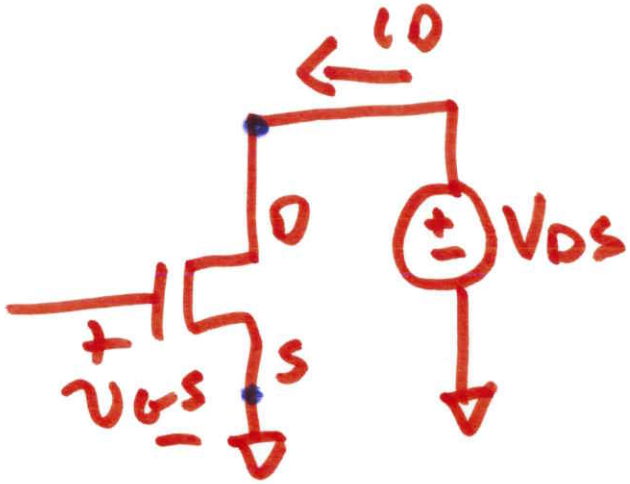
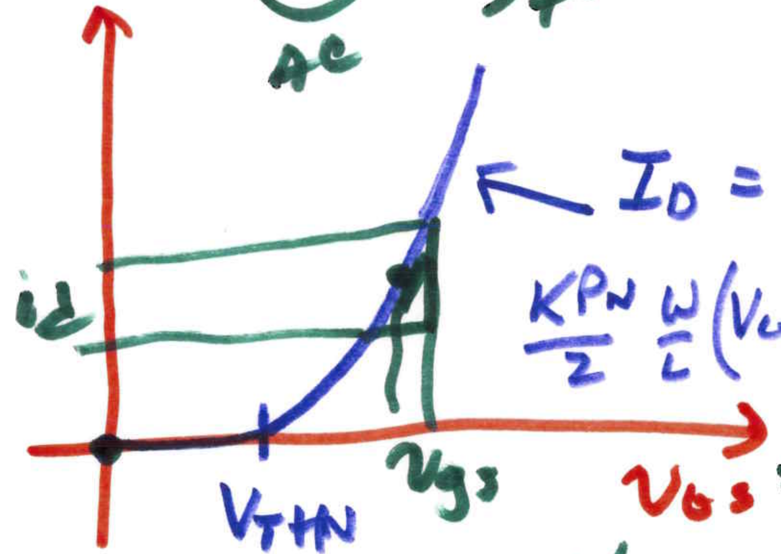
Ch9_9_1_p2

