$V_{th} = 1.5\,V$ $K_n = 0.25\,mA/V^2$

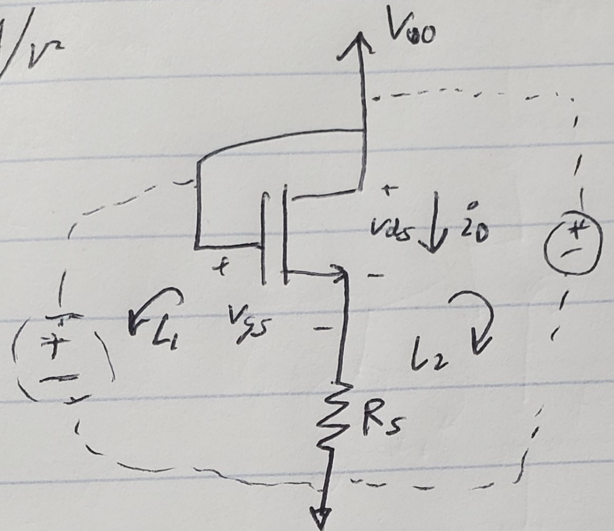
$V_{DD} = 8\,V$ $R_s = 2.2\,k\Omega$

Assume saturation

$I_d = \frac{K_n}{2}(V_{gs} - V_{th})^2$

$L_1: 8 - (2.2K)I_d - V_{gs} = 0$

$V_{gs} = 8 - (2.2K)I_d$



substitute

$I_d = 0.125m\left(8 - (2.2K)I_d - 1.5\right)^2$

$= 0.125m(6.5 - 2.2K\,I_d)^2$

$= 0.125m(42.25 - 28600\,I_d + 4840000\,I_d^2)$

$= 0.0005 - 3.575\,I_d + 605\,I_d^2$

$I_d = (\underline{0.14mA},\ 5.8mA)$

$V_{gs}\big|_{I_d=0.14m} = 8 - 2200(0.14m) = 7.692$

$V_{gs}\big|_{I_d=5.8m} = 8 - 2.2K(5.8m) = 12.76$

$V_{gs} > V_{th}$ $V_{ds} > V_{gs} - V_{th}$

$L_2: 8 - 2200\,I_d - V_{ds} = 0$

$v_{ds} = 8 - 2200\,I_d$

$= 8 - 2200(0.00014)$

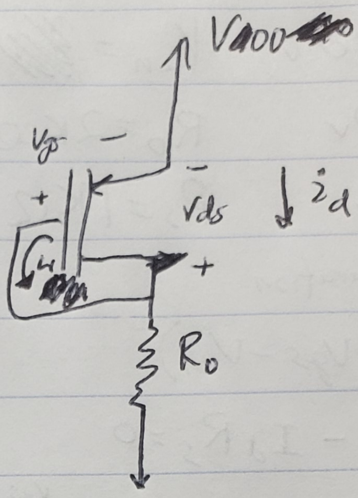
$= \underline{7.692}$

2. $V_{th} = -1v$ $K_p = 0.5m$

$V_{DD} = 10v$ $R_D = 1K\Omega$

Assume saturation

$I_d = K_n/2 \, (V_{sg} - |V_{th}|)^2$



L_1: $10 - I_D R_D - V_{sg} = 0$

$V_{sg} = 10 - I_D R_D$

Substitute

$I_d = 0.25m\,(10 - 1000 I_d - 1)^2$

$= 0.25m\,(9 - 1000 I_d)^2$

$= 0.25m\,(81 - 18000 I_d + 1000000 I_d^2)$

$= 0.02025 - 4.5 I_d + 250 I_d^2$

$I_d = \dfrac{4.5 \pm \sqrt{20.25 - 20.25}}{500} = \dfrac{4.5}{500} = \underline{9mA}$ X $I_d = \underline{0A}$ ✓

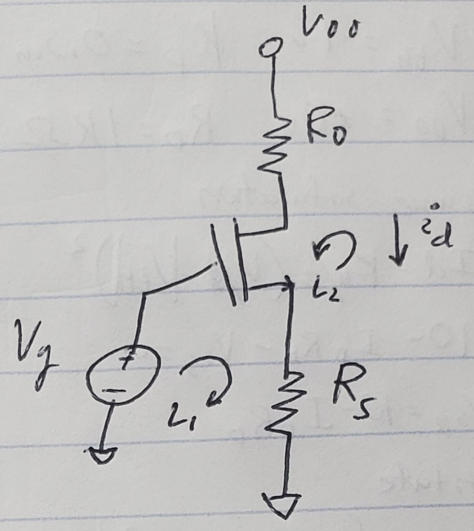
$V_{sg} = 10 - 1000(9m) = 1$

cutoff: $V_{sg} \le |V_{th}| \rightarrow 1 \le 1$

3. $V_{th} = 2v$ $\quad K_n = 0.5m$

$V_{DD} = 10v$ $\quad R_D = 2K\Omega$

$V_G = 5v$ $\quad R_S = 1K\Omega$



Assume saturation

$I_d = \frac{K_n}{2}(V_{gs} - V_{th})^2$

L_1: $V_g - V_{gs} - I_d R_s = 0$

$V_{gs} = I_d R_s - V_g, \quad I_d = \frac{V_{gs} + V_g}{R_s}$

substitute

$I_d = 0.25m\left(I_d(1000) - 5 - 2\right)^2$

$= 0.25m\left(I_d(1000) - 7\right)^2$

$= 0.25m\left(1000000 I_d^2 - 14{,}000 I_d + 49\right)$

$I_d = 250 I_d^2 - 3.5 I_d + 0.01225$

$250 I_d^2 - 4.5 I_d + 0.01225 = 0$

$I_d = (3.3mA, \underline{14.6mA})$

$V_{gs} = I_d R_s - V_g \Big|_{I_d = 3.3mA} = -1.7v$

$V_{gs} = I_d R_s - V_g \Big|_{I_d = 14.6mA} = 9.6v$

$V_{gs} > V_{th} \rightarrow V_{gs} = 9.6v$

$10 - I_d(R_D + R_s) - V_{ds} = 0$

$\cancel{V_{ds} - I_d(R_D + R_s) = 10}$

$V_{DS} = 10 - 3000 I_d = -33.8V$

$-33.8 < V_{gs} - V_{th}$

Assume Triode

$I_d = K_n\left((V_{gs} - V_{th})V_{ds} - \frac{V_{ds}^2}{2}\right)$

$14.6mA = 0.5m\left((9.6 - 2)V_{ds} - \frac{V_{ds}^2}{2}\right)$

$29.2 = 7.6 V_{ds} - \frac{V_{ds}^2}{2}$

$-0.5 V_{ds}^2 + 7.6 V_{ds} - 29.2 = 0$

$V_{ds} = (-18.4v, \underline{3.2v})$

$3.2 < 9.6 - 2$