Microelectronics Circuit Analysis and Design Homework(7th)

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4.36 The parameters of the circuit in Figure P4.36 are $R_S = 4k\Omega$, $R_1 = 850k\Omega$, $R_2 = 350k\Omega$, and $R_L = 4k\Omega$. The transistor parameters are $V_{TP} = -1.2\text{V}$, $k_p' = 4\mu\text{A}/\text{V}^2$, $W/L = 80$, and $\lambda = 0.05\text{V}^{-1}$. (a) Determine I_{DQ} and V_{SDQ} . (b) Find the small-signal voltage gain $A_v = v_o/v_i$. (c) Determine the small-signal circuit transconductance gain $A_g = i_o/v_i$. (d) Find the small signal output resistance R

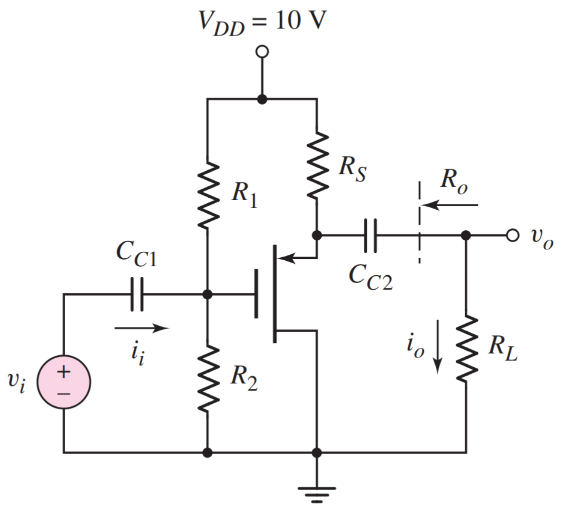

Figure 1: Problem 4.36

Solution:

It's a PMOS-Enhanced transistor

(a)$K_p = \dfrac{k_p'}{2}\dfrac{W}{L} = 1.6\text{mA}$

Assume the transistor work in the saturation region, we have equation:

$$\begin{cases} I_{DQ} = K_n(V_{SGQ} + V_{TP})^2 \\ V_S = V_{DD} - I_{DQ}R_S \\ V_G = \dfrac{R_2}{R_1 + R_2} V_{DD} \end{cases} \Rightarrow \begin{cases} I_{DQ} = 1.25\text{mA} \\ V_{SDQ} = 5\text{V} \\ V_{SGQ} = 2.084\text{V} \end{cases}$$

The answer coordinate with the problem. (b)$g_m = 2K_p(V_{SGQ} + V_{TP}) = 2.828\text{mA/V}, r_o = (\lambda I_{DQ})^{-1} = 16\text{k}\Omega$ $R_o = r_o||R_S||R_L = 1.778\text{k}\Omega$

$\therefore A_v = \frac{g_m R_o}{1+g_m R_o} = 0.834$

(c)$A_g = \dfrac{i_o}{v_i} = \dfrac{i_o}{v_o} \cdot \dfrac{v_o}{v_i} = \dfrac{A_v}{R_L} = 0.2085\text{mA/V}$

4.40 For the circuit in Figure P4.39, $R_S = 1k\Omega$ and the quiescent drain current is $I_{DQ} = 5\text{mA}$. The transistor parameters are $V_{TN} = -2\text{V}$, $k_n' = 100\mu\text{A/V}^2$, and $\lambda = 0.01\text{V}^{-1}$. (a) Determine the transistor width-to length ratio. (b) Using the results of part (a), find the small-signal voltage gain for $R_L = \infty$. (c) Find the small-signal output resistance R_o. (d) Using the results of part (a), find A_v for $R_L = 2k\Omega$.

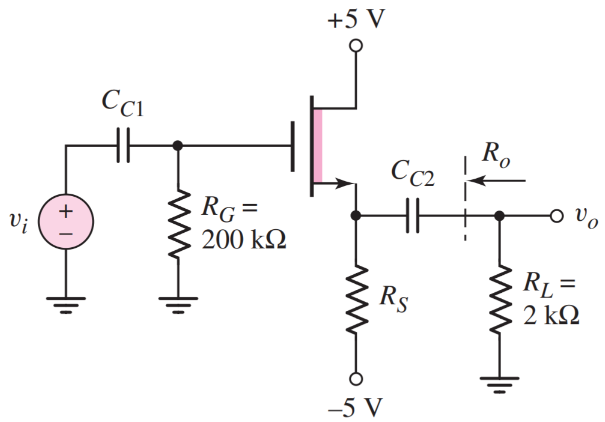

Figure 2: Problem 4.40

Solution:

