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: $V_{TN} = 0.8$V, $K_n = 1$mA/V^2, and $\lambda = 0$. The circuit parameters are $V_{DD} = 5$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).

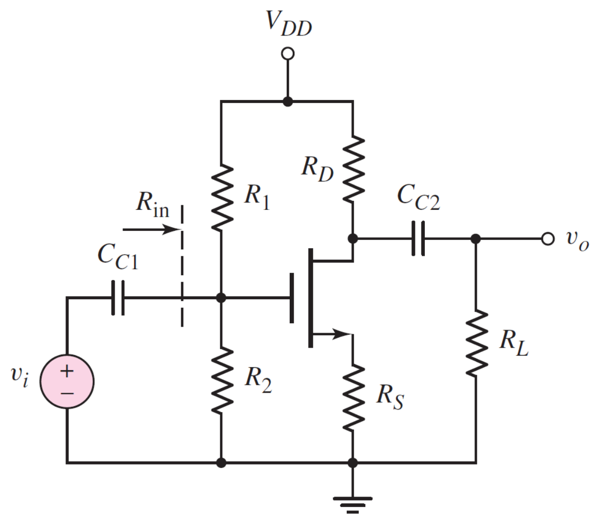

Figure 1: Problem 4.15/4.17

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:

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

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

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

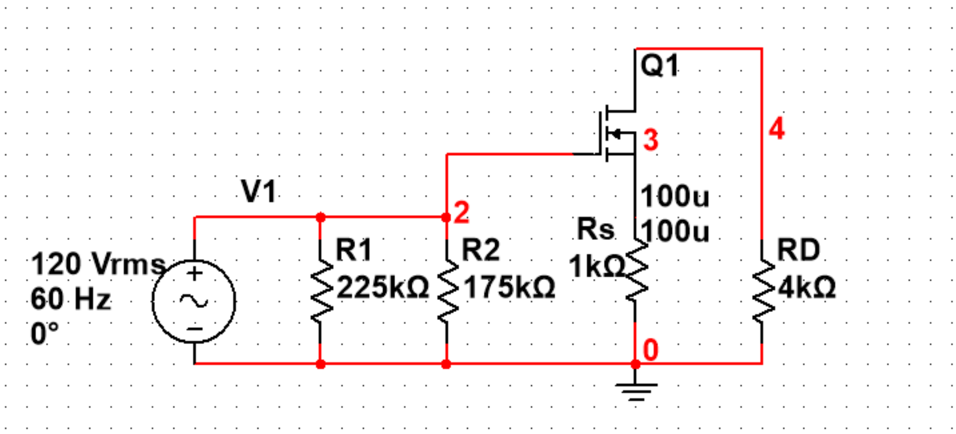

Figure 2: Problem 4.15

$g_m = 2K_n(V_{GSQ} - V_T N) = 1,56\text{mS}, i_d = g_m v_{gs}, v_o = -i_d R_D, v_1 = v_{gs} + i_d R_s = v_{gs} + g_m v_{gs} R_S$

$\therefore A_v = \frac{v_o}{v_1} = -2.44$

(c)$A_v' = 0.75 A_v = \frac{-i_d(R_L||R_D)}{v_1} \Rightarrow R_L = 12\text{k}\Omega$

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)In the case of AC, the resistor R_S is shorted, so:

$$A_v = \frac{-i_d R_d}{V_{gs}} = -g_m R_d = -6.24$$

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

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 $I_{DQ} = 6\text{mA}$, $V_{GSQ} = 2.8$ V, and $V_{DSQ} =$10 V. The transconductance is $g_m = 2.2\text{mA/V}$. 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} .

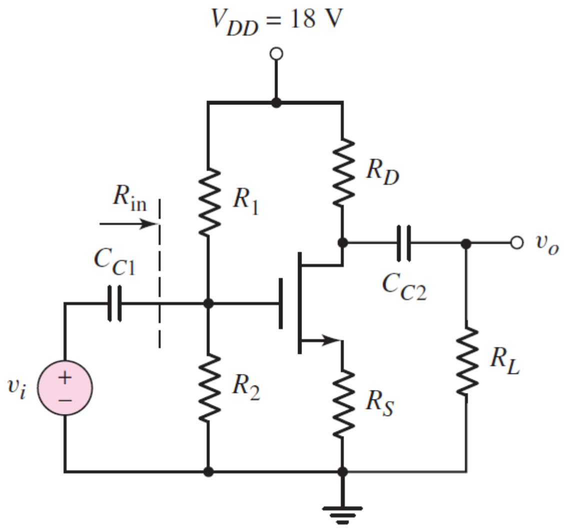

Figure 3: Problem 4.26

Solution:

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

$$\begin{cases} I_{DQ} = K_n(V_{GSQ} - V_{TN})^2 \\ V_{DSQ} = V_{DD} - I_D R_D \\ V_G = \dfrac{R_2}{R_1 + R_2} V_{DD} \\ V_S = I_D R_S \\ g_m = 2K_n(V_{GSQ} - V_{TN}) \\ R_{in} = \dfrac{R_1 R_2}{R_1 + R_2} \\ A_v = \dfrac{-g_m v_{gs}(R_D || R_L)}{v_1} \\ v_1 = v_{gs} + i_d R_s \end{cases} \Rightarrow \begin{cases} R_1 = 529\text{k}\Omega \\ R_2 = 123\text{k}\Omega \\ R_S = 0.1\text{k}\Omega \\ R_D = 1.23\text{k}\Omega \\ K_n = 0.20\text{mA} \\ V_{TN} = -2.65\text{V?(another answer is 8.25?)} \end{cases}$$