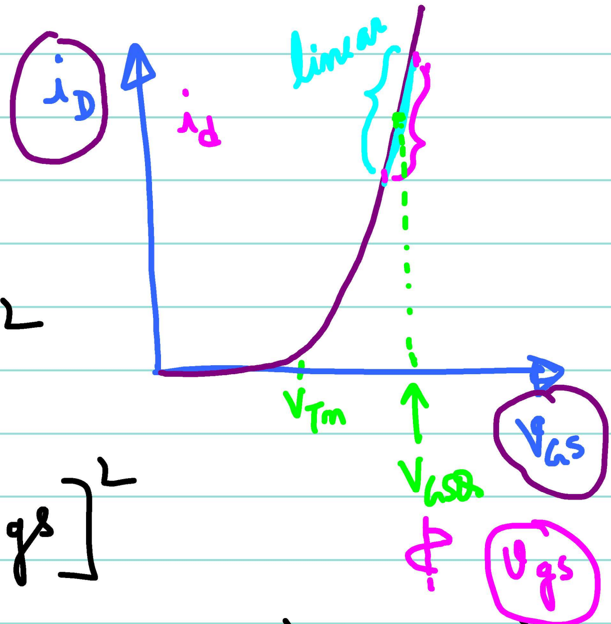
$v_{GS} \rightarrow$ total instantaneous value of v_{GS} (→ AC + DC)

$V_{GS} \rightarrow$ DC, $v_{gs} \rightarrow$ AC

$$v_{GS} = V_{GSQ} + v_i = V_{GSQ} + v_{gs}$$

$$i_D = k_n (v_{GS} - V_{Tn})^2$$

$$\rightarrow v_{GS} = V_{GSQ} + v_{gs}$$



$$i_D = k_n (v_{GS} - V_{Tn})^2$$

$$= k_n [V_{GSQ} + v_{gs} - V_{Tn}]^2$$

$$= k_n [(V_{GSQ} - V_{Tn}) + v_{gs}]^2$$

$$I_{DQ} + i_d = i_D = \underbrace{k_n (V_{GSQ} - V_{Tn})^2}_{I_{DQ}} + \underbrace{2 k_n (V_{GSQ} - V_{Tn}) v_{gs} + v_{gs}^2}_{i_d}$$

linear Amp. , $i_d \propto v_{gs}$ $\left(\frac{W}{L}\right)$

if, $v_{gs} << 2(V_{GSQ} - V_{Tn})$

$$\hookrightarrow i_d = 2 k_n (V_{GSQ} - V_{Tn}) v_{gs}$$

$$\hookrightarrow \boxed{g_m} = \left.\frac{\partial i_d}{\partial v_{gs}}\right|_{V_{GSQ}} = \boxed{2 k_n (V_{GSQ} - V_{Tn})} = 2 k_n \sqrt{\frac{I_{DQ}}{k_n}}$$

trans conductance

$$I_{DQ} = k_n (V_{GSQ} - V_{Tn})^2$$

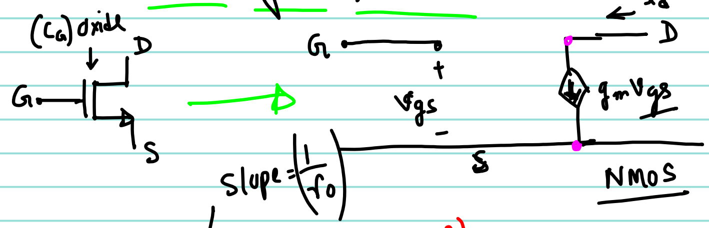
$$\uparrow \boxed{g_m = 2\sqrt{I_{DQ} k_n}}$$

$$V_{GSQ} - V_{Tn} = \sqrt{\frac{I_{DQ}}{k_n}}$$

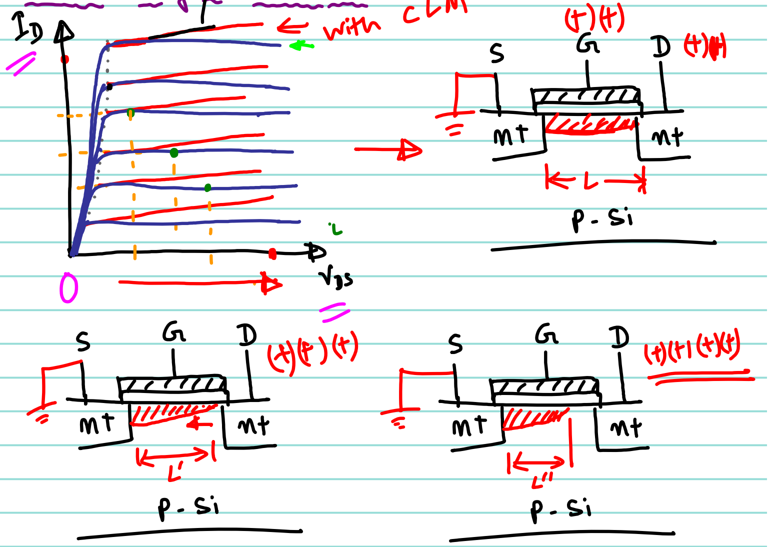
$$g_m \uparrow \quad \uparrow k_n \propto \left(\frac{W}{L}\right) \uparrow$$

$\uparrow X = \frac{1}{\omega C}$ range of freq. for which gate is open circuit.

MOSFET Small signal equivalent circuit:



Channel length modulation: (CLM)

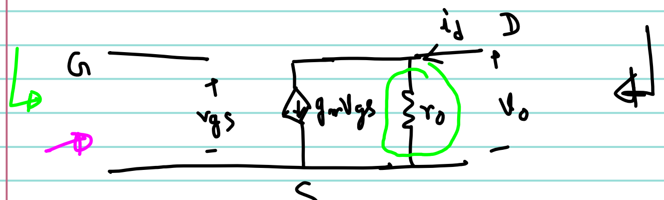


$\uparrow I_D \propto \left(\frac{W}{L}\right)\downarrow, \downarrow (L)$ is decreasing.

$$i_D = k_n [V_{GS} - V_{Tn}]^2 (1 + \lambda V_{DS}) \quad ; \quad \lambda = \text{channel length modulation parameter.}$$

$$r_o = \left(\frac{\partial i_D}{\partial V_{DS}}\right)^{-1} = \left[k_n (V_{GS} - V_{Tn})^2 \lambda\right]^{-1}$$

$$\rightarrow r_o = [I_{DQ} \lambda]^{-1} = \frac{1}{\lambda I_{DQ}}$$



Lec-24

For PMOS: