EC332 Devices 2

Lecture 5

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MOSFET as an amplifier

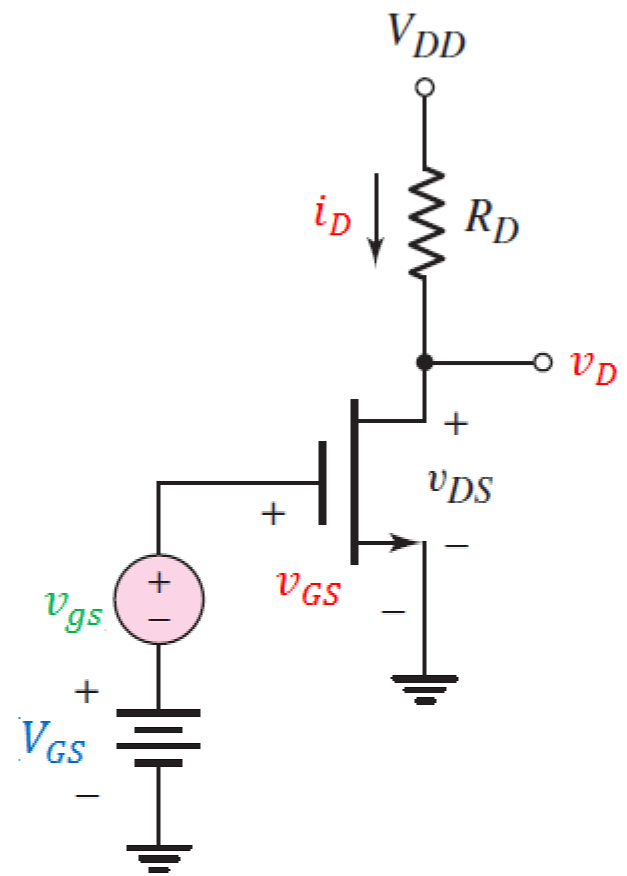
Transconductance（g_m）

$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(v_{GS} - V_t)^2$$

$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left((V_{GS} + v_{gs}) - V_t\right)^2$$

$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left((V_{GS} - V_t) + v_{gs}\right)^2$$

$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\Big((V_{GS} - V_t)^2 + 2v_{gs}(V_{GS} - V_t) + {v_{gs}}^2\Big)$$



MOSFET as an amplifier

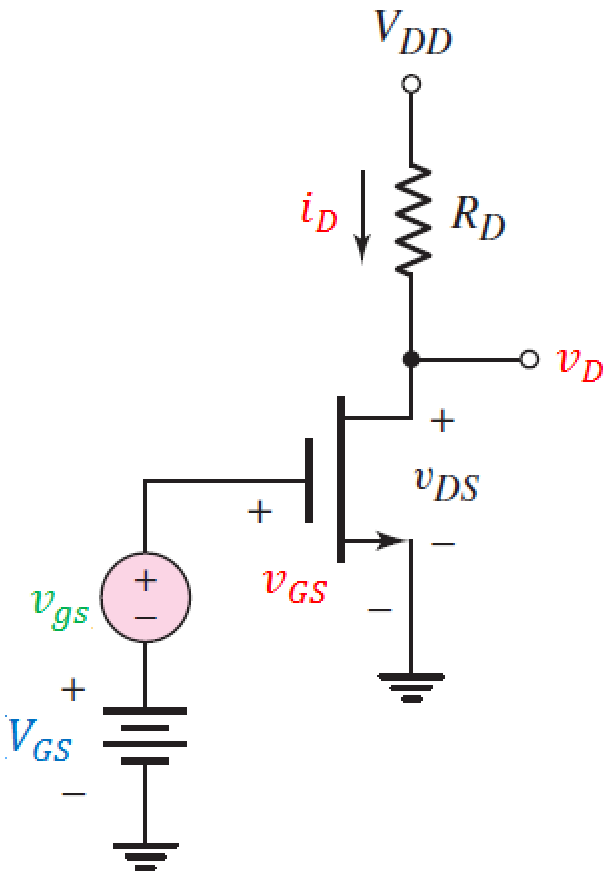
Transconductance (g_m)

$$i_d = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(2v_{gs}(V_{GS} - V_t) + v_{gs}^2\right)$$

Neglected
for small signal i/p

$$i_d = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(2v_{gs}(V_{GS} - V_t)\right)$$

$$i_d = \mu_n C_{ox}\frac{W}{L}v_{gs}(V_{GS} - V_t)$$



MOSFET as an amplifier

Transconductance (g_m)

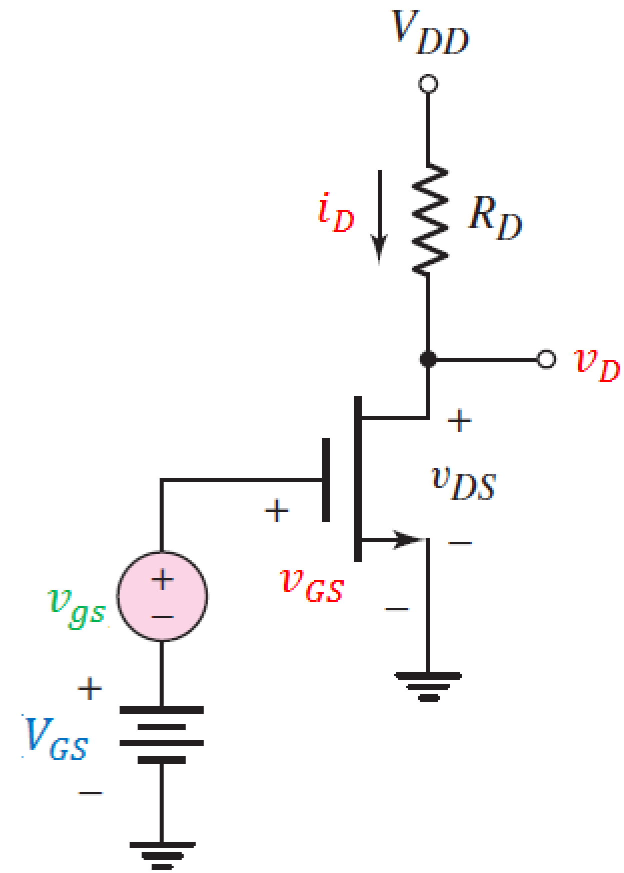
$$i_d = \mu_n C_{ox}\frac{W}{L} v_{gs}(V_{GS} - V_t)$$

Define transconductance = $g_m = \dfrac{i_d}{v_{gs}}$

$$g_m = \frac{i_d}{v_{gs}} = \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_t)$$

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

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

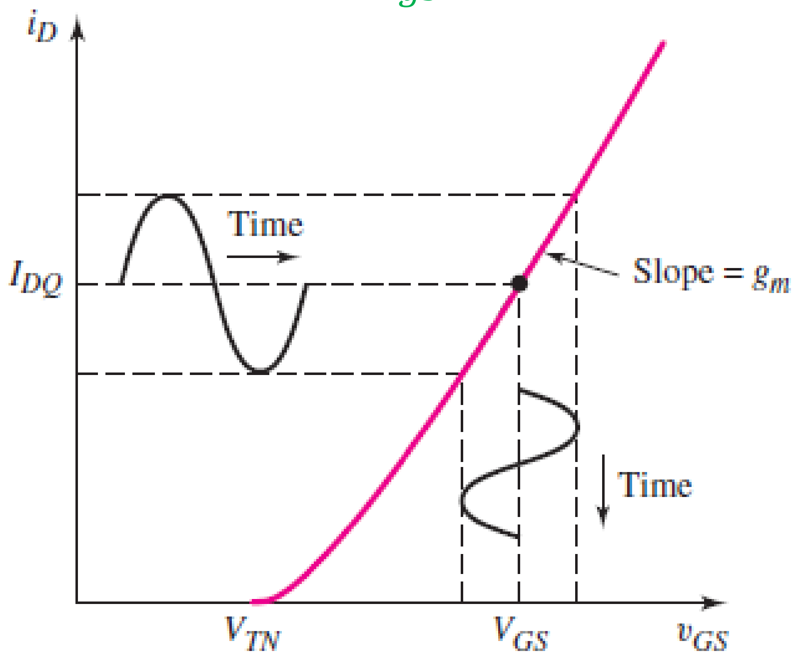


MOSFET as an amplifier

Transconductance (g_m)

$$g_m = \mu_n C_{ox} \frac{W}{L}(V_{GS} - V_t) = \frac{2I_D}{(V_{GS} - V_t)} = \sqrt{2 I_D \mu_n C_{ox} \frac{W}{L}}$$

$$g_m = \frac{i_d}{v_{gs}}$$



MOSFET as an amplifier

Voltage Gain（A_V）

$$v_O = v_D = \underbrace{V_{DD} - I_D R_D}_{} - i_d R_D$$

$$v_O = v_D = V_D - v_d$$

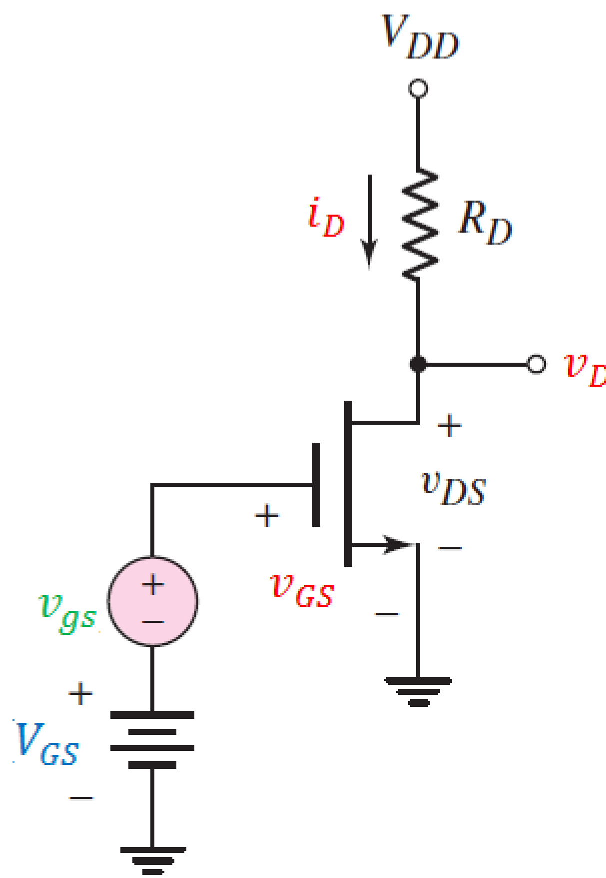
DC + AC

$$v_d = -i_d R_D$$

$$v_d = -\mu_n C_{ox} \frac{W}{L} v_{gs} (V_{GS} - V_t) R_D$$

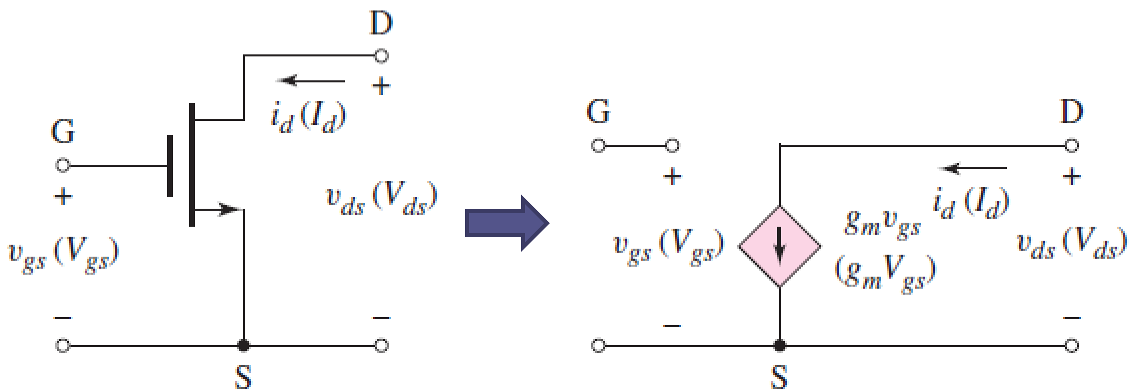
$$A_V = \frac{v_d}{v_{gs}} = -\mu_n C_{ox} \frac{W}{L} (V_{GS} - V_t) R_D$$

$$A_V = -g_m R_D$$

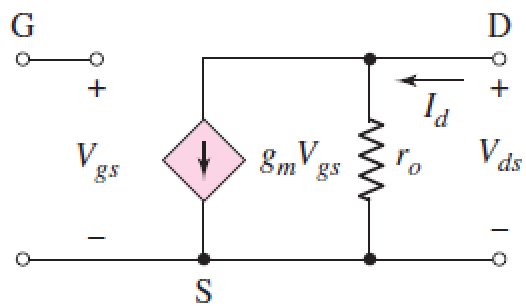


Small Signal Equivalent Circuit Model

Π-Model



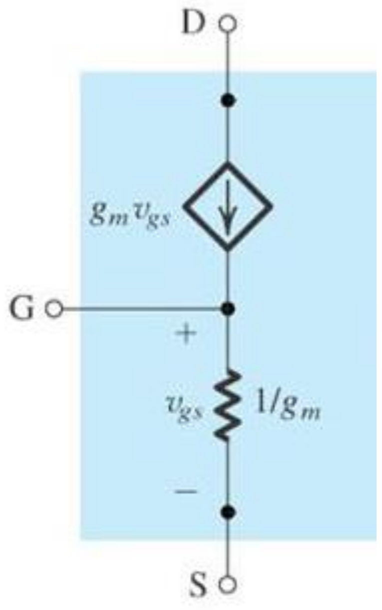
If λ=0



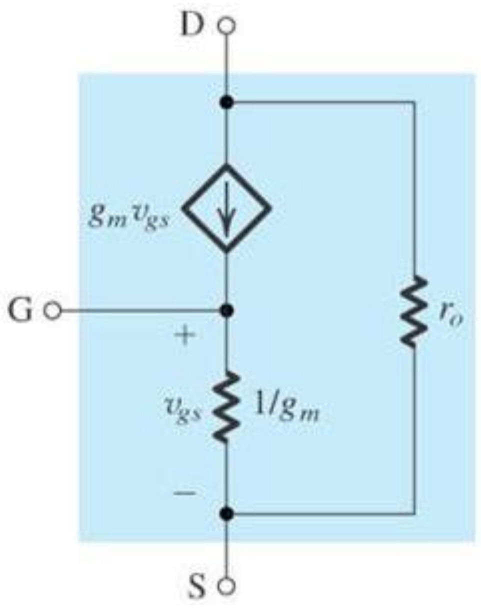
If λ≠0

Small Signal Equivalent Circuit Model

T-Model



If λ=0



If λ≠0