9.1.2 Small-Signal Models

$i_D = \underbrace{i_d}_{AC} + \overbrace{I_D}^{DC}$ Square-law

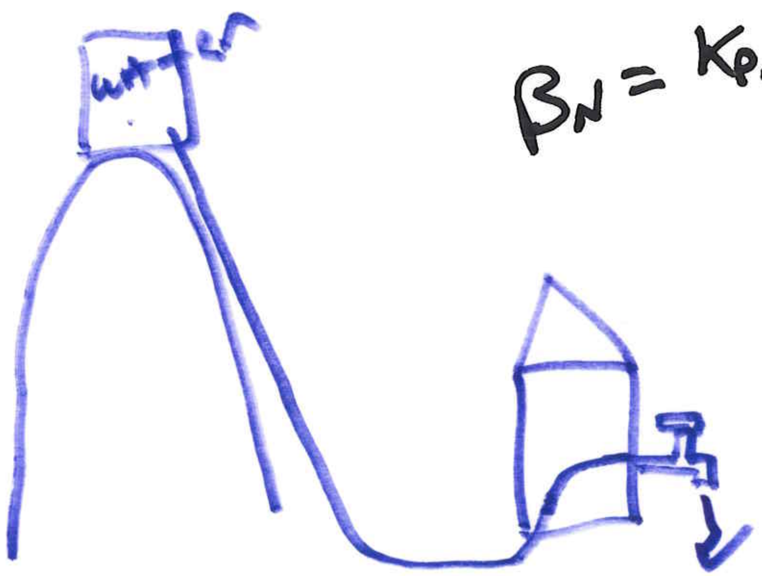




$I_D = \frac{KP_N}{2}\frac{W}{L}(V_{GS}-V_{THN})^2$

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

$\beta_N = KP_N \cdot \frac{W}{L}$



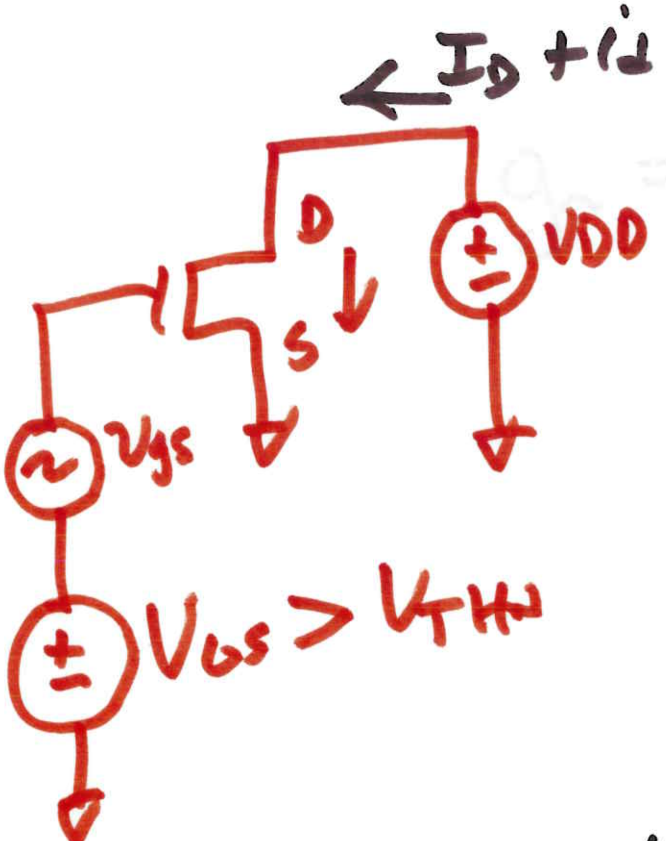
for sat

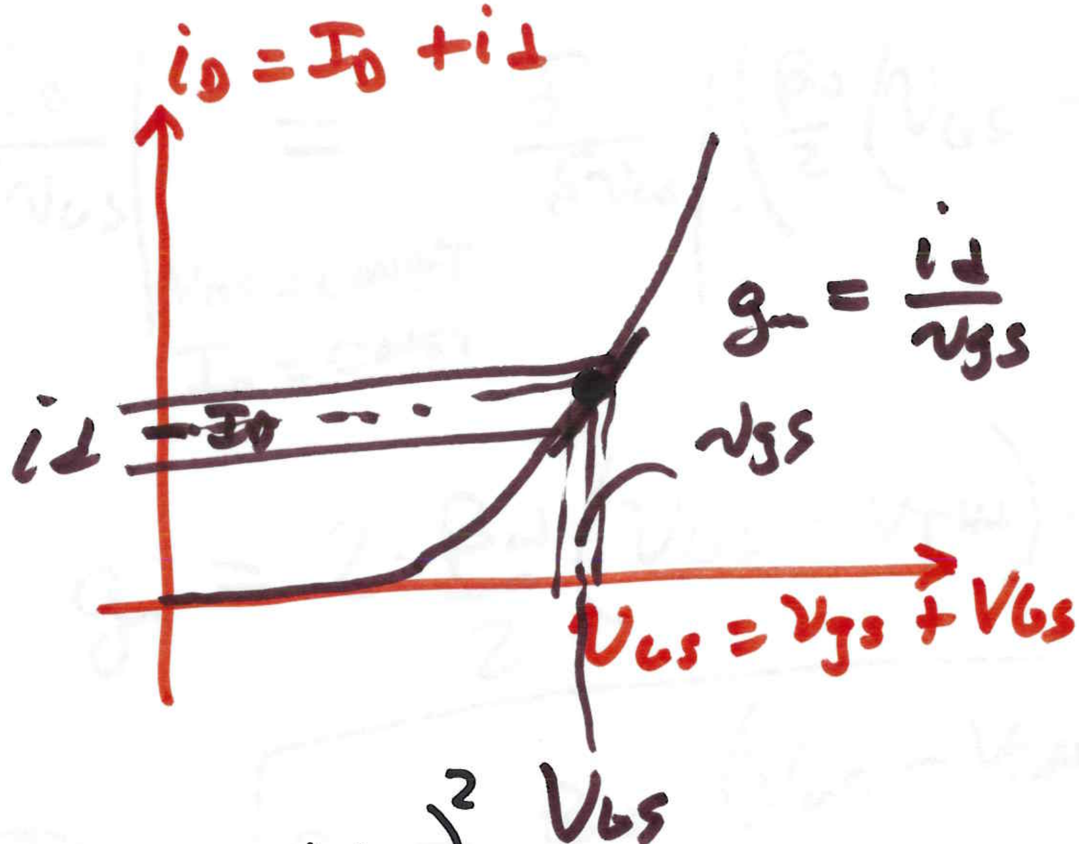
$V_{GS} > V_{THN}$

$V_{DS} > V_{GS} - V_{THN}$

$V_{DD} \geq V_{GS} - V_{THN}$

yes!





$$\frac{\delta}{\delta v_{GS}}\left[\underbrace{I_D + i_d}_{i_D}\right]_{\substack{V_{GS}=CONST\\ I_D=CONST}} = \frac{\delta \frac{\beta_N}{2}\left(\underbrace{V_{GS} + v_{gs}}_{v_{GS}} - V_{THN}\right)^2}{\delta v_{GS}}\Bigg|_{\substack{V_{GS}=CONST\\ I_D=CONST}}$$

$$\beta_N = KP_N \cdot \frac{W}{L} = \mu_n C_{ox} \cdot \frac{W}{L} = \mu_n \cdot \frac{\varepsilon_{ox}}{t_{ox}} \cdot \frac{W}{L}$$

$$g_m = \frac{\delta i_D}{\delta v_{GS}}\Bigg|_{\substack{V_{DS}=CONST \\ I_D = CONST}} = \frac{\delta}{\delta v_{GS}}\Bigg| \left(\frac{\beta_N}{2}(v_{GS} - V_{THN})^2\right)$$

$$g_m = 2 \cdot \frac{\beta_N}{2}(v_{GS} - V_{THN}) \cdot 1$$

$$\boxed{g_m = \beta_N \cdot (v_{GS} - V_{THN})}$$

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

$$g_m = \beta_N (V_{GS} - v_{gs} - V_{THN})$$

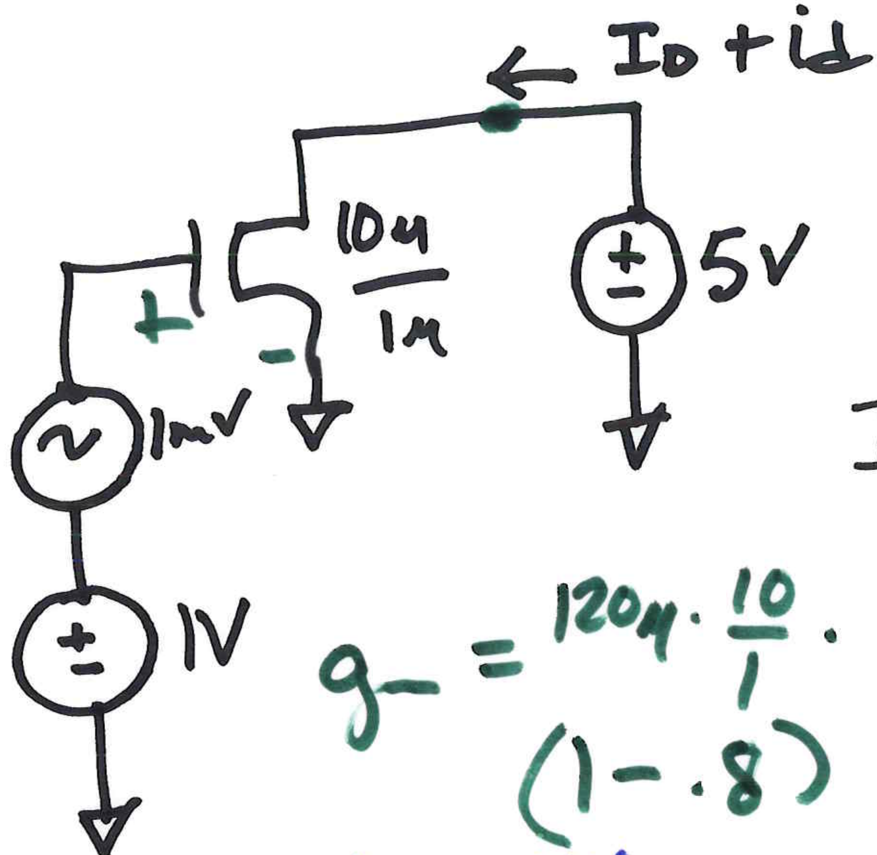
Small-signal approximation $V_{GS} \gg v_{gs}$

$$\boxed{g_m = \beta_N (V_{GS} - V_{THN})}$$

$$I_D = \frac{\beta_N}{2}\left(V_{GS} - V_{THN}\right)^2$$

$$V_{GS} = \sqrt{\frac{2I_D}{\beta_N}} + V_{THN}$$

$$\boxed{g_m = \sqrt{2\beta_N I_D}}$$



$V_{THN} = 800\,mV$

$KP_n = 120\ \mu A/V^2$

$$I_D = \frac{KP_n}{2}\cdot\frac{W}{L}\left(V_{GS} - V_{THN}\right)^2$$

$$= \frac{120\mu}{2}\cdot\frac{10}{1}\left(1 - .8\right)^2$$

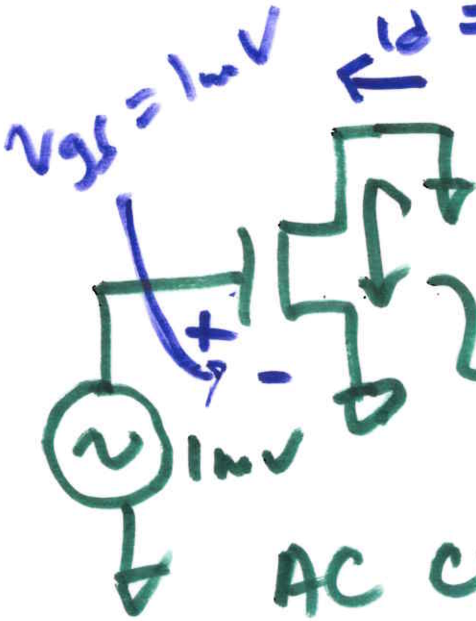
$$= 600\mu \cdot .04 = 24\mu A$$

$$\boxed{I_D = 24\mu A}$$

$$g_m = 120\mu\cdot\frac{10}{1}\cdot(1-.8)$$

$1200 \cdot .2$

$$g_m = 240\ \mu A/V$$



$i_d = g_m v_{gs}$

$$i_d = g_m \cdot \frac{1mV}{v_{gs}} = 240\ \frac{\mu A}{V}\cdot 1mV = 240\,nA$$

AC CKT

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