# Microelectronics Circuit Analysis and Design
# Homework(6th)

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4.15 For the NMOS common-source amplifier in Figure P4.15, the transistor parameters are: $V_{TN} = 0.8\text{V}$, $K_n = 1\text{mA/V}^2$, and $\lambda = 0$. The circuit parameters are $V_{DD} = 5\text{V}$, $R_S = 1k\Omega$, $R_D = 4k\Omega$, $R_1 = 225k\Omega$, and $R_2 = 175k\Omega$. (a) Calculate the quiescent values $I_{DQ}$ and $V_{DSQ}$. (b) Determine the small-signal voltage gain for $R_L = \infty$. (c) Determine the value of $R_L$ that will reduce the small-signal voltage gain to 75 percent of the value found in part (b).

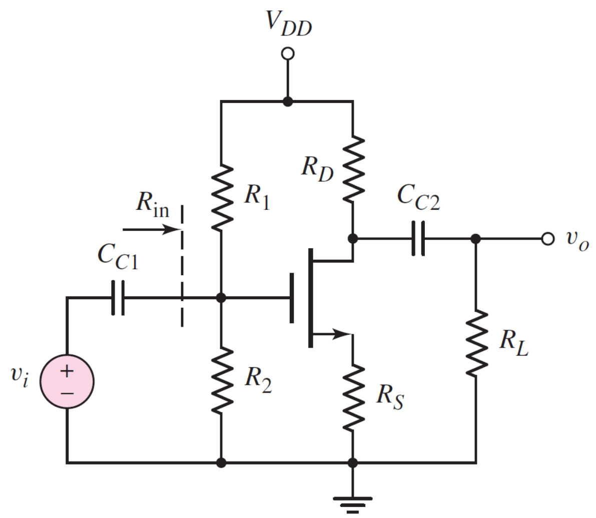


Figure 1: Problem 4.15/4.17

Solution:

(a)$V_G = \dfrac{R_2}{R_1+R_2}V_{DD} = \dfrac{35}{16}$V, assume that the transistor work in the saturation region:

$V_S = I_D R_S, I_D = K_n(V_G - V_S - V_{TN})^2 \Rightarrow I_D = 0.61\text{mA}$ or $3.17\text{mA}(\mathit{Ignore})$

$\therefore V_{GS} = V_G - V_S = 1.58\text{V} V_{DSQ} = V_{DD} - I_D R_D = 1.96\text{V} > V_{GS} - V_{TN}$

(b)$R_L = \infty \Leftrightarrow$ Circuit is open, so the equivalent circuit is as follow:

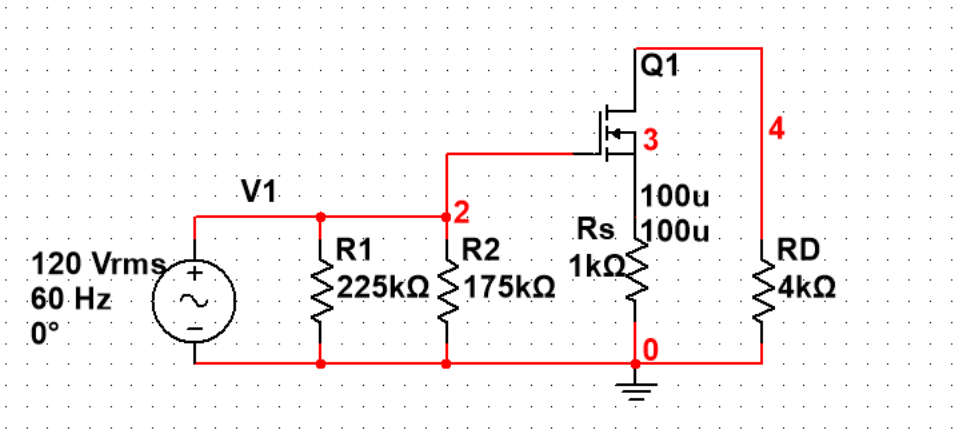


Figure 2: Problem 4.15

$g_m = 2K_n(V_{GSQ} - V_T N) = 1,56\text{mS}, i_d = g_m v_{gs}, v_o = -i_d R_D, A_v = \dfrac{v_o}{v_{gs}} = -2.44$

(c)$A_v' = 0.75A_v = \dfrac{-i_d(RL||R_D)}{v_{gs}} \Rightarrow R_L = 12\text{k}\Omega$

4.17 Repeat Problem 4.15 if the source resistor is bypassed by a source capacitor $C_S$.

(a)The answer is the same as 4.15(a), because in the case of DC, the source capacitor is open, answer doesn't change.

$I_D = 0.61\text{mA}, V_{DSQ} = 1.96\text{V}$

(b)(c)In this case, the $R_S$ is shorted, but $i_d$ doesn't change, so the answer is the same as 4.15(b)(c)

$\therefore$(b)$A_v = -2.44$ (c)$R_L = 12\text{k}\Omega$

D4.26 Design the common-source circuit in Figure P4.26 using an n-channel MOSFET with $\lambda = 0$. The quiescent values are to be $I_{DQ} = 6$mA, $V_{GSQ} = 2.8$ V, and $V_{DSQ} =$10 V. The transconductance is $g_m = 2.2$mA/V. Let $R_L = 1k\Omega$, $A_v = -1$, and $R_{in} = 100k\Omega$. Find $R_1, R_2, R_S, R_D, K_n$, and $V_{TN}$ .

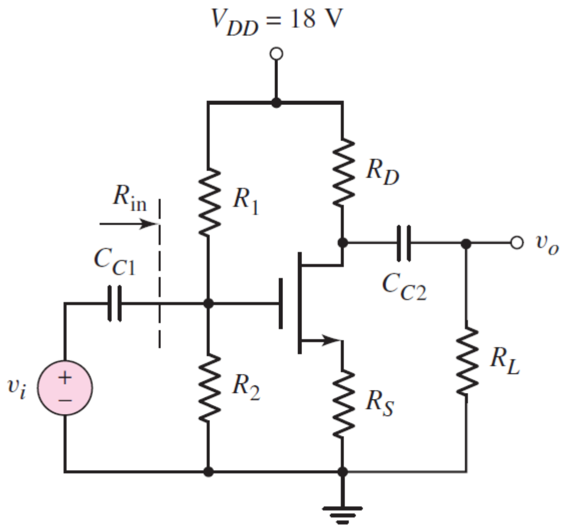


Figure 3: Problem 4.26

Solution:

Obviously, the transistor is work in the saturation region, we have equation:

$$\begin{cases} I_{DQ} = K_n(V_{GSQ} - V_{TN})^2 \\ V_{DSQ} = V_{DD} - I_D R_D \\ V_G = \dfrac{R_2}{R_1 + R_2} V_{DD} \\ V_S = I_D R_S \\ g_m = 2K_n(V_{GSQ} - V_{TN}) \\ R_{in} = \dfrac{R_1 R_2}{R_1 + R_2} \\ A_v = \dfrac{-g_m v_{gs}(R_D || R_L)}{v_{gs}} \end{cases} \Rightarrow \begin{cases} R_1 = \\ R_2 = \\ R_S = \\ R_D = \\ K_n = \\ V_{TN} = \end{cases}$$