Obviously, it's a NMOS-Depletion transistor (a)Assume the transistor works in the saturation region:

$$\begin{cases} V_S = V_{SS} + I_D R_S \\ V_G = 0 \\ I_{DQ} = \dfrac{k_n'}{2} \cdot \dfrac{W}{L} \end{cases} \Rightarrow \frac{W}{L} = 25$$

(b)$g_m = 2\sqrt{K_n I_{DQ}} = 5\text{mA/V}, r_o = (\lambda I_{DQ})^{-1} = 20\text{k}\Omega$

$A_v = \dfrac{g_m(r_o||R_s)}{1+g_m(r_o||R_S)} = 0.826$

(c)$R_o = \dfrac{1}{g_m}||r_o||R_S = 165\Omega$

(d)$A_v = \dfrac{g_m(r_o||R_S||R+L)}{1+g_m(r_o||R_S||R+L)} = 0.763$

4.45 Figure P4.45 is the ac equivalent circuit of a common-gate amplifier. The The transistor parameters are $V_{TN} = 0.4$ V, $k_n' = 100\ \mu\text{A/V}^2$, and $\lambda = 0$.The quiescent drain current is $I_{DQ} = 0.25$ mA. Determine the transistor W/L ratio and the value of R_D such that the small-signal voltage gain is $A_v = V_o/V_i = 20$ and the input resistance is $R_i = 500\Omega$.

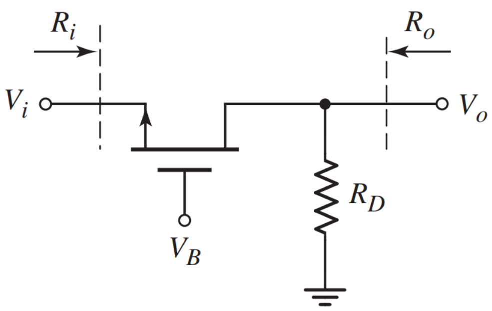

Figure 3: Problem 4.45

Solution:

$R_i = \dfrac{1}{g_m} = 0.5\text{k}\Omega \Rightarrow g_m = 2\text{mA/V} = 2\sqrt{\dfrac{k_n'}{2} \cdot \dfrac{W}{L} I_{DQ}} \Rightarrow \dfrac{W}{L} = 80$

$A_v = \dfrac{g_m R_D}{1+g_m R_{Si}} = g_m R_D = 20 \Rightarrow R_D = 10\text{k}\Omega$

4.48 For the common-gate circuit in Figure P4.48, the NMOS transistor parameters are:$V_{TN} = 1$V , $K_n = 3\text{mA/V}^2$, and $\lambda = 0$. (a)Determine I_{DQ} and V_{DSQ}. (b)Calculate g_m and r_o (c) Find the small- signal voltage gain $A_v = v_o/v_i$.

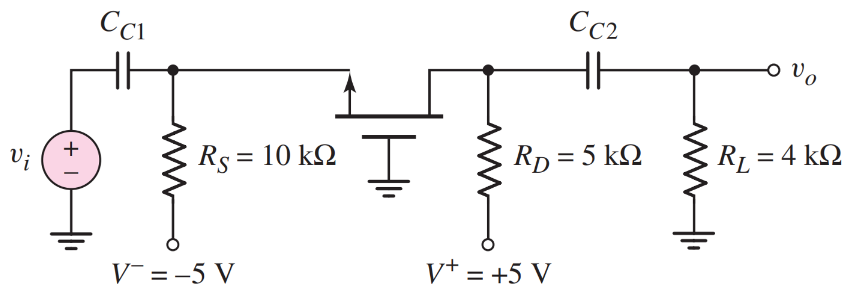

Figure 4: Problem 4.48

Solution:

Assume the transistor works in the saturation region, we have equations:

$$\begin{cases} V_{GS} + I_{DQ}R_S = 0 - V^- \\ I_{DQ} = K_n(V_{GS} - V_{TN})^2 \end{cases} \Rightarrow \begin{cases} V_{GS} = 1.35\text{V} \\ I_{DQ} = 0.365\text{mA} \end{cases}$$

$V_{DSQ} = (V^+ - I_{DQ}R_D) - (V^- + I_{DQ}R_S) = 4.53\text{V}$

(b)$g_m = 2K_n(V_{GSQ} - V_{TN}) = 2.093\text{mA/V}, r_o = \infty$

(c)$A_v = g_m(R_D||R_L) = 4.65$