Microelectronics Circuit Analysis and Design
Homework(5th)

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3.27 The transistor in the circuit in Figure P3.27 has parameters $V_{TN} = 0.8$V and $K_n = 0.25$ mA/V^2. Sketch the load line and plot the Q-point for (a) $V_{DD} = 4$V, $R_D = 1k\Omega$ and (b) $V_{DD} = 5$V, $R_D = 3k\Omega$. What is the operating bias region for each condition?

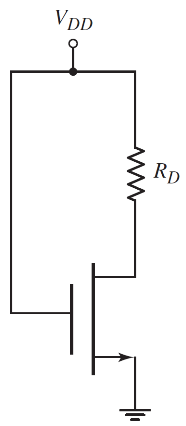

Figure 1: Problem 3.27

Solution:

(a)Assume the transistor works in the saturation region:

$V_{GS} = V_{DD} = 4V \Rightarrow i_d = K_n(V_{GS} - V_{TN})^2 = 2.56$mA.

$\therefore V_{DS} = V_{DD} - i_d R_D = 1.44\text{V} < V_{GS} - V_{TN} \Rightarrow$ the transistor works in the nonsaturation region

$$\therefore \begin{cases} i_d = K_n\left[2(V_{GS} - V_{TN})V_{DS} - V_{DS}^2\right] \\ V_{DS} = V_{DD} - i_d R_D \end{cases} \Rightarrow \begin{cases} i_d = 2.12\text{mA} \\ V_{DS} = 1.88\text{V} \end{cases}$$

(b)Assume the transistor works in the saturation region:

$V_{GS} = V_{DD} = 4V \Rightarrow i_d = K_n(V_{GS} - V_{TN})^2 = 4.41\text{mA}.$

$\therefore V_{DS} = V_{DD} - i_d R_D = -8.23\text{V} < V_{GS} - V_{TN} \Rightarrow$ the transistor works in the nonsaturation region:

$$\therefore \begin{cases} i_d = K_n\left[2(V_{GS} - V_{TN})V_{DS} - V_{DS}^2\right] \\ V_{DS} = V_{DD} - i_d R_D \end{cases} \Rightarrow \therefore \begin{cases} i_d = 1.42\text{mA} \\ V_{DS} = 0.741\text{V} \end{cases}$$

3.35 For the transistor in the circuit in Figure P3.35, the parameters are $V_{TN} = 0.4$ V, $k_n' = 120\mu\text{A/V}^2$, and $W/L = 25$. Determine V_{GS}, I_D, and V_{DS}. Sketch the load line and plot the Q-point.

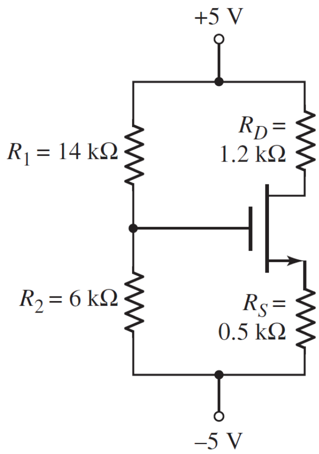

Figure 2: Problem 3.35

Solution:

Actually, $K_n = \dfrac{k_n'}{2} \cdot \dfrac{W}{L} = 1.5\text{mA}/\text{V}^2$

Assume the transistor works in the saturation region:

$V_G = \dfrac{R_2}{R_1 + R_2}(V_{DD} - V_{SS}) + VSS = -2\text{V}$, $V_S = I_D R_S + V_{SS} = (0.5I_D - 5)\text{V}$

$\therefore I_D = K_n(V_G - V_S - V_{TN})^2 \Rightarrow I_D = 2.58\text{mA}$ or 10.49mA(Ignore)

$\therefore V_{GS} = V_G - V_S = 1.71\text{V}, V_{DS} = V_{DD} - I_D R_D - V_S = 5.61\text{V}